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DEMERSAL FISH ON THE CONTINENTAL SLOPE OFF NORWAY

By

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ABSTRACT

Investigations on distribution and abundance of demersal fish in 400-1000 m depth were carried out in three selected areas off Norway in July-August 1974. Based on catches in 48 hauls by bottom trawl and 3 long-line settings the relationships between depth, fish quantity and species composition were determined. In 800 m the catch in weight was reduced to about 10% and in 1000 m to 1% of that taken on the edge of the shelf (400-500 m). The number of fish species caught was reduced from about 10 to 3 over the same depth range as boreal species were replaced by a few arctic species. Trawl catches were small, about 70 kg per hr in 600 m, while long-line in this

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depth gave 150 kg per 1000 hooks; mostly Macrourus berglax, Raja hyperborea and Reinhardtius hippoglossoides.

The abundance and vertical distribution of the fish on the continental slope are closely related to the hydrography of the Norwegian Sea. Atlantic water with temperature 5-7°C cover the edge of the shelf down to about 500 m while deep water of arctic origin with typical temperature -0.9°C is found along the slope in depths below 600-700 m. A variable transitional layer occurs between.

Prospects of commercial utilization of the fish resources on the slope are briefly discussed.

INTRODUCTION

The fish fauna of the continental slope off Norway is relatively poorly known regarding both species composition and abundance. The fisheries, and hence the research, has mainly been focused on the porductive bank areas in shallower depths.

Fishing by trawl off the Norwegian coast rarely exceeds 300 m in depth. Deep water prawn and fish for reduction purposes are, however, taken somewhat deeper in the Norwegian Trench, and cod are occationally fished in depths down to 500-600 m off northern Norway and in the Bear Island area. The bottom long-line fishery generally reaches a depth of 400 m, except that for Greenland halibut which takes place in 600-700 m.

Diminishing returns of many exploited fish stocks in the Northeast-Atlantic has created an interest for fish species of deeper waters. Some investigations of such potential demersal fish resources have therefore been carried out in later years (PECHENIK and TROYANOVSKII 1971, J. P. BRIDGER Fisheries Laboratory, Lowestoft, England, Unpubl). The results show that commercial catches of demersal fish in deep water can be obtained in some areas. On the continental slope west of the British Isles in depths between 550 and 1100 m catches of about 700 kg per hr

of trawling were typical of the best locations. Deep water species dominated, particularly Alepocephalus bairdi, Coryphaenoides rupestris, Chimaera monstrosa, Aphanopus carbo and a number og elasmobranchs.

These circumstances led to the present investigation, which aimed at obtaining data on abundance and distribution of demersal fish on the continental slope in depths 400-1000 m off the Norwegian coast.

A report on the investigation has also been published in Norwegian (BAKKEN, LAHN-JOHANNESSEN og GJØSÆTER 1975).

MATERIAL AND METHODS

The investigation was carried out by R/V "G. O. Sars" 18 July to 6 August 1974 in the following three selected areas on the continental slope (Fig. 1):

A. Storegga
B. West of the Sklinna Bank
C. Western part of Tromsøflaket

In area A a total of 13 trawl hauls were made in depths ranging from 400 to 700 m. The corresponding figures in area B and C were 21 hauls from 300 to 1000 m and 14 hauls from 400 to 1000 m (Table 1). Trawling was carried out in both N and S directions along the slope at depth intervals of approximately 100 m. Each haul lasted for 1 hour and the towing speed was kept at 2.5 knots.

For the investigations a Granton trawl with mesh size 130 mm fitted with 50 cm diam. steel bobbins was used. A cover net in the cod-end had a mesh size of 16 mm. During towing the vertical opening was 5-6 m and the distance between the wings 18-20 m.

Location for the trawl hauls were determined by depth alone regardless of echo recordings, but echo sounder was used to select bottom suitable for trawling.

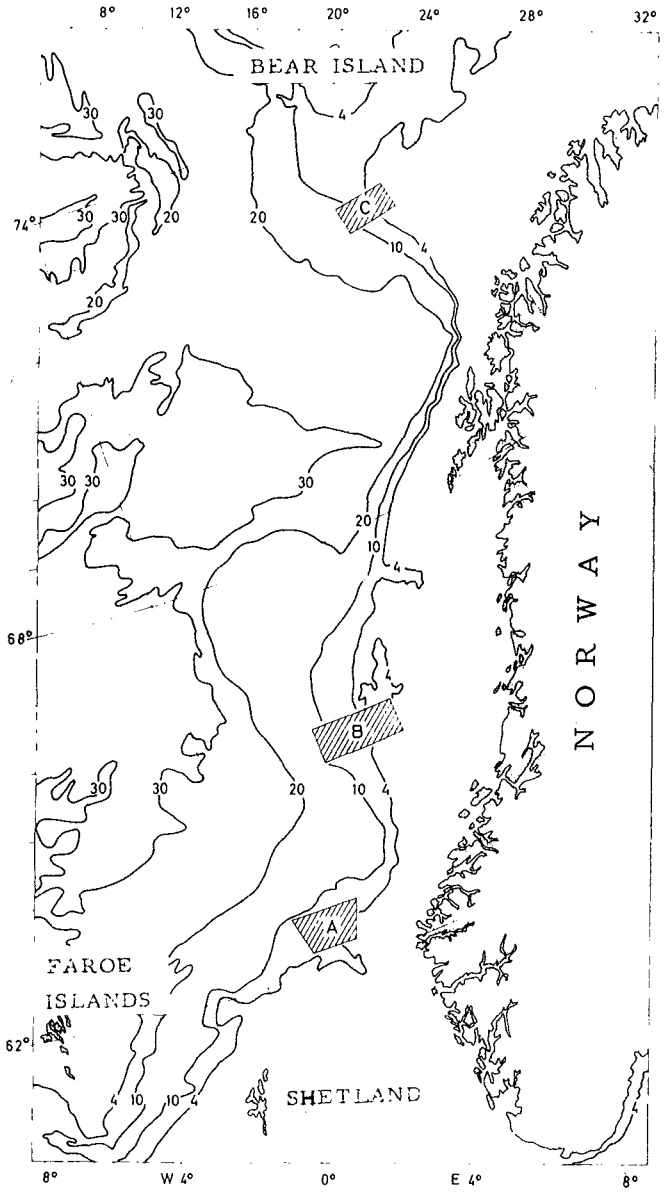

Fig. 1 The eastern part of the Norwegian Sea with investigated areas A, B and C. Depth in m x 100.

In order to supplement data from trawling three bottom long-line settings were made: in area B one setting of 3230 hooks in 600 m, in area C one setting of 1520 hooks in 600 m and one of 1520 hooks in 700 m depth. The hook size was Mustad No. 6 and mackerel was used as bait.

Hydrographic observations were made by STD-sonde which continuously records the vertical distribution of temperature and salinity.

RESULTS

Hydrography

The hydrographical condition in the investigated areas are illustrated by the temperature measured about 15 m above the bottom (Fig. 2). Comparatively warm water in the upper 400-500 m, very cold water below 700-800 m and a transitional layer between are characteristic for all the areas. In the two southern areas the transitional layer covered 100-200 m while in the northern area a wider zone was covered and the borders between the layers were more diffuse.

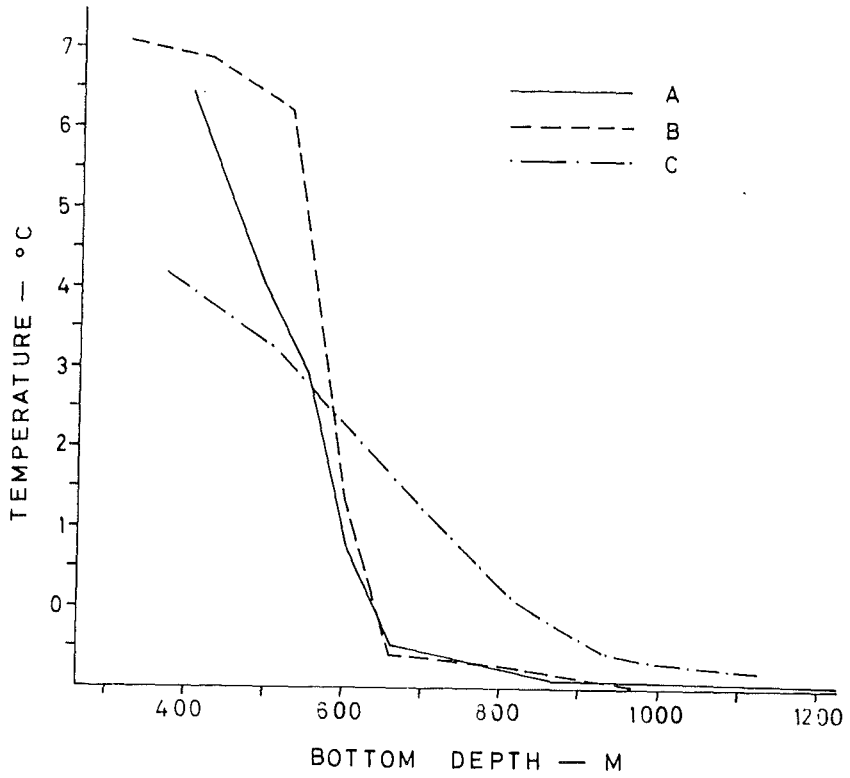

Fig. 2 Temperature near bottom on the continental slope in area A, B and C.

Fig. 3 shows a generalized picture of the hydrographical conditions at the continental slope off Norway (partly from LEINEBØ 1969 and MOSBY 1970). The figure reflects typical features demonstrated by the hydrographical stations (Fig. 2), although the surface layer is subject to wide seasonal fluctuations in temperature and salinity.

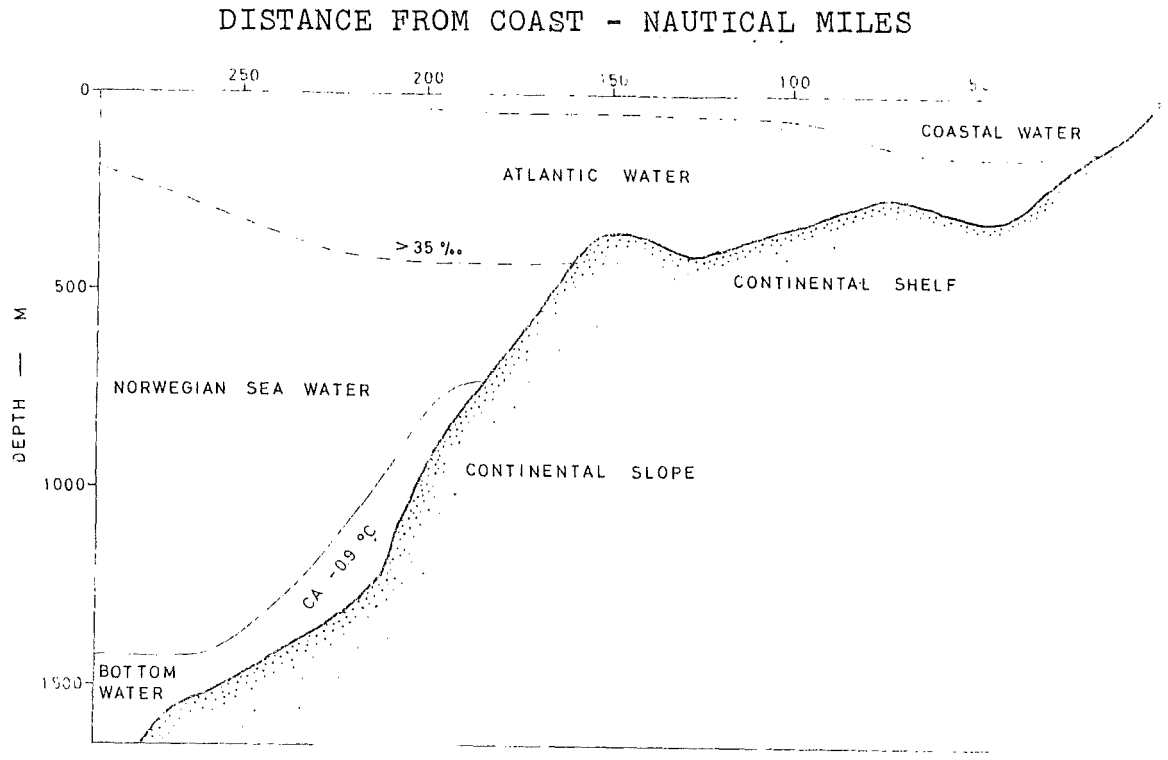

Fig. 3 Simplified outline of the water masses off the Norwegian coast (approx. 66°N).

The watermasses which cover the shelf are predominantly of Atlantic origin. They reach the Norwegian Sea through the Faroe-Shetland channel were the sill depth is about 600 m. This depth, therefore, determines the vertical extension of this warm water. Below the sill depth the slope is covered by the extremely cold bottom water of the Norwegian Sea. The transitional layer between these water masses is found at greatest depth in the northern part of the slope. At depths below 600 m the temperature therefore is higher in area C than in the southern areas (Fig. 2).

Abundance and species composition.

The species caught at the trawl stations are listed in Table 1. The relationship between depth and catch per hour of trawling is shown

in Fig. 4. In the upper 500 m the variation between hauls was extensive. This variation was mainly caused by schooling benthopelagic species as e. g. Micromesistius poutassou, Argentina silus and Sebastes viviparus.

Area	A				B								C						
Depth in metres	400	500	600	700	300	400	500	600	700	800	900	1000	400	500	600	700	800	900	1000
Number of hauls	2	2	5	4	2	2	3	3	3	3	3	2	2	2	2	2	2	2	2
Myxine glutinosa				1															
Etmopterus spinax	7	4				19	9	1											
Galeus melanostomus					5	3													
Raja oxyrinchus					1														
R. radiata			4				1			2			2		6	1	1		
R. hyperborea		1	13	6				19	4	3	2		3			2	2	2	
Bathyraja spinicauda													1			1			
Chimaera monstrosa	24	2			35	24	40												
Argentina silus	133	4	6		114	520	1903	100	2				31	4					
Notolepis rissoi			3					1		1	1		1			1			
Benthosema glaciale		1	26	7					5	2	1	5					1		
Macrourus berglax			81	8				87	42	3	2			4	5	27	7	11	
Brosme brosme					9		2						2	2					
Phycis blennoides	1				2	2													
Molva molva					2														
M. dypterygia	6	13		1	2	11	28	1						1	1				
Gadus morhua														2	2				
Pollachius virens	13		1		18	27	1						6	5	1				
Melanogrammus aeglefinus					11	11					9	1							
Trisopterus esmarkii	18				1														
Micromesistius poutassou	553	94	537	4	261	168	319	61	14	1	1	2	270	115	20	28	2		
Merlangus merlangus							1												
Gadiculus thori	4				760	207	8												
Anarhichas lupus													1						
A. denticulatus													8	11	1				
A. minor													3						
Lycodes spp.			11	9				3	2	15	26	7	1	6	2	1	1		
Sebastes marinus		3	9	1	56	51	134	7	3				356	299	109	17			1
S. viviparus	97	16			758	124	72		1				10						
Artediellus europeus					3														
Cottunculus microps			1																
Careproctus reinhardti											1								
Lepidorhombus whiffiagonis					8														
Reinhardtius hippoglossoides			61	164				15	54	55	25		4	157	53	122	49	12	2
Hippoglossoides platessoides	4	3			1														
Glyptocephalus cynoglossus					2	1	1												
Total	860	141	753	201	2049	1168	2519	295	127	82	68	15	699	606	200	200	63	25	3

Table 1. Average number of fish per hr of trawling in area A, B and C.

In depths greater than 500 m both mean catch and variance decreased. The catches were about 80 kg per hour in 600 m while they decreased to about 5 kg in 1000 m. The differences between the areas were small.

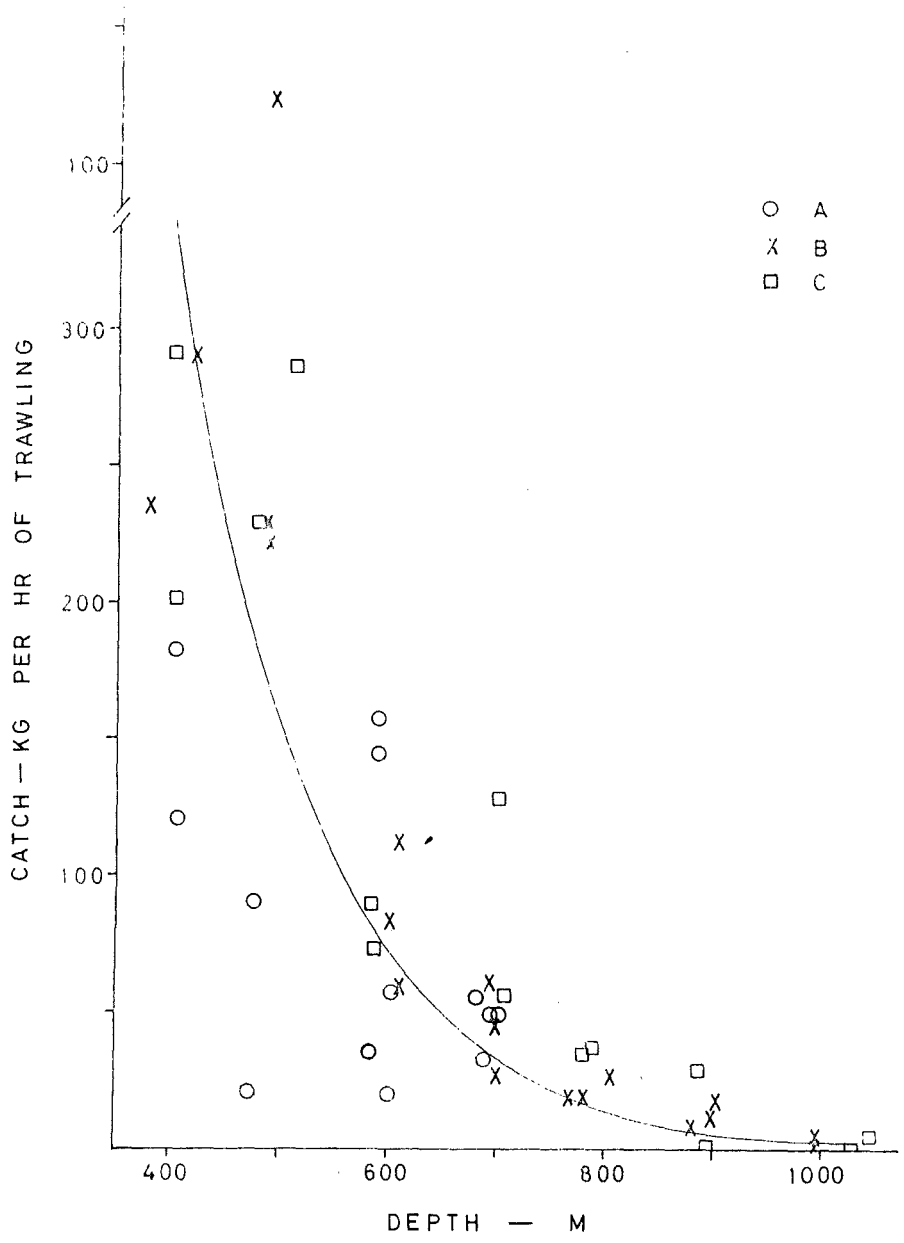

Fig. 4 Relationship between catch per hr of trawling and depth in area A, B and C. (Calculated regression lg y = -0, 0034 x + 3, 8334).

The number of species also decreased with increasing depth (Fig. 5). On the upper part of the slope a mean of about 10 species per haul were taken, while only 2-3 were caught in 1000 m. The trawl used is selective, and the catches therefore are biased, but the reduction in abundance and number of species with depth are probably real and typical to the continental slope.

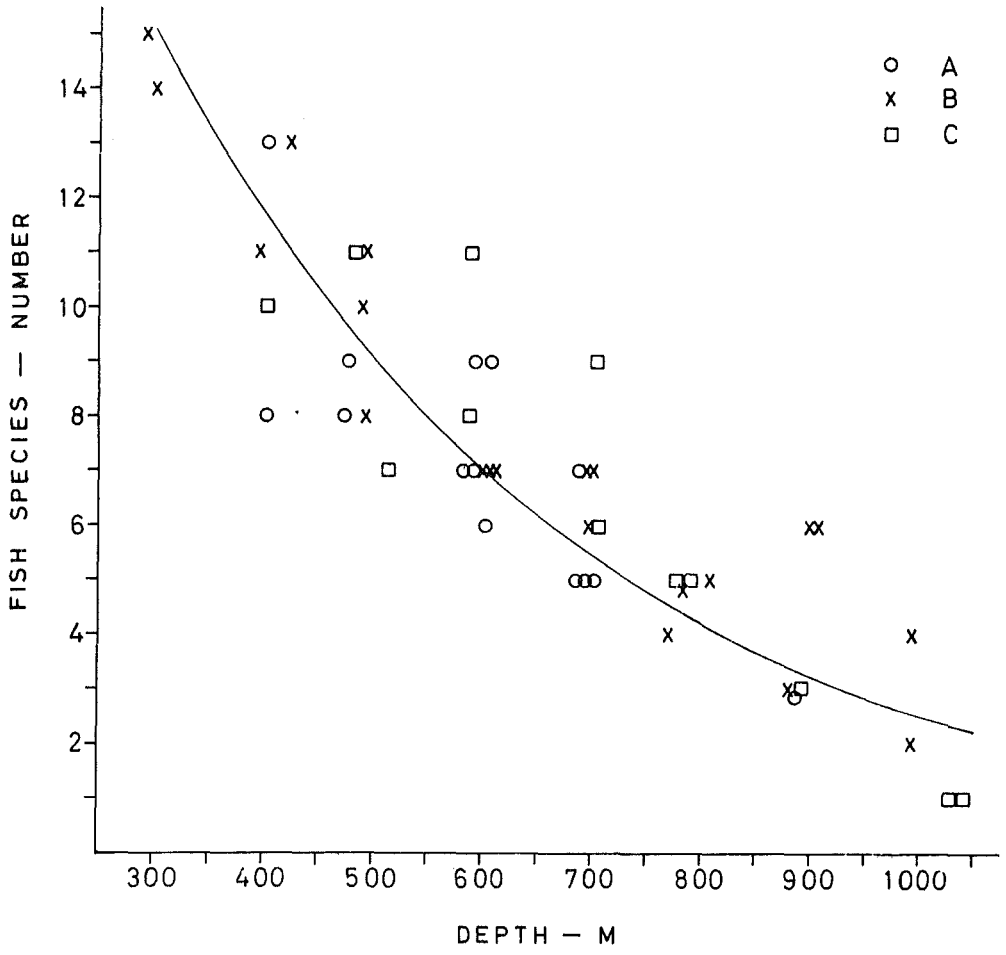

Fig. 5 Relationship between the number of fish species caught per haul and depth in area A, B and C. (Calculated regression lg y = -0,0011 x + 1,5454).

The proportions caught of the most important species in deep water were relatively constant between the areas. Macrourus berglax and Reinhardtius hippoglossoides dominated catches in the 600-700 m zone in all the areas. Raja hyperborea and Lycodes spp were also characteristic in this depth.

Fishing with long-line in area B and C showed that the type of gear strongly influences abundance and species composition of the catches (Table 2). Only few species were caught on the long-line. In area B Raja hyperborea made

up 64% of the catch and Macrourus berglax nearly 30% in weight. In area C the corresponding percentages were 3 and 45 while Reinhardtius hippoglossoides made up 35%.

Area	B		C			
Depth, m	600		600		700	
Temperature, °C	2, 0		2, 4		2, 0	
	N	Kg	N	Kg	N	Kg
Raja radiata	8	12	11	13	9	7
R. hyperborea	222	784			5	20
R. spinicauda	10	88	2	39		
Macrourus berglax	300	338	127	199	55	57
Brosme brosme			24	37		
Molva dypterygia	1	8				
Sebastes marinus			1	2	1	2
Reinhardtius hippoglossoides	2	4	74	177	12	21
Total	543	1234	239	467	83	107
Catch per 1000 hooks	168	382	157	307	55	70

Table 2. Catches on bottom long-line in area B and C.

Fig. 6 shows the length distribution of the dominating species caught on long-line. Macrourus berglax was slightly larger in area C than in area B. In general, fish caught on long-line were larger than those of the trawl catches.

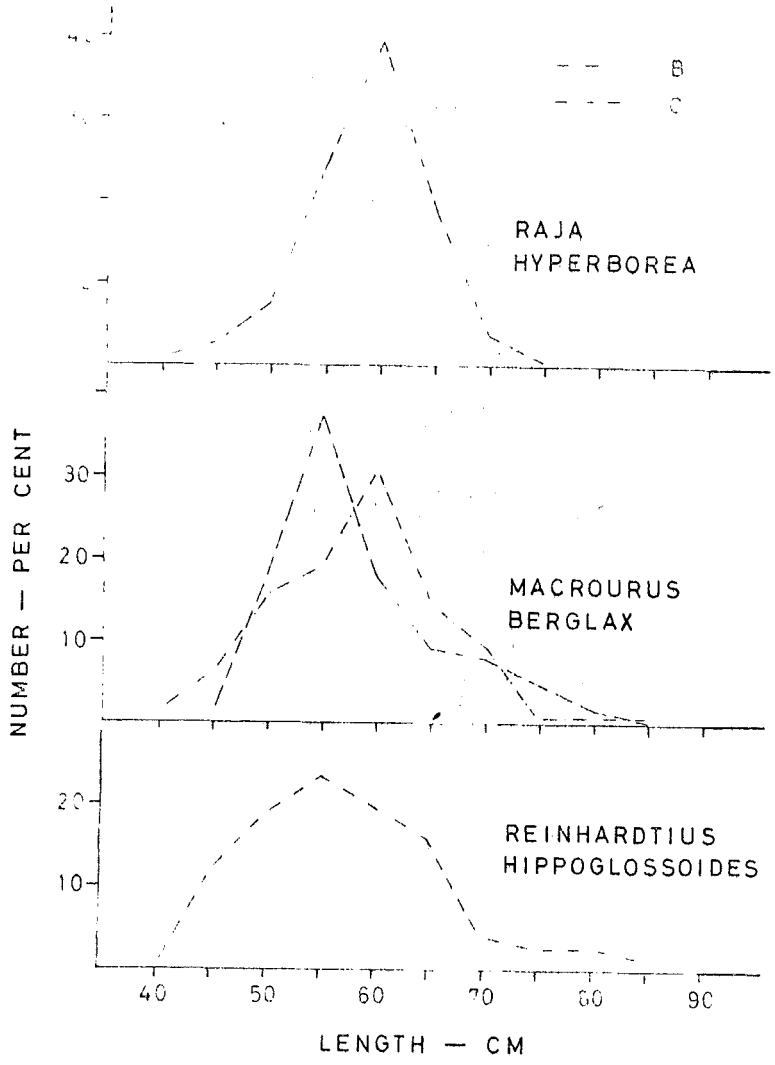

Fig. 6 Length distribution of dominating species in catches on long-line. in area B and C.

Zoogeography

None of the species collected were typical deepwater species. In the cold Norwegian Sea water an arctic fauna predominated. Characteristic species were Raja hyperborea, Macrourus berglax, Anarhichas denticulatus, Cottunculus microps, Careproctus reinhardti, Reinhardtius hippoglossoides and Lycodes spp. The arctic species were submerged in the two southern areas, and did not enter the Atlantic water. In area C they were also caught in more shallow depths.

Some of the species collected have a boreo-arctic distribution, e.g. Raja spinicauda, R. radiata, Sebastes marinus and Hippoglossoides platessoides. These species were, with a single exception, never taken below 700 m.

There were also a considerable number of boreal species, e.g. Galeus melanostomus, Etmopterus spinax, Molva dypterygia, Gadiculus thori and Sebastes viviparus. Some benthopelagic species, e.g. Micromesistius poutassou and Argentina silus, also belong to the boreal group. None of the typical bottom living boreal species were taken below 700 m. These species were most important in area A and B, although Argentina silus, Molva dypterygia and Sebastes viviparus were also taken in area C.

The vertical distribution of species from area B is illustrated in Fig. 7. Area B is representative for the two southern areas where the transitional layer between warm and cold water masses was narrow. In these areas the borders between arctic and boreal fauna were fairly sharp. In the northern area both hydrographical and faunistical gradients were more diffuse.

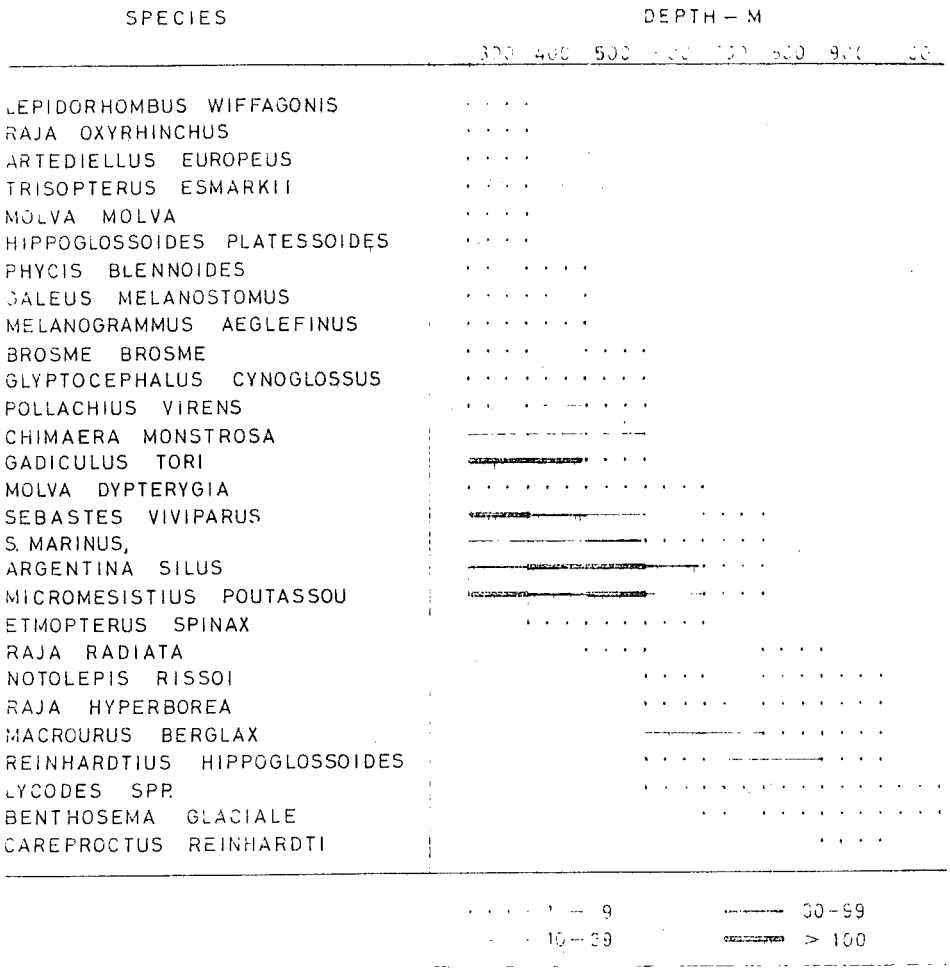

Fig. 7 Depth distribution of fish species caught in bottom trawl in area B. Number of fish per hr of trawling indicated.

A total of 37 species (Lycodes spp. are regarded as one species) were taken in the trawl. Of these 13 occured in all the areas (Table 1). The fish fauna on the Norwegian continental slope has few species compared to e.g. the British slope where BLACKER (1962) reported 107 species from 280 trawl stations. 22 of these species were also taken on the Norwegian slope. The dominating species in deep water off Norway are, however, different from those caught west of the British Isles (see p. 2).

In depths between 300 and 500 m hard bottom with sponges and corals dominated. In depths greater than 500 m the bottom was usually soft, and shrimps, amphipods, pantopods, sea cucumbers etc. were abundant. These animals also made up a considerable part of the stomach contents of the fish taken in deep water.

DISCUSSION

The water temperature below 600 m in the Norwegian Sea is very different from that found in the Atlantic Ocean west of the British Isles. In the latter area bottom temperatures in depths 600-1000 m are generally 10° to 7°C while they are only 4° to -0,5°C north of the sill between the Faroe Islands and Shetland (DIETRICH 1969). This difference explains the contrast between the composition of the demersal fish fauna in the two areas. Similar contrasts have also been found among evertebrates (EKMAN 1953).

The bottom trawl used in the present investigation has a relatively low vertical opening. This, together with large bobbins, restrict the effectively fished layer. The trawl was chosen because of its rugged construction, although comparisons with a lighter gear showed that it was more selective. The catches are influenced by this.

The decrease in catch with depth is, however, likely to be generally valid and can be expressed in relative terms:

Depth - m	Per cent
400 - 500	100
600	31
700	21
800	10
900	5
1000	1

The catches on bottom long-line as given i Table 2 are minimum figures since a substantial part was lost because the lines were left in the sea too long, particularly in area B. Still, long-line catches were remarkably high in comparison with trawl catches. This may be related to the low stock density which influence trawl catches and well developed chemical sense organs of many deep water fish tend to favour bait fishing.

Of the few dominating species caught on long-line, Reinhardtius hippoglossoides only is exploited commercially at present. It has been fished for a long time in deep water along the continental slope from northern Norway to Spitzbergen. The biology of this species is relatively well known (MILINSKII 1968, SOROKIN 1967).

Raja hyperborea was taken in great number in area B. This species has been regarded as rare (STEHMANN 1973), but is occasionally taken as by-catch in the fishery for Reinhardtius hippoglossoides. It has not been utilized in Norway.

Macrourus berglax was found in 600-700 m depth in all three areas, and may be of some commercial interest. Preliminary age determinations indicate that it is slow-growing, and being unexploited the average size is high (Fig. 6). A possible fishery would most likely rapidly reduce the average size and age, and a sustained yield of a relatively large total stock is dependant of a comparatively large total stock.

During the cruise simple tests of the eating quality of the dominating species from deep water were arranged. Macrourus berglax was regarded

excellent with firm, white flesh resembling cod in flavour. Raja hyperborea was palatable, but soft in texture. The only species considered unacceptable was Bathyraja spinicauda.

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