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Bottom Water Effects on the Distribution and Density of Bottom Fish in NAFO Subarea 3

by

V. A. Borovkov, A. Yu. Bulatova, A. K. Chumakov, P. I. Savvatimsky and I. I. Tevs

Polar Research Institute of Marine Fisheries and Oceanography (PINRO)
6 Knipovich Street, 183763 Murmansk, USSR

ABSTRACT

Influence of oceanographic factors responsible for year-to-year variations in the distribution, species composition of catch, abundance and biomass of commercially-important fish in the Newfoundland area is studied on the basis of historic data from USSR and Canada surveys. Relations are ascertained between mean catch of cod, beaked redfish, long rough dab, numbers of young cod in separate divisions and the area occupied by bottom waters of certain temperatures. Mean catch per hour tow, abundance and biomass of witch in Divs. 3K,3L,3N are found to vary by depth during 1983 and 1984.

INTRODUCTION

Catch per unit effort is widely used in fisheries research and practice. This index is commonly assumed to reliably represent variations in abundance and biomass of surveyed fish stock. For example, T.F.Dementjeva (1976) suggests that catch per fishing effort is a useful tool of estimating the relative abundance of population at any time of the year and reflects reliably changes in its distribution.

Being in line with the aforesaid, we at the same time think that CPUE is an integrated index of effects of many factors, both environmental which induce changes in the distribution of aquatic organisms and their availability to fisheries, and natural stock dynamics.

A study of the influence of environment on the distribution of harvested fish stock needs comprehensive and systematic data on spatial and temporal variability of oceanographic factors.

In view of this, oceanographic observations carried out annually by the Polar Institute during trawl surveys in NAFO

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SA 3 in spring and summer are of particular interest. A total of up to 350 oceanographic stations are completed annually during the same time periods and cover densely and uniformly the area surveyed.

The purpose of this paper is to study oceanographic factors responsible for year-to-year variations in the density and distribution of fish, species composition of bottom catches, abundance and biomass of major commercial fish.

MATERIAL AND METHODS

On the basis of data collected during annual trawl surveys on the Grand Bank catches of different species per hour tow are analyzed, total catch and catch of each species in per cent of the total catch (by biomass) by 100 m depth intervals are estimated. Curves in some figures and tables are smoothed, and this is noted in their legends. Smoothing has been accomplished in accord with standard technique by the formula

$$B = \frac{a+2b+c}{4}$$

where a,b,c, - preceding, medium and following terms in a series, and B is an estimated one.

Tables of mean catches in number and by weight per hour tow of major commercial species in the Newfoundland area in the period from 1971 to 1988 were compiled in accord with the technique established in previous years. Total number and total weight of each species captured in a division were divided by the number of tows. Data for 1984–1988 were doubled for to obtain catch/hour tow estimates, because 30 min.tows were made during this period. Division area was not taken into account. In calculations of the mean catch account of the distribution depth was made, tows deeper 500 m (for cod and long rough dab), deeper 100 m (for dab) and shallower than 100 m (for beaked redfish) were not included.

Bottom temperatures measured at oceanographic stations during trawl surveys for bottom and pelagic fish were used as indicator of environmental conditions. For every survey in spring and summer seasons of 1972 to 1988 maps of bottom temperatures were plotted. Temperature values were interpolated into fixed points of a regular grid with a step of 30 min.latitudinally and 30 min.longitudinally, as well as into some extra points. For every point in the grid samples were formed, including successive annual temperature values for 1972–1988. For these samples a series of statistical characteristics was obtained - arithmetic mean, standard deviation etc.

Bottom temperature anomalies (A) were compared to corresponding values of standard deviation (σ) - measure of year-to-year variation of bottom temperature - for to evaluate the significance of the anomalies. Standardized anomalies(A/σ) were divided into 5 classes:

MAN	- much above the norm, ...	$A/\sigma > 1.5$
AN	- above the norm, ...	$0.5 < A/\sigma \leq 1.5$
N	- the norm, ...	$-0.5 \leq A/\sigma \leq 0.5$
BN	- below the norm, ...	$-0.5 > A/\sigma \geq -1.5$
MBN	- much below the norm, ...	$A/\sigma < -1.5$

RESULTS

Species compositions of catches from Divs. 3N, 3L, 3M were, in general, nearly identical due to closeness of the surveyed areas and similar oceanographic conditions in them (Table 1). However, it should be noted that small relative numbers of Greenland halibut were found in catches from Div.3M, probably, because of small depth of fishing (only 6 tows were completed deeper 800 m, that is 0.6% of the total number of tows), and relative numbers of beaked redfish were large. Species composition changed sharply with increasing depth. Of most plentiful species, cod and long rough dab dwelt in small depth, beaked redfish in 300-700 m, Greenland halibut and rock greanadier in 700-900 m and deeper (Tables 2-4). In different divisions these species inhabited nearly the same depth range (Fig. 1). However, their percentage in catch was different. For example, long rough dab was most numerous in Div. 3K and accounted for 70% in catches from 0-100 m. In Div. 3M this species accounted for only 20% in catches from 101-200 m. Beaked redfish predominated in catches from mid-depth in Div.3M. The percentage of Greenland halibut in catches from deep waters was higher in Div. 3K than in other divisions. Rock grenadier prevailed in catches from deeper than 1000 m.

Species composition in catches varies within the year as well as between years owing to changing environmental conditions and redistribution of fish to deeper or shallower waters. For example, in separate years relative numbers of cod and beaked redfish in catches from 201-300 m varied by tens of times compared to other years (Fig. 2). Such variations in the catch size were associated with different distribution of fish in the mid-water and biased the results from trawl and trawl-acoustic surveys and sometimes brought about underestimation of stock size.

In SA 0,2,3 gradual redistribution of grenadier, halibut and redfish to deeper waters, noted earlier, reduced their accessibility to bottom trawls (Savvatimsky, 1986,1987;

Chumakov, Savvatimsky, 1987). It was also noted, that a reduction of biomass and abundance of cod, long rough dab, witch and Greenland halibut reported by Canada trawl surveys in Divs. 2J and 3KL in 1985 was due to distribution of fish at lower bottom temperatures than in the previous years (Baird, Bishop, 1986). Redistribution of fish to deeper waters was evident from variation of the mean catch, abundance and biomass of witch in Divs. 3K,3L,3N in the period from 1983 to 1988. Relative catch size during this time increased during fishing in deep waters and decreased in shallower depths (Fig.3). For example, in 1983 over 50% of witch in number and by biomass dwelt in shallow waters, whereas by 1988 the witch were found to be distributed chiefly in deep waters (Fig.4)

Variations in mean catch of main commercial species per hour tow during trawl surveys in the Newfoundland area in different years are rather significant (Tables 5,6). By 1984-1985 mean catch of cod in Divs. 3KL, 3NO and beaked redfish in Divs. 3LNO, 3M increased, and catches of long rough dab and dab in Divs.3LNO decreased. These variations may,probably, be associated with changes in hydrological conditions. However, an attempt at correlating the variations in mean catch with changes of the mean bottom temperature had yielded no definitive relationship. Different results were obtained from comparison of the mean catch of cod in Divs.3KL and 3NO with the area occupied by waters of specific temperatures. This relationship established from a 17-year data series was characterized by reliable coefficients of correlation at the significance level P=0.05. Mean catches of cod in Div. 3KL were correlated to the area occupied by waters of 2-3°C in the same divisions, correlation coefficient was R=-0.676, i.e. the smaller the area with the above temperatures, the larger cod catches were (Table 7). One more relationship was established: the larger the area with bottom temperatures below normal in Div.3KL, the greater mean catches of cod were obtained in Div. 3NO, correlation coefficient R=0.637. Catch size of beaked redfish on the Flemish Cap Bank depended on the area occupied by waters with temperatures above the norm in Div. 3KL: the larger the area, the greater the catches were (correlation coefficient R=0.692).

Hydrological conditions exert influence not only on the distribution of fish and catch size, but also on the year-class strength. A correlation of the mean number of cod at age 1-6 per standard tow during Canada surveys in Div. 3NO in the period from 1972 to 1982 (Table 8) to the area occupied by waters of certain temperatures produced reliable correlation coefficients at the significance level P=0.05 (Table 9). For example, the mean number of cod at age 1 in Divs. 3NO depended on the area occupied by waters with temperatures much above the norm in Div. 3L (correlation coefficient R=0.798). The larger the area occupied by waters of 2-3°C in Divs. 3NO, the greater the catch of cod at age 2 (R=0.839), at age 3 (R=0.733) and 1-3 years (R=0.829) was in the same divisions. The larger the area occupied by waters with temperatures above the norm, the larger the number of cod at age 6 was in the catch from Divs. 3NO (R=0.748).

Soviet trawl survey data provide evidence of the correlation between the area occupied by cold waters in Div. 3L and the number of juvenile cod on the Flemish Cap (Table 9). If the area occupied by bottom waters with temperatures much below the norm increases in Div. 3L, the number of cod (mean catch per hour tow) of respective year-classes at age 1,2,3 on the Flemish Cap increases too (correlation coefficient R=0.902, R=0.846, R=0.908, respectively). Oceanographic conditions in both divisions are under the decisive influence of the Labrador Current. Thus, our results are in conformity with the inference, that cooling of waters in the Labrador Current enhance the probability of production of strong year-classes of cod (Borovkov, 1980).

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Table 1

Composition of research bottom trawl catches in Divs. 3K, 3L, 3M during 1971-1988 (in per cent by weight)

Composition of catches	3K	3L	3M
Reinhardtius hippoglossoides	14.7	5.3	1.1
Hippoglossus hippoglossus	0.1	0.1	0.1
Coryphaenoides rupestris	1.5	0.1	0.2
Macrourus berglax	0.5	0.7	0.2
Nezumia bairdi	+	0.1	-
Sebastes mentella	42.8	21.0	67.4
Sebastes marinus	11.1	0.3	7.6
Anarhichas denticulatus	1.6	1.1	0.7
Anarhichas minor	0.5	1.0	0.8
Anarhichas lupus	0.9	1.1	1.6
Rajiformes	1.0	6.8	0.3
Somniosus microcephalus	0.1	0.1	-
Other Squaliformes	0.1	0.1	+
Antimora rostrata	+	+	-
Gadus morhua	18.8	27.8	14.4
Glyptocephalus cynoglossus	1.3	1.4	0.1
Hippoglossoides platessoides	4.1	28.5	5.0
Limanda ferruginea	+	1.4	-
Notacanthidae	-	-	0.1
Mallotus villosus	0.1	1.7	-
Ammodytes americanus	-	0.5	-
Lycodes	0.3	0.6	-
Others	0.5	0.3	0.4
Mean catch, kg/hour	593	418	525
Number of catches	1199	1385	1208

Table 2. Composition of bottom trawl catches from different depths in Div.3K for 1971-1988 according to research vessel data (in per cent by weight)

Catch composition	Depth, m													
	0-I00	I0I-200	20I-300	30I-400	40I-500	50I-600	60I-700	70I-800	80I-900	90I-I000	I00I-II00	II0I-I200	I20I-I300	I30I-I400
Reinhardtius hippoglossoides	-	6.6	4.4	II.3	4I.2	I2.3	I5.5	30.I	63.0	6I.8	30.0	35.4	3I.2	23.9
Hippoglossus hippoglossus	-	-	0.I	0.I	0.2	0.I	-	-	+	-	-	-	-	-
Coryphaenoides rupestris	-	-	-	+	+	+	+	7.3	0.2	24.9	56.9	49.6	6I.5	72.8
Macrourus berglax	-	+	0.2	0.4	0.5	0.9	I.4	I.7	2.4	2.3	I.4	2.7	4.5	I.5
Nezumia bairdi	-	-	-	+	+	0.I	0.I	0.I	0.I	-	-	-	-	-
Sebastes mentella	-	I.5	23.6	57.5	44.2	76.9	74.2	49.I	24.I	0.2	-	-	0.4	-
Sebastes marinus	-	-	27.6	4.6	0.I	0.6	-	+	-	-	-	-	-	-
Anarhichas denticulatus	-	I.3	I.I	I.5	I.9	3.I	2.6	4.9	6.9	2.I	3.I	3.7	I.2	-
Anarhichas minor	0.2	I.9	0.6	0.6	0.3	0.I	0.2	+	-	-	-	-	-	-
Anarhichas lupus	-	0.3	I.6	0.9	0.I	+	0.I	0.I	-	-	-	-	-	-
Rajiformes	0.9	I.9	0.8	0.9	0.8	0.5	0.3	3.2	0.2	5.3	6.5	5.4	-	0.3
Somniosus microcephalus	-	-	-	0.I	-	-	2.0	-	0.6	-	-	-	-	-
Other Squaliformes	-	-	-	-	+	0.6	0.7	1.3	0.3	I.0	I.6	3.2	0.9	-
Antimora rostrata	-	-	-	+	-	0.I	0.I	0.5	0.6	0.9	0.3	-	-	-
Gadus morhua	I2.I	I3.2	32.6	I7.2	5.3	0.9	+	0.I	-	-	-	-	-	-
Glyptocephalus cynoglossus	-	0.4	0.5	I.6	2.8	I.5	I.7	0.3	0.6	0.4	-	-	-	-
Hippoglossoides platessoides	78.5	69.3	6.I	2.5	I.7	0.2	0.2	0.2	-	-	-	-	-	-
Limanda ferruginea	8.I	+	+	+	-	0.I	+	-	-	-	-	-	-	-
Lycodes	0.2	2.5	0.4	0.3	0.2	+	+	+	-	-	-	-	-	-
Mallotus villosus	-	+	0.2	-	-	-	-	-	-	-	-	-	-	-
Others	-	I.0	0.2	0.4	0.7	2.0	0.8	I.0	0.9	I.I	0.2	-	0.3	I.5
Mean catch, kg/hour	265	243	524	646	672	629	I00I	584	480	722	604	830	368	687
Number of catches	8	22	450	457	I44	35	I5	23	I5	6	7	5	8	4

Table 3. Composition of bottom trawl catches from different depth in Div. 3L for 1971-1988, according to research vessel data (in per cent by weight)

Catch composition	Depth, m									
	0-I00	I0I-200	20I-300	30I-400	40I-500	50I-600	60I-700	70I-800	80I-900	90I-I00
Reinhardtius hippoglossoides	-	0.9	4.7	I0.7	I0.4	9.5	I3.2	II.4	50.0	I6.4
Hippoglossus hippoglossus	+	+	0.I	0.I	0.I	0.3	0.7	-	-	-
Coryphaenoides rupestris	-	+	+	+	-	0.I	0.4	0.8	-	83.6
Macrourus berglax	+	+	0.7	I.9	I.3	0.9	I.I	I.I	4.0	-
Nezumia bairdi	-	+	+	0.I	0.4	0.I	0.I	0.I	-	-
Sebastes mentella	+	0.2	8.0	38.I	63.2	63.9	63.7	76.7	35.0	-
Sebastes marinus	+	+	I.0	0.I	+	+	+	-	-	-
Anarhichas denticulatus	+	0.3	I.5	I.7	I.5	I.9	2.3	7.2	5.0	-
Anarhichas minor	+	I.3	I.9	0.6	0.2	0.6	0.3	-	-	-
Anarhichas lupus	+	0.5	2.8	I.7	0.2	0.I	0.I	-	6.0	-
Rajiformes	4.I	4.4	5.5	7.8	I0.9	I7.I	I0.8	0.6	-	-
Somniosus microcephalus	-	-	-	-	0.5	0.3	-	-	-	-
Other Squaliformes	-	-	-	-	-	0.I	2.2	0.5	-	-
Antimora rostrata	-	-	-	-	-	-	-	0.6	-	-
Gadus morhua	33.3	22.8	47.5	3I.3	6.8	0.I	+	-	-	-
Glyptocephalus cynoglossus	0.I	0.3	I.4	2.5	3.0	2.7	3.7	0.4	-	-
Hippoglossoides platessoides	45.6	64.2	22.5	2.6	I.I	I.6	0.4	+	-	-
Limanda ferruginea	9.6	0.I	+	+	+	-	0.I	-	-	-
Mallotus villosus	3.8	3.5	I.0	0.I	-	-	-	-	-	-
Ammodytes americanus	3.0	0.2	-	-	-	-	-	-	-	-
Lycodes	0.2	0.9	I.2	0.3	0.I	0.I	+	0.2	-	-
Others	0.2	0.3	0.2	0.4	0.3	0.6	0.8	0.4	-	-
Mean catch, kg/hour	306	349	40I	42I	656	899	736	544	I00	350
Number of catches	250	397	365	2I0	70	47	35	8	I	2

Table 4. Composition of bottom trawl catches from different depth in Div. 3M for 1971-1988, according to research vessel data (in per cent by weight).

Catch composition	Depth, m									
	I0I-200	20I-300	30I-400	40I-500	50I-600	60I-700	70I-800	80I-900	90I-I000	II0I-II00
Reinhardtius hippoglossoides	-	0.3	0.5	I.7	I.2	5.6	3.4	5I.2	I4.2	20.I
Hippoglossus hippoglossus	0.2	0.I	0.I	+	-	-	-	-	-	-
Coryphaenoides rupestris	-	-	0.I	+	0.I	0.6	0.6	39.4	81.3	5I.4
Macrourus berglax	+	+	0.I	0.3	0.4	I.3	2.7	2.5	I.I	II.4
Nezumia bairdi	+	+	+	0.I	0.I	0.3	0.I	-	-	I.0
Sebastes mentella	I2.2	3I.I	79.4	88.0	95.8	90.3	92.0	6.9	-	4.0
Sebastes marinus	8.5	25.9	2.2	+	+	+	-	-	-	-
Anarhichas denticulatus	0.7	0.4	0.7	I.0	0.8	0.7	0.3	-	I.I	I.9
Anarhichas minor	I.5	I.2	0.7	0.8	0.2	+	-	-	-	-
Anarhichas lupus	7.4	2.9	I.I	0.2	+	+	+	-	-	-
Rajiformes	0.2	0.2	0.2	0.3	0.2	0.2	-	-	-	-
Somniosus microcephalus	-	-	-	-	-	-	-	-	-	-
Other Squaliformes	-	+	-	+	+	-	-	-	-	-
Antimora rostrata	-	-	-	-	-	-	+	-	-	-
Gadus morhua	32.7	3I.3	I2.3	4.0	0.2	-	0.2	-	-	-
Glyptocephalus cynoglossus	0.4	0.3	0.I	+	+	-	-	-	-	-
Hippoglossoides platessoides	34.6	6.2	2.2	2.7	0.I	0.2	-	-	-	-
Limanda ferruginea	-	+	-	-	-	-	-	-	-	-
Notacanthidae	-	-	0.I	0.3	0.4	0.I	0.2	-	-	-
Others	I.6	0.I	0.2	0.5	0.5	0.7	0.5	-	2.3	I0.2
Mean catch, kg/hour	255	38I5	674	7I6	898	487	508	249	I77	I66
Number of catches	I68	4I6	264	I72	I02	70	I0	2	I	3

Table 5. Mean catches of main commercial fishes in the Newfoundland area during 1971-1988, trawl survey data (fish per hour haul, smoothed series)

Species	Area	YEAR																	
		I97I	I972	I973	I974	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986	I987	I988
Cod	3KL	I60	I27	75	35	40	65	66	66	70	74	60	63	70	I87	I79	I23	I2I	I52
	3NC	II6	I08	I00	II0	98	90	II2	I08	60	36	56	98	II0	I97	274	228	II2	58
	3M	80	90	I70	350	540	600	460	200	I00	60	40	80	I60	246	I79	I23	I08	88
Beaked redfish	3K	450	500	600	750	700	480	450	500	680	II50	I500	I300	I000	III3	II39	765	404	29I
	3LNC	580	450	460	660	780	840	720	I080	I620	I500	I200	960	720	2556	2208	II39	862	I0I7
	3M	200	300	400	400	300	350	600	I500	3I00	2500	I800	2250	2700	I298	I209	I876	I448	707
Long rough dab	3K	72	80	I20	I85	200	2I5	I85	II0	70	80	80	80	88	70	58	49	46	50
	3LNC	350	360	380	400	380	480	540	490	400	480	480	400	4I0	365	283	268	260	I99
	3M	40	44	56	72	II0	I24	94	36	28	30	32	36	40	35	58	73	54	35
Dab	3LNC	200	225	265	260	230	230	220	200	230	248	260	232	220	208	I54	9I	53	38

Table 6. Mean catches of main commercial fishes in the Newfoundland area during 1971-1988, trawl survey data (kg per hour haul, smoothed series)

Species	Area	YEAR																	
		I97I	I972	I973	I974	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986	I987	I988
Cod	3KL	I20	II5	60	30	40	75	63	68	77	I00	83	88	I25	227	232	2I6	I87	I84
	3NO	79	65	40	50	70	75	I00	95	60	55	80	I55	I90	I84	2I2	200	I38	88
	3M	75	70	60	70	I50	290	3I0	I75	75	60	70	70	60	I30	II0	69	4I	25
Beaked redfish	3K	I80	200	240	280	250	I80	I80	240	320	460	500	420	400	480	50I	339	2II	I9I
	3LNO	I00	80	I00	I40	I20	I20	I40	260	420	380	280	I80	I20	4I0	338	2I7	2II	2I2
	3M	80	I40	I30	I20	I20	I40	240	320	550	600	5I0	530	5I0	344	346	48I	358	I72
Long rough dab	3K	I2	40	38	54	55	55	48	30	20	25	30	32	28	30	23	I8	I7	II
	3LNO	I25	II0	II0	I25	I30	I50	I90	I60	I50	I80	2I0	I90	I80	I70	I29	98	77	65
	3M	I8	27	45	58	75	84	54	27	I8	I8	I8	2I	2I	38	42	43	33	22
Dab	3LNO	84	90	I04	I00	88	89	90	90	I00	II2	II4	I08	I00	9I	68	42	24	I7

Table 7 Linear correlations between mean catch per hour tow (USSR trawl survey data) and area occupied by bottom waters of certain temperatures, 1972–1988

Dependent index (mean catch per hour tow) in Divs. 3KLMNO	Independent index (area occupied by bottom waters of certain temperatures)		Correlation coefficient R	Sample size, n	Significance level, P
Cod, 3KL	t=2–3°C,	3KL	–0.676	17	0.01
Cod, 3NO	A/б =BN,	3KL	0.637	17	0.01
Cod, 3M	t >3°C ,	3K	–0.528	17	0.05
Beaked redfish, 3K	t=2–3°C,	3NO	0.530	17	0.05
Beaked redfish, 3M	A/б =AN,	3KL	0.692	17	0.01
Long rough dab, 3LNO	A/б =BN,	3NO	–0.640	17	0.01
Long rough dab, 3M	t > 3°C,	3K	–0.654	17	0.01

Table 8. Mean number of cod at age 1–6 per standard haul in Canadian trawl surveys in Div. 3NO*

Year-class	AGE I	2	3	I–3	4	5	6	4–6
I972	0.07	I.39	4.70	2.05	I.83	4.63	0.96	2.47
I973	0.05	3.I6	2.89	2.03	6.29	2.48	I.76	3.5I
I974	0.46	3.89	9.7I	4.69	8.I7	7.84	0.44	5.48
I975	0.58	2.35	7.07	3.33	9.25	I.07	2.32	4.2I
I976	0.0I	0.7I	2.33	I.02	0.67	I.83	0.47	0.99
I977	0.55	0.93	I.38	0.95	I.58	0.60	0.3I	0.83
I978	3.09	5.39	5.39	4.62	3.54	6.87	5.60	5.34
I979	0.0I	0.38	I.I8	0.52	3.69	5.29	0.88	3.29
I980	0.35	9.37	I7.30	9.0I	9.90	2.4I	I.62	4.64
I98I	I.56	6.2I	6.20	4.66	6.05	6.46	2I.25	II.25
I982	0.52	3.28	4.47	2.76	7.71	34.86	I.06	I4.54

* According to Baird, Bishop, NAFO, SCR Doc. 88/19, Ser. No. N1455, Table 10

Table 9. Linear correlations between mean number of cod at age 1-6 in a research trawl catch (Canada trawl survey data, Div.3NO) and area occupied by bottom waters of certain temperatures, 1971-1982

Dependent index (mean number of cod at age 1-6 per standard tow in Div. 3NO)	Independent index (area occupied by waters of certain bottom temperatures)		Correlation coefficient, R	Sample size, n	Significance level, P
Age 1	A/б = MAN,	3L	0.798	11	0.01
Age 2	t = 2-3°C,	3NO	0.839	11	0.01
Age 3	t = 2-3°C,	3NO	0.733	11	0.05
Age 6	A/б = AN	3NO	0.748	11	0.01
Age 1+2+3	t = 2-3°C,	3NO	0.829	11	0.01

Table 10. Linear correlations between mean number of cod at age 1-3 from 1972-1987 year-classes (USSR trawl survey data) and area occupied by bottom waters of certain temperatures

Dependent index (mean number of cod at age 1-3 per standard tow in Div. 3KLM)		Independent index (area occupied by bottom waters of certain temperatures)		Correlation coefficient, R	Sample size, n	Significance level, P
Age 1,	3K	A/б = MBN,	3L	0.761	17	0.001
Age 2,	3K	A/б = MAN,	3NO	0.808	16	0.001
Age 3,	3L	A/б = AN,	3NO	0.557	15	0.05
Age 1,	3M	A/б = MBN,	3L	0.902	17	0.001
Age 2,	3M	A/б = MBN,	3L	0.846	16	0.001
Age 3,	3M	A/б = MBN,	3L	0.908	15	0.001
AGE 1+2+3	3M	A/б = MBN,	3L	0.909	15	0.001

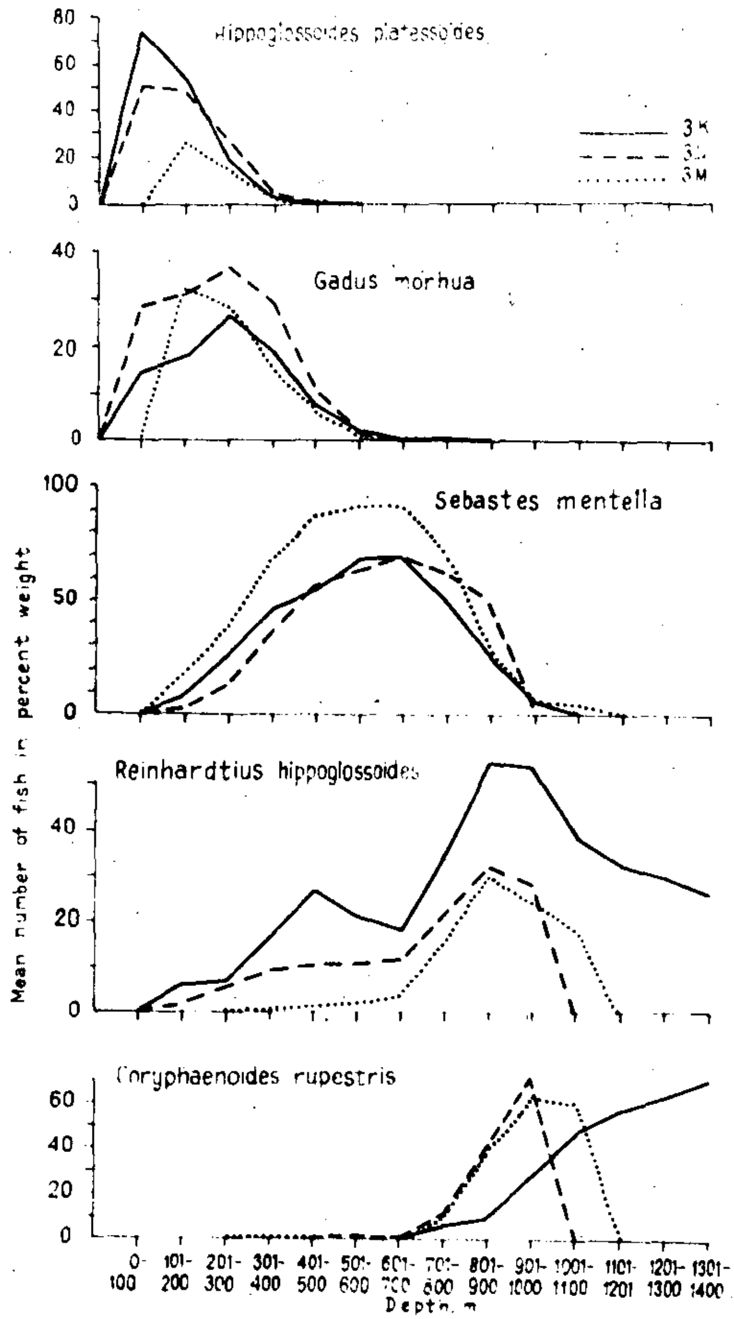

Fig. 1 Distribution by depth of major commercial fish in Divs. 3K,3L,3N, trawl survey data for 1971-1988 (smoothed series).

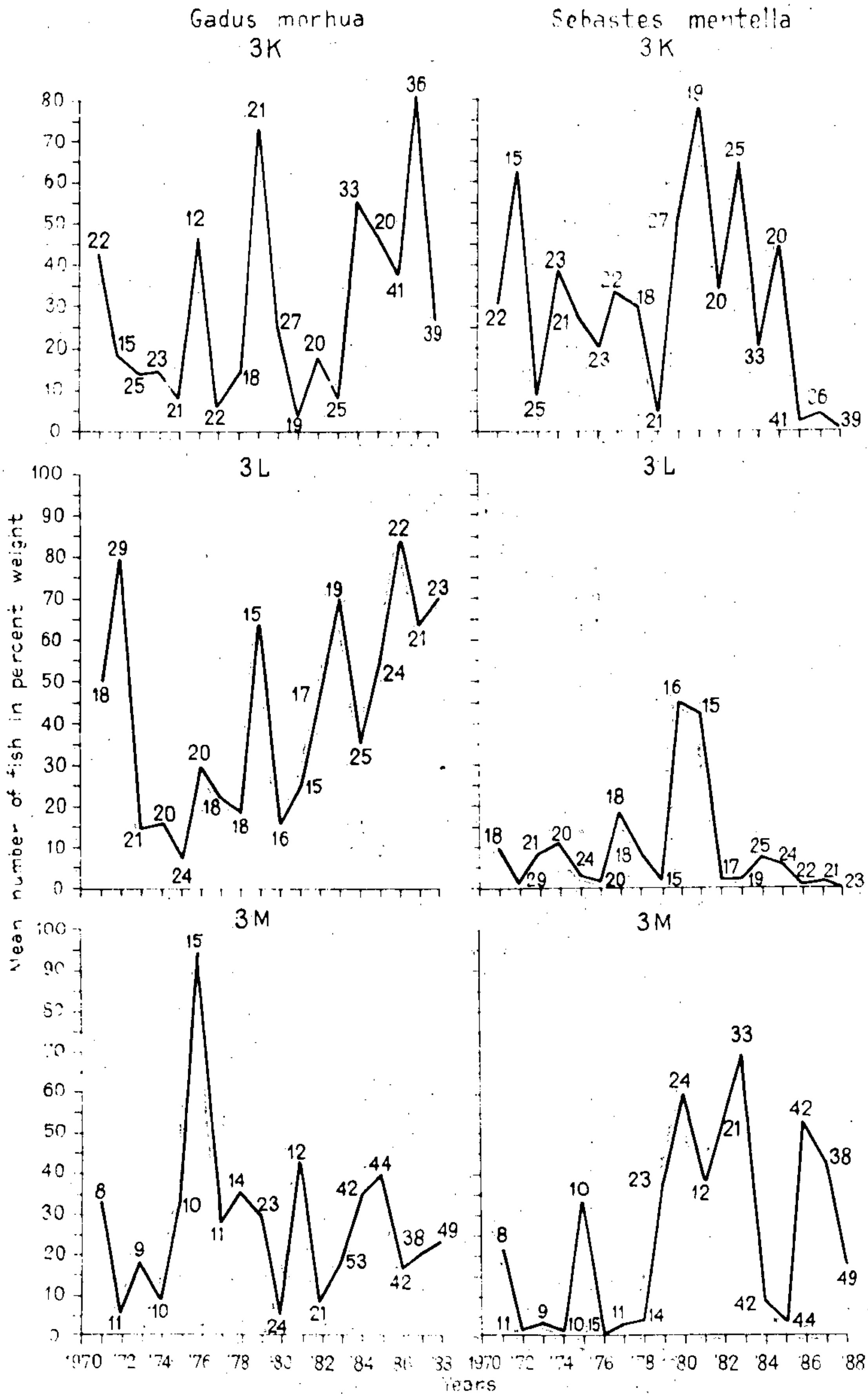

Fig. 2 Mean numbers of cod and redfish Sebastes mentella (in per cent of total catch, by weight) in Div. 3K,3L,3M in 201-300 m depth interval, trawl survey data for 1971-1988 (figures in diagrams - number of tows).

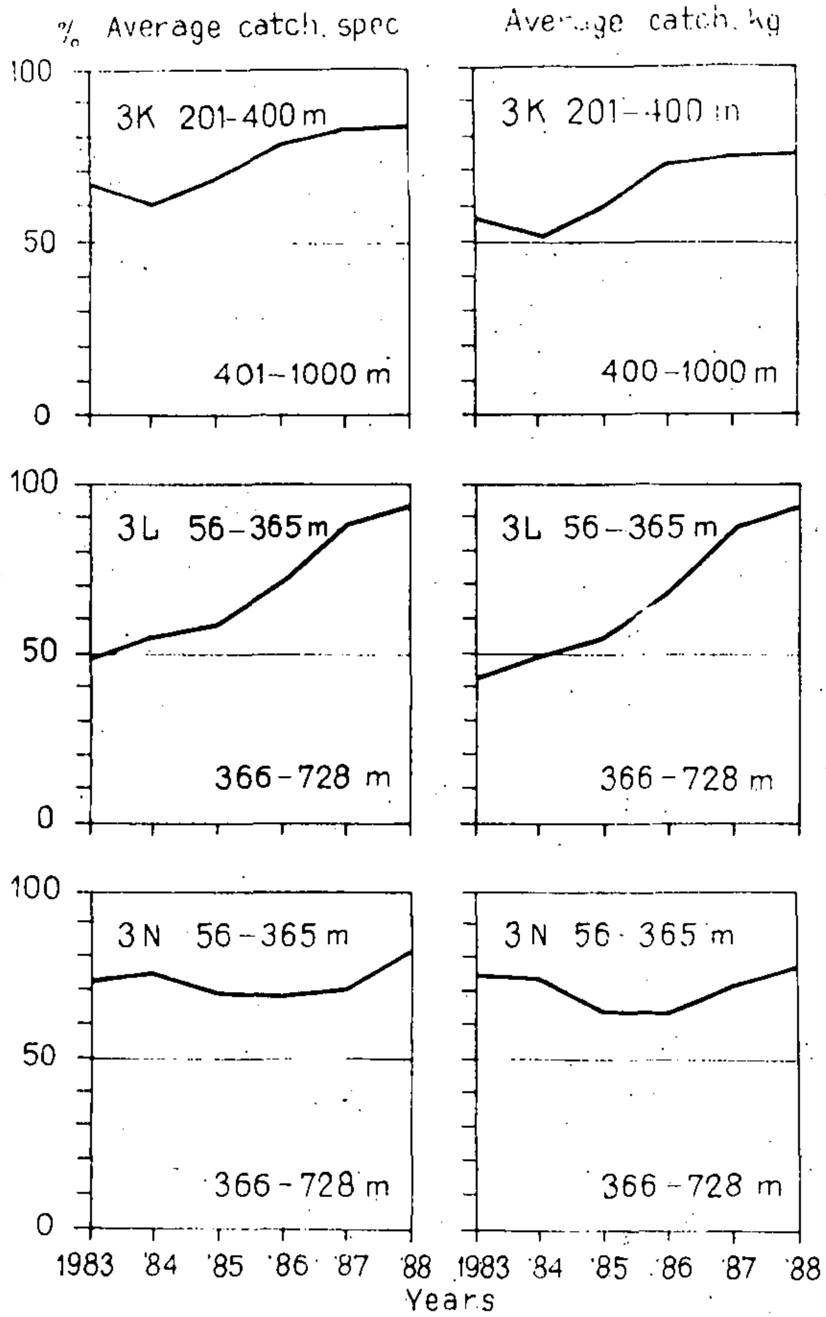

Fig. 3 Mean catch of witch by depth during 1983-1988 in Divs. 3K,3L,3N (smoothed series)

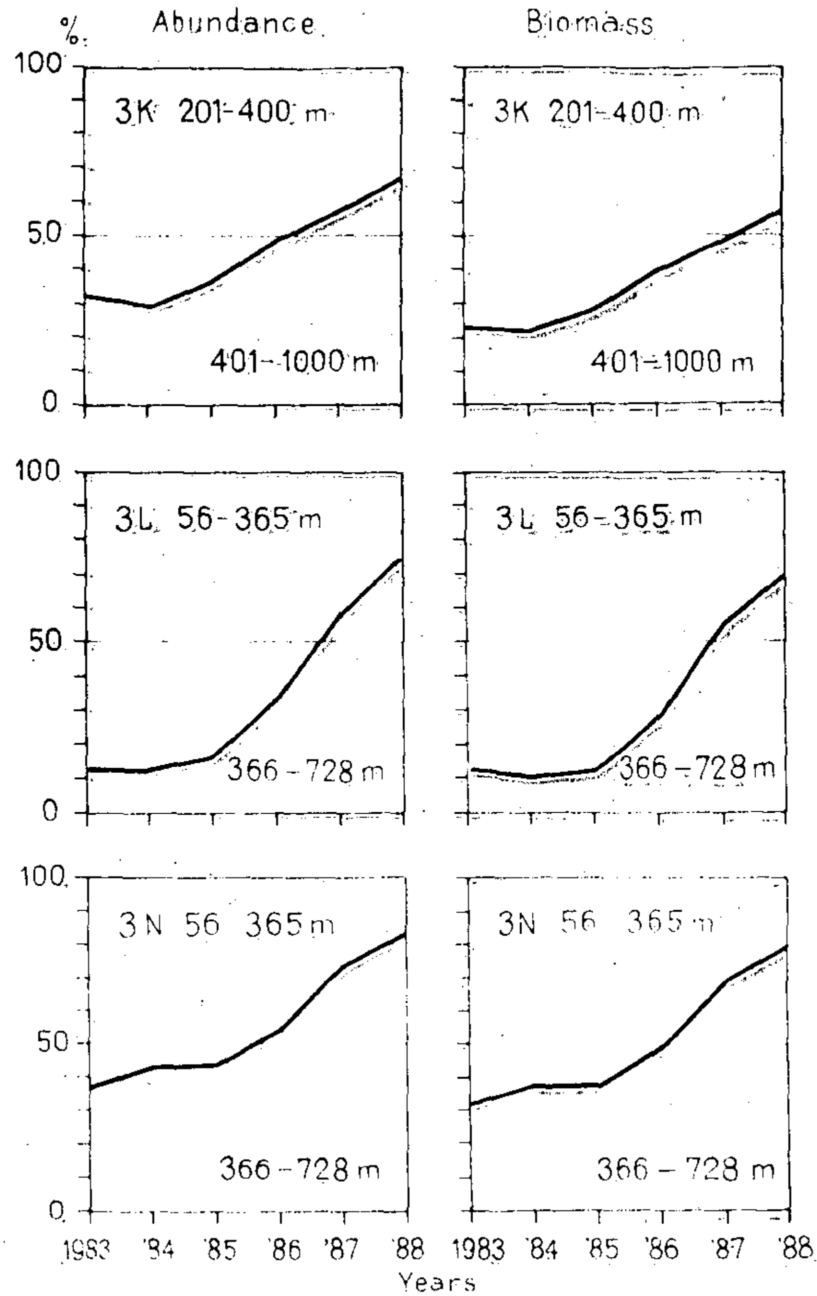

Fig. 4 Abundance and biomass of witch by depth in Divs. 3K,3L,3N during 1983-1988 (smoothed series)