International Council for the Exploration of the Sea

Early Life History Symposium
1988 Paper No. 81

HABITAT SELECTION AND COMPETITION AMONG 0-GROUP GADIDAE OFF MID-NORWAY

by

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ABSTRACT

Juvenile gadids and other co-occurring fishes were collected during August in the years 1981 to 1983 at the Møre coast (Mid-Norway). The gears used were pelagic trawl, bottom trawl, Danish seine and beach seine. All species collected were indentified and counted.

Saithe and pollack were never observed in the pelagic hauls. Cod were abundant pelagically in 1981, but had already settled in 1982 and 1983. Haddock and whiting were caught both pelagically and at the bottom during all years. Saithe, pollack and partly cod therefore seem to settle before August, while the other species are settling during this month.

Cod settled mainly in shallow sheltered areas and were absent at the most exposed locations and in deep water. Haddock generally settled at greater depths and in more exposed areas than cod, but were also observed in the fjords. Saithe were caught mainly at exposed littoral locations, and pollack were found in shallow water both in exposed and sheltered areas. Whiting were less abundant than the others, but were found pelagically mostly inshore all over the area studied. Single specimens of settled whiting were found in the sheltered littoral and sublittoral. Although the distribution to some degree overlapped, it seemed that differences in distribution and size reduced competition between the juvenile gadids.

In the beach seine hauls about 30 other species occurred, and some of these may compete with cod for food.

INTRODUCTION

In recent years comprehensive studies have been carried out on the distribution and biology of larval and postlarval stages of cod (Gadus morhua L.) and other gadids in northern Norwegian coastal and offshore waters (e.g. Tilseth 1984, Tilseth and Ellertsen 1984, Bjørke and Sundby 1984). Abundance and distribution of pelagic and settled 0-group gadids in the Barents Sea have also been investigated (e.g. Randa 1984, Ponomarenko 1984). Information on the biology of 0-group gadids from the Norwegian Skagerrak coast are given by Dahl and Dannevig (1906) and Tveite (1971, 1984) and around the British Isles by Hawkins et al. (1986) and Riley and Parnell (1984). Knowledge of the 0-group distribution of gadids settling along the coast of Mid-Norway is, however, sparse.

Year class strength appears to be determined when the fish reach an age of about 6 months (e.g. Hylen and Dragesund 1973, Randa 1984). Resent studies also indicate a direct relationship between postlarvae abundance and subsequent year class strength (Sundby, Bjørke, Soldal and Olsen 1988)

Recently the mechanisms regulating recruitment of gadids in coastal waters have received special attension due to the development of methods for artificial production of cod fry for release in Norwegian inshore areas.

The objective of this paper is to describe the distribution of juvenile gadids occurring at the coast of western Norway (Fig. 1). The distribution is analysed in relation to depth and degree of exposure and compared to the distribution of other fish species. The habitat selection and the posibility of competition and predator-prey relationships between species during settling are discussed.

MATERIAL AND METHODS

Sampling

The investigations were carried out in August of the years 1981 to 1983 with R/V Håkon Mosby, which was equipped with bottom and pelagic trawls as well as a rubber boat from which a beach seine was operated. In 1983 a commersial Danish seiner was hired . The trawl and Danish seine had codends with small meshes. Description of the gears are given in Table 1.

The investigations were carried out at the coast of Møre between 62^0 N and 64^0 N. This coastline is permeated by fjords and sheltered by an almost complete row of islands (Fig.1). Skerries further shelter the islands and the coast. The investigated locations were catogerized according to the degree of exposure to the open sea:

Degree 1, sheltered; including most fjord locations, but also islands locations extremely sheltered by skerries.
Degree 2, moderately exposed; including most locations between fjord mouths and islands
Degree 3, exposed; including most locations between the islands or mainland and the outer skerries.
Degree 4, extremely exposed; including locations off the outer skerries.

The gears and locations were chosen with the aim of getting a reasonable coverage of the various depths in the four categories of exposure. The investigations were primarily designed to map the nursery areas of cod. Based on experience from saithe (Pollachius virens) surveys, beach seine hauls were concentrated in sheltered and moderately exposed areas, and at locations with bottom substrates which permitted safe operation of the seine. Also, a random distribution of the bottom trawl and Danish seine hauls was impossible due to rough bottom. Most of the pelagic trawl hauls were made in the fjords.

The entire catch or a representative subsample was sorted and the catch by numbers was recorded. Total length was measured to the nearest 0.5 cm below (specimen from the Danish seine catches were measured to the nearest cm below).

RESULTS

Variation between years in geographic distribution of the different types of sampling stations are illustrated in Fig. 1 to 3.

Pelagic distribution

In 1981 a considerable number of 0-group cod (maximum 33 specimens per trawl haul) were found pelagically in the fjords, mostly in the upper 50 m (Fig. 4). In the two subsequent years cod were recorded in only one pelagic trawl haul (Figs. 5 and 6). Settling of cod therefore appear to occur in the period July to August.

Haddock (Melanogrammus aeglefinus) and whiting (Merlangius merlangus) were found in all exposure zones (Figs. 7 and 8), haddock having the more offshore distribution. Saithe and pollack (Pollachius pollachius) were not observed in the pelagic trawl catches (Fig. 9, 10).

Demersal distribution

Surface to 10m: The beach seine sampled the zone from the surface to 10 m depth. In the catches cod (Figs. 4-6), saithe (Fig. 9), and pollack (Fig.10) were frequent. Single specimens of haddock and whiting (Figs. 7 and 8) occurred in 1 and 14 of the hauls respectively.

Saithe were considerably more abundant in 1983 than in the two preceeding years (frequently more than 100 specimens per haul). In 1981 and 1982 saithe were most frequent in the areas with degree of exposure 2 to 4. In 1983 the area of distribution had expanded, and the species was also found in sheltered areas (exposure degree 1). Cod were found on the sheltered and moderately exposed locations. The largest catch was 200 specimens per haul, but most catches were below 30. Pollack were found on all types of locations, but the catches seldom exceeded 50 specimens per haul.

20 - 120m (Danish seine grounds): In 1983 coastal and offshore regions with exposure 2 to 4 and with depths ranging from 20 to 120 meters were surveyed with Danish seine (Fig. 3). In the 43 hauls, cod, haddock and whiting were found in 10, 10 and 5 hauls respectively (Figs. 6, 7 and 8). A maximum of about 600 0-group cod were caught per haul. The 0-group haddock and whiting were less numerous in these catches. These species appeared to be settling during the period studied, as they were also caught by pelagic trawl. No 0-group fish were recorded offshore (exposure degree 4). Pollack and saithe were absent in the Danish seine catches.

100 - 300m (bottom trawl grounds): Bottom trawling was done in all exposure zones, but suitable bottom conditions were only found deeper than 100m. No 0-group cod, saithe, pollack or whiting were found in the bottom trawl catches except for a single cod in 1983. Haddock were caught in small numbers mostly offshore. (Fig.7).

Length distributions

Size distribution of the five species were compared based on data from 1983, i.e. the year with most extensive sampling.

The area of investigation was divided in four subareas; subarea 1 being the southmost and subarea 4 the northmost (Fig. 1). The length of cod and saithe caught in the littoral zone differed considerably, saithe being the largest, whereas pollack were smaller than cod. Mean length measurements of cod, saithe and pollack from beach seine catches are shown in Fig. 11 and in the following text table:

	Cod	Saithe	Pollack
Subarea 1	7.3	11.2	5.7
Subarea 2	6.0	9.7	5.2
Subarea 3	7.1	10.3	5.2
Subarea 4	7.1	11.0	6.2

Species specific differences between areas were minor compared with the interspecies differences.

The differences between cod and haddock length distributions in the Danish seine catches were rather pronounced (Fig.12). More than 80% of the haddock, but only 10% of the cod were 9 cm or more. The haddock in the pelagic trawl catches (l=7.9) were smaller than haddock caught by Danish seine (l= 10.1 cm) (Fig. 12), which indicated that settling was occurring, the larger fish settling first. The mean length of the pelagic haddock was close to the size of settled cod (l=7.3 cm in beach seine and l=7.1 cm in Danish seine catches).

Cod from the Danish seine and the beach seine hauls in the same subarea had approximately the same length distributions (Fig. 11, subarea 1, and Fig. 12).

Other species

In addition to 0-group gadids 35 to 40 other fish species were caught in the beach seine hauls. Most of these occurred only occasionally, but some were of considerable importance (Table 2).

The most regular and also the most abundant species was Gobiculus flavescens occuring at about 90% of all stations with an average catch of almost 80 specimens at each positive station. Pomatoschistus minutus, Gasterosteus aculeatus and Ctenolabrus rupestris occurred at about 25% to 50% of the stations with an average of 10 to 20 specimens per positive haul. In 1983 positive stations of these species were less frequent than positive stations of cod, while they were about equally frequent in 1982. Where they occurred, they were approximately equally abundant.

In the Danish seines about 20 species were caught, but less than 10 were important (Table 3). Out of these, saithe, whiting, hake and also the older age groups of cod are known as predators of 0-group fish, but more knowledge on feeding behavior and habitat selection is needed to assess the importance of the interaction.

DISCUSSION

The five gadids had either settled or were settling in the beginning of August. Saithe and pollack appeared to have finished the settling in August as they were not caught in the pelagic trawl. In 1982 and 1983 cod had also settled at this time, while in 1981 pelagic trawl catches indicated that settling took place somewhat later. Haddock and whiting were settling in the period studied all years. For cod and haddock this is about two months earlier than in the Barents Sea (Hylen and Dragesund 1973), but similar to what is found in Scottish coastal waters (Hawkins et al. 1985).

Hislop (1985) compared reproductive tactics and strategy of gadids and found considerable species differences. Richards et al. (1978) correlated estimates of abundance through the years 1922 to 1971 of various fish

species in the North Sea. The abundance of the species varied independently. To some extent this is also found for the year classe strength of abundant species at the Norwegian coast, however, here also strong year classes of several species often co-occurred (Dragesund, 1971). Studies of the diets and feeding behaviour of juvenile gadids in the North Sea indicated a low degree of competition among pelagic 0-group fish (Robb and Hislop 1980, Robb 1981). A general conclussion drawn was that competition among gadids during the pelagic and adult stages is limited or absent.

This study has shown that the degree of exposure and bottom depth are important factors for characterizing the settling areas of the gadids. Cod were found in sheltered areas in the littoral zone, however, the Danish seine catches showed that 0-group cod were also abundant at intermediate depths (20 to 50m) in more exposed locations. This is in accordance with observations from the North-Norway coast and fjords (Strømme, 1977; Soldal and Olsen, 1988), but contrast observation from the Norwegian Skagerrak coast where 0-group cod mostly are found above 20m depth (Dahl and Dannevig, 1906; Flødevigen Biological Station, unpubl. data). Taking into acount the greater area with intermediate bottom depths and the occationally very high abundance observed here, it is plausible that these depths have the major settling areas for 0-group cod.

Saithe mainly settle in the littoral. This species is most abundant in the exposed areas. In years of high abundance, saithe were frequently found in high numbers also in the sheltered littoral locations and co-occurred here with cod and pollack. Similar distribution pattern of 0-group saithe is found by Lie (1961) and Jakobsen (Institute of Marine Research, Bergen, pers. com.).

0-group haddock were settling during the observation period. Based on findings both in the Danish seine and bottom trawl catches, the lack of haddock in the littoral and the offshore recordings of pelagic 0-group haddock, the presumed main settling areas for haddock are at the higher degrees of exposure and at depths below 60m. This is also confirmed by high bottom trawl catches of 1-group haddock offshore at about 100m depth in March (Institute of Marine Research, Bergen, unpubl. data).

A synthesis of the above discussed distribution patterns of the 0-group gadids is suggested in Fig. 13. Pollack are categorized together with saithe as this species co-occurred with saithe and cod in the littoral. Whiting were scarce in the demersal catches but occurred frequently in the pelagic trawl hauls. Compared with the other gadids, this species settle later in the year, and the uncertainty as to the main settling location, prevent us from including it in Fig. 13.

Cod and saithe as well as cod and haddock do co-occur as settled 0-group fish, however, each species also inhabit major areas with no or insignificant occurrence of the others. Further, the length data showed

that when co-occurring both cod/haddock and cod/saithe exhibited pronounced size differences. There is a clear correlation between fish size and prey size among pelagic 0-group gadids (Robb and Hislop 1980), and also for older cod (Ursin 1973, Horbowy 1982). It is therefore likely that the different species of gadids will take different size of prey, and so reduce interspecific competition in the areas where they co-occur. Pollack were found to inhabit the littoral together with saithe and cod. The small size of this species (half the length of saithe) probably minimize competition.

The gadids settle in areas inhabited by a number of other species, and at least in some cases they seem to occupy the same habitats as them (i.e. Gjøsæter 1987 a, b. 1988). Competition from these species, and also predator - pray relationships can, therefore, be expected.

The food of various gadids has been described by many authors (i. e. Wiborg 1948, Lie 1961, Daan 1973, Kislalioglu and Gibson 1977). For other species data are more scarce, but apparently gobids and sticklebacks take food similar to the gadids (Kislalioglu and Gibson 1977). Crenolabrus and other labrids are assumed to take more bentic organisms (Wheeler 1969). Recent studies suggest however that Crenolabrus often look for food at the same places as 0-group cod do (Gjøsæter in prep). Although it seem likely that the species in question partly will take similar food from the same places, it is not known to what extent food is limiting, and how important competiton for food may be.

None of the species taken frequently in the beach seine are assumed to be predators on 0-group gadids. In the Danish seines about 20 species were caught, of which less than 10 were abundant (Table 3). Whiting, cod, hake and to some extent saithe are known to be predators of juvenile gadids. Of these cod may be the most important one. It has been shown, however, that 0-group cod avoid habitats with older cod, and hide among bentic algae when older cod approaches (Gjøsæter 1987 b,1988).

It is, therefore, tentatively concluded that intraspecific competition among 0-group gadids is not important, while competition between 0-group gadids and other fishes from the littoral and sublittoral may be. Further it seem that predation may not be important in the littoral, but it may be at deeper waters, where older gadids probably are the most important predators.

The data presented give a qualitative picture of the distribution of juvenile gadids at the coast of Møre. It is difficult to come to quantitative conclusions because little is known about the efficiency of the different gears, and because the sampling was not random, i.e. the sampling was restricted by topographical factors. Areas with rocks and dense vegetation could not be sampled, and hence fishes prefering open beaches with sand and mud will be overrepresented. Also, the sampling was aimed on cod based on experience from beach seine surveys conducted by T. Jakobsen (Institute of Marine Resaerch, Bergen, pers.

comm.).

Gjøsæter (1987 a, b) and Keats et al. (1987) indicated that O-group cod preferre areas with algal vegitation. Other studies have suggested that cod and saithe, and possible also the other O-group gadids are less attached to the substratum than most of the litoral species caught during this survey (Kislaliogly and Gibson, 1977) and therefore the type of bottom at the sampling locations may be of less importance.

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Table 1. Gear spesifications.

Gear size	Mesh-size	Otter boards	Sweap-lines/ weight
Pelagic trawl 20 m vertical opening	1600 meshes 200-20 mm	$6m^2$	80m/300kg
Bottom trawl 6m vertical opening	1800meshes 80-20 mm	$6\ m^2$	40 m
Beach seine 50 m x 4 m	9 mm	-	-
Danish seine 62 m headrope Perepheri mouth 460 meshes	150-35 mm	-	

Table 2. Occurence of some fish species in the beach seine catches in 1982 and 1983.

Species	1982 Occurence No Sta-tions	% of Sta-tions	Mean No of spec.	Var.	1983 Occurence No Sta-tions	% of Sta tions	Mean No of -spec.	Stand div.
Cod, (Gadus morhua)	12	37,5	20,8	2911	59	68,6	12,4	16.8
Pollack, Pollacius pollacius)	21	65,6	16,0	423	46	53,5	7,5	16.9
Gobiculus flavescens	28	87,5	79,0	19766	76	88,4	77,3	202.5
Pomatoschistus miuntus	16	50,0	12,4	396	32	37,2	21,8	39.6
Gasterosterus acculatus	14	43,8	16,2	575	22	25,6	12,6	21.6
Ctenolabrus rupestris	9	28,1	14,6	331	33	38,4	8,3	23.2

Table 3. Occurrence of the most abundant fish species in the Danish seine catches.

Species	Occurrence No Sta- tions	Occurrence % of Sta- tions	Mean no of spec.	Stand div.
Cod, Gadus morhua, all ages	32	74.4	11.3	11.8
Cod, 0-group	10	23.3	88.1	169.8
Haddock, Melanogrammus aeglefinus all ages	37	86.0	31.3	40.1
Haddock, 0-group	10	23.3	20.8	30.2
Saithe, Pollachius virens	19	44.2	6.8	9.5
Place, Pleuronectes platessa	31	72.1	20.4	21.5
Whiting, Merlangius merlangus	15	34.9	53.6	87.5
Norway pout, Boreogadus esmarkii	5	11.6	37.0	60.3
Hake, Merluccius merluccius	5	11.6	8.8	8.7

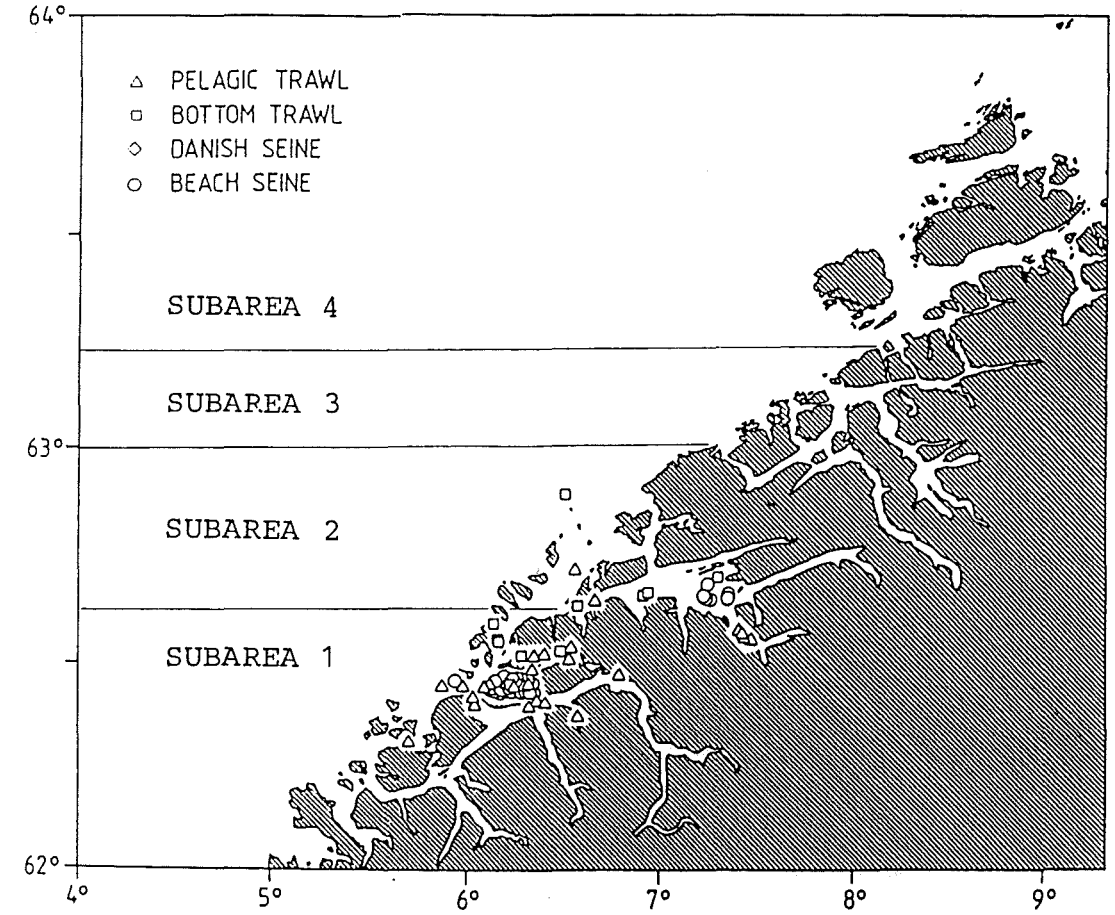


Fig. 1. Sampling stations in 1981 with sub-areas 1-4 indicated.

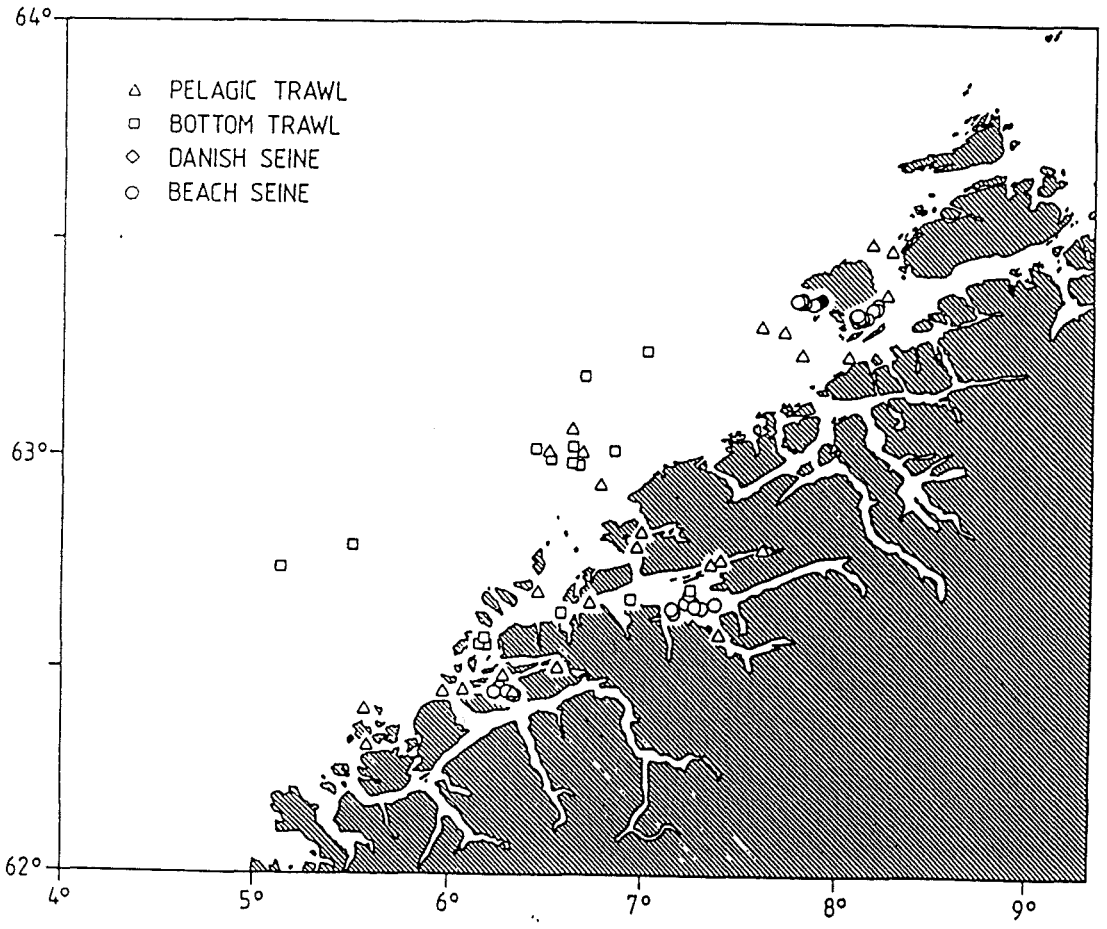


Fig. 2. Sampling stations in 1982.

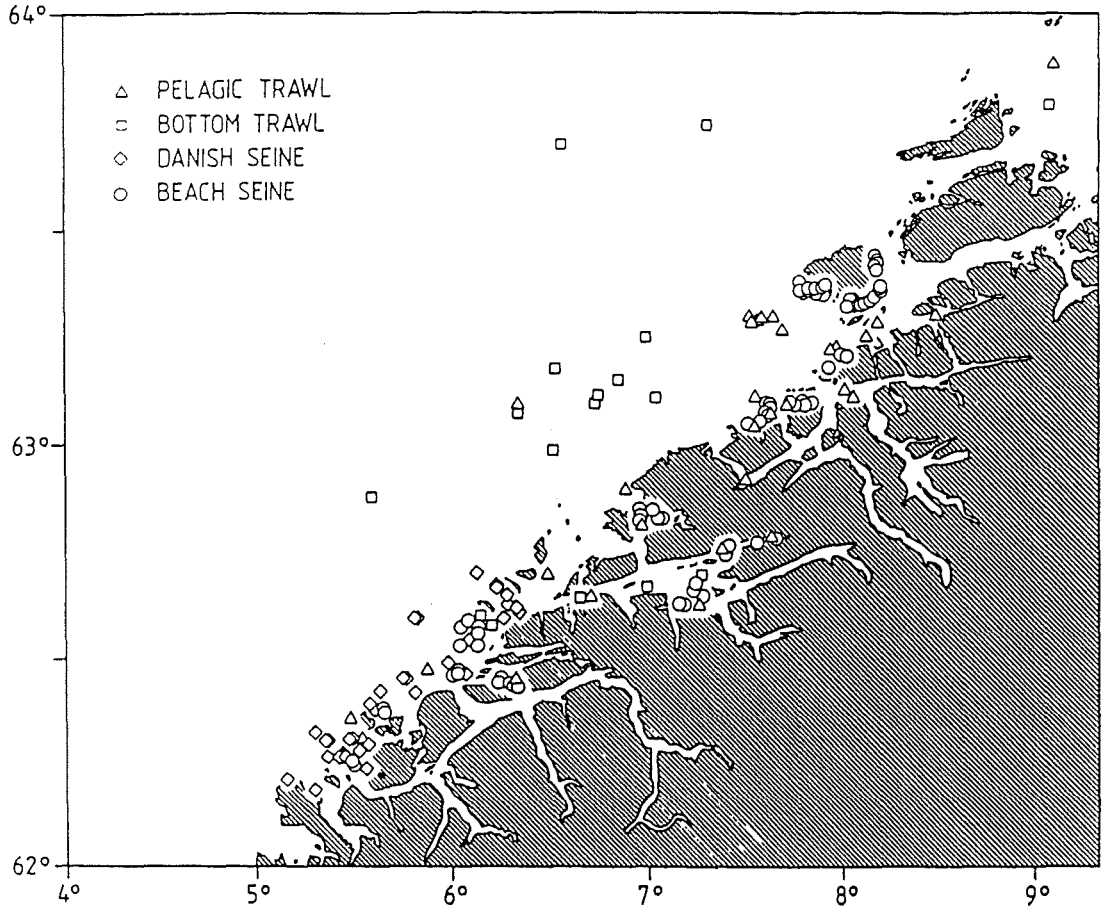


Fig. 3. Sampling stations in 1983.

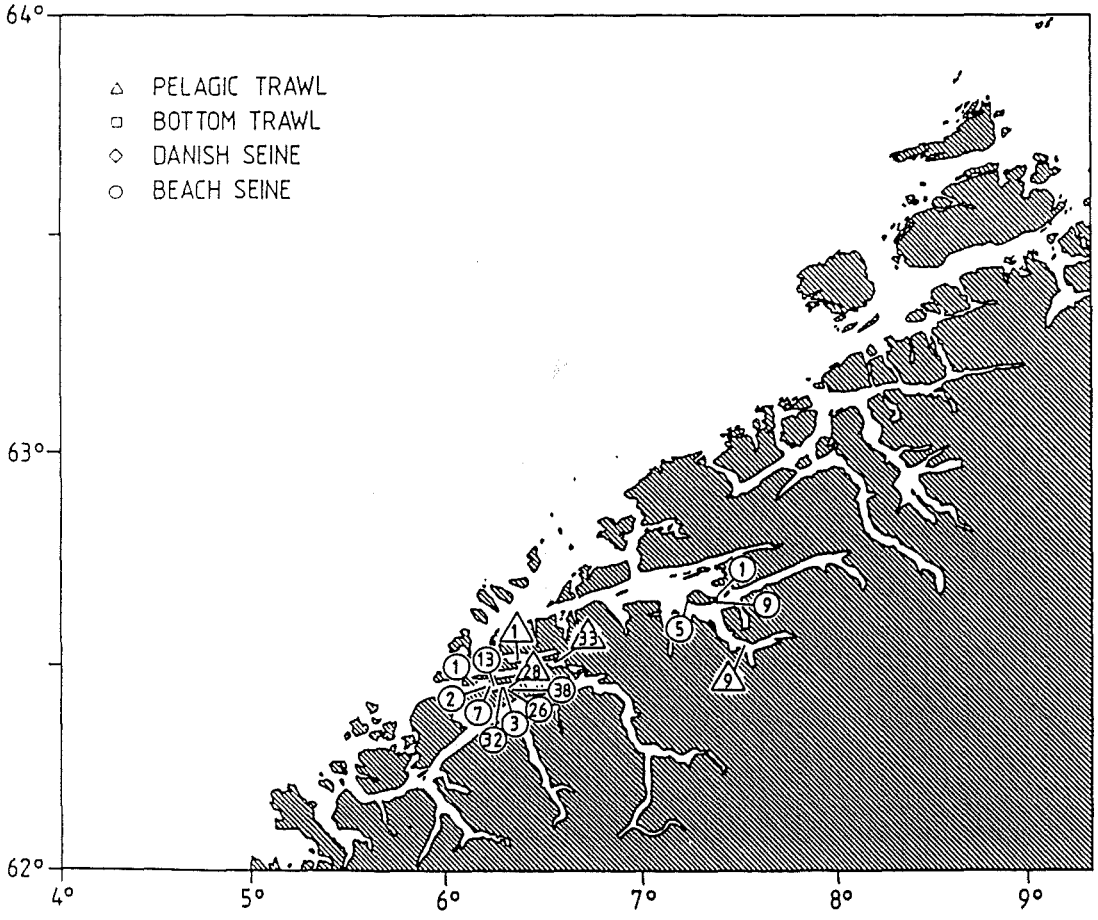


Fig. 4. Catches of cod in numbers taken by the different sampling gears in 1981.

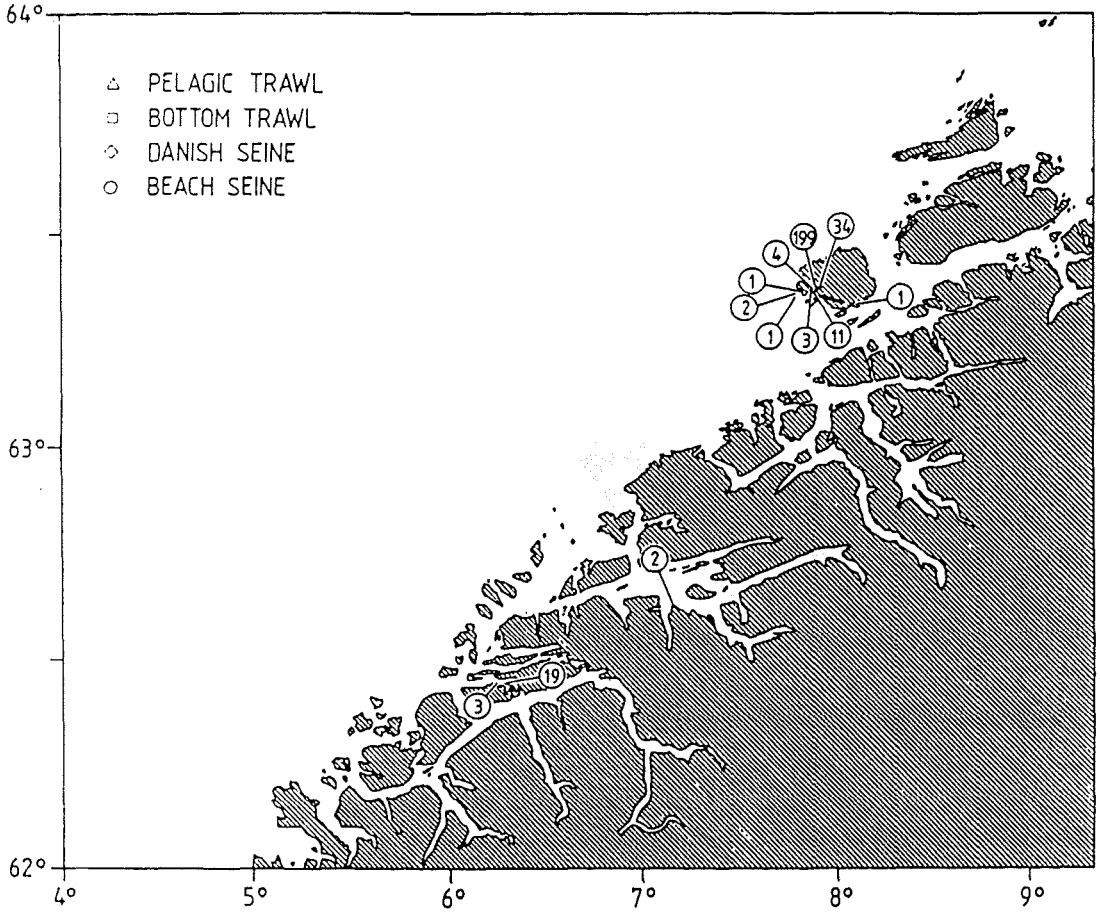


Fig. 5. Catches of cod in numbers taken by the different sampling gears in 1982.

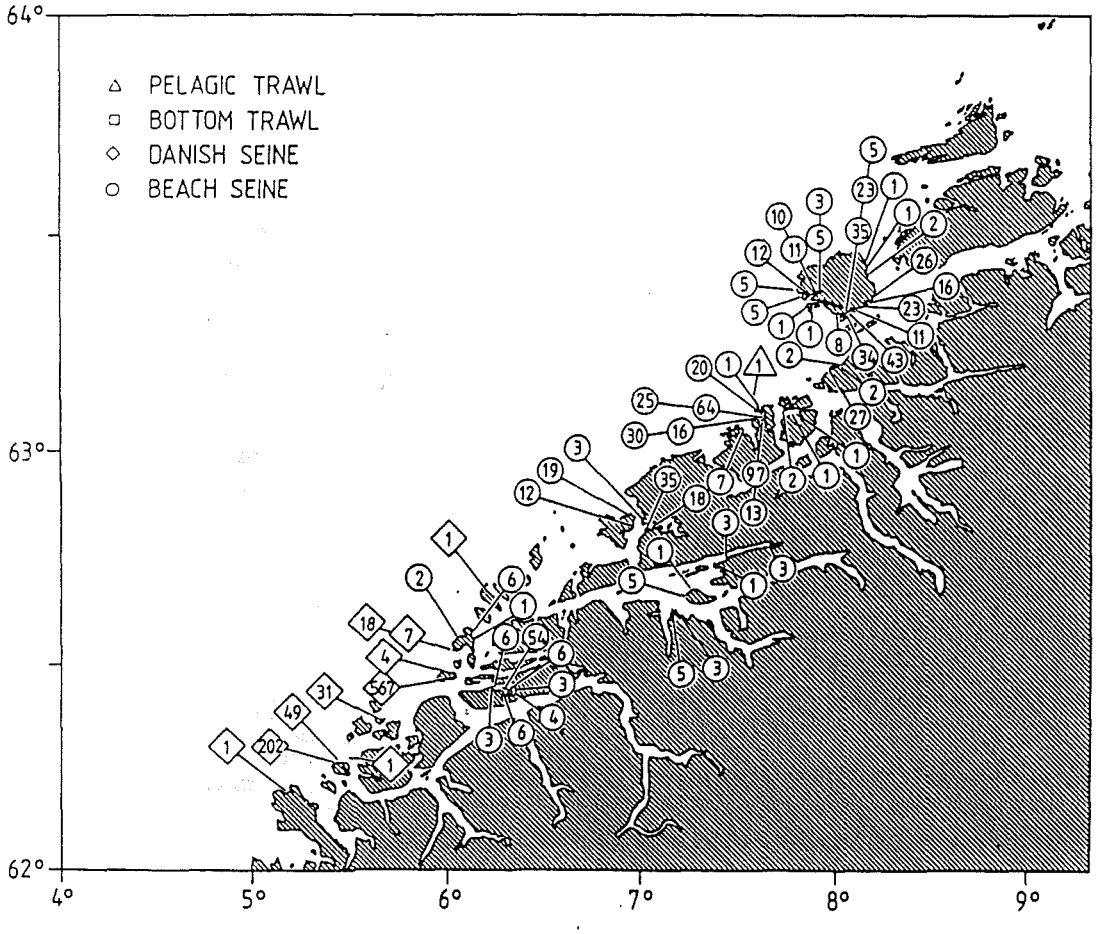


Fig. 6. Catches of cod in numbers taken by the different sampling gears in 1983.

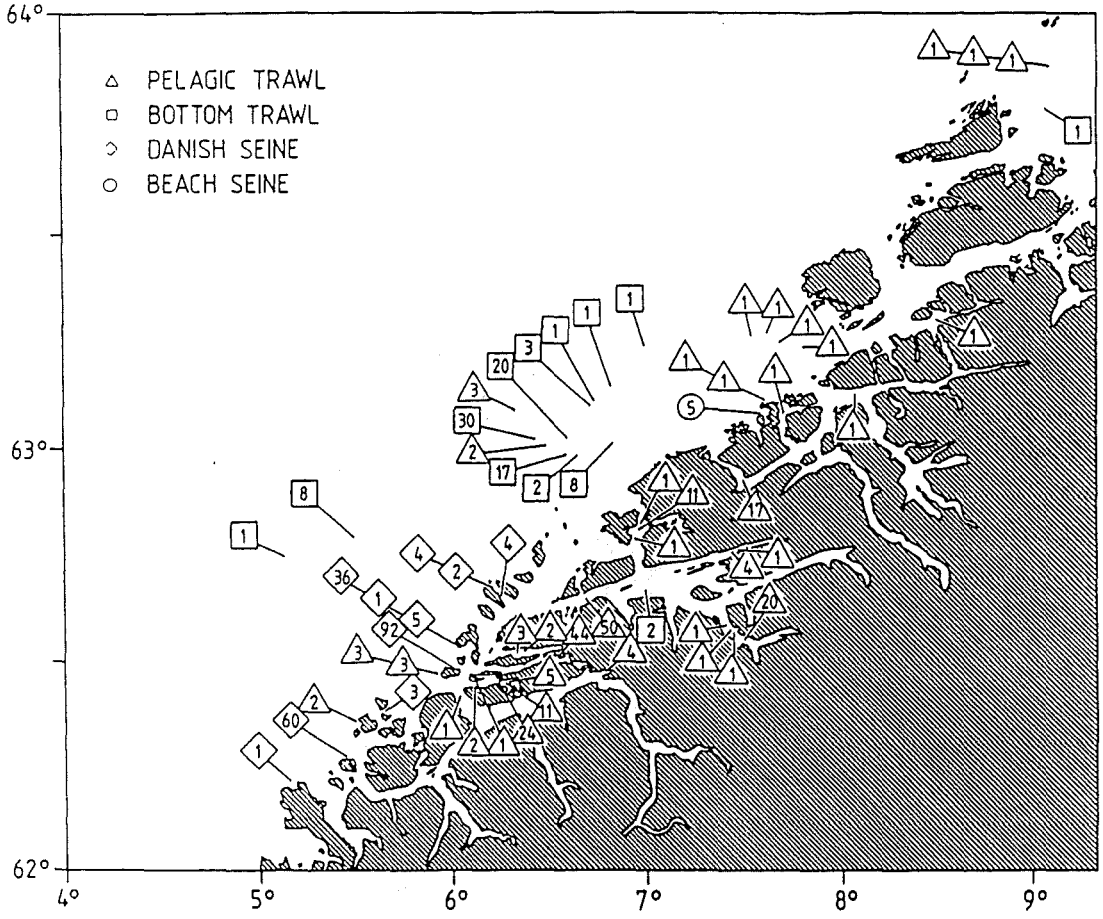


Fig. 7. Catches of haddock in numbers taken by the different sampling gears in 1981 - 1983.

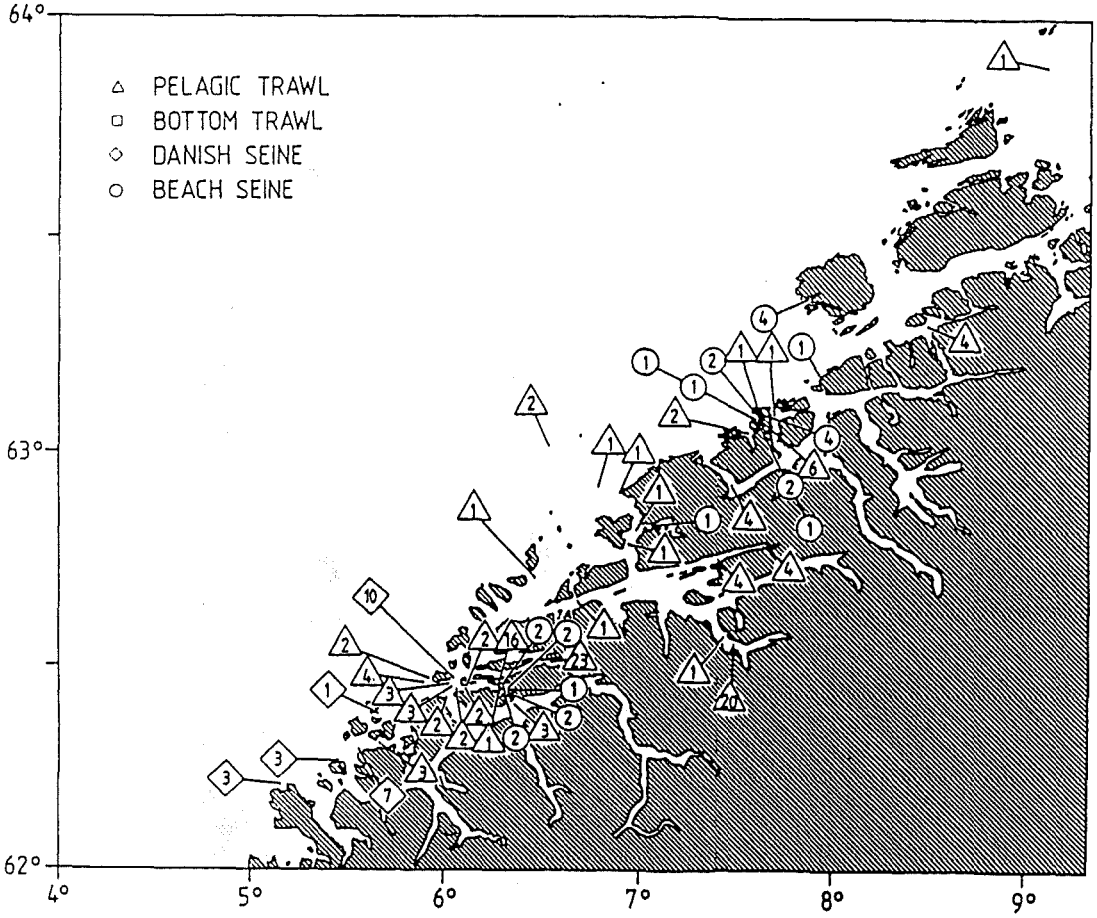


Fig. 8. Catches of whiting in numbers taken by the different sampling gears in 1981 - 1983.

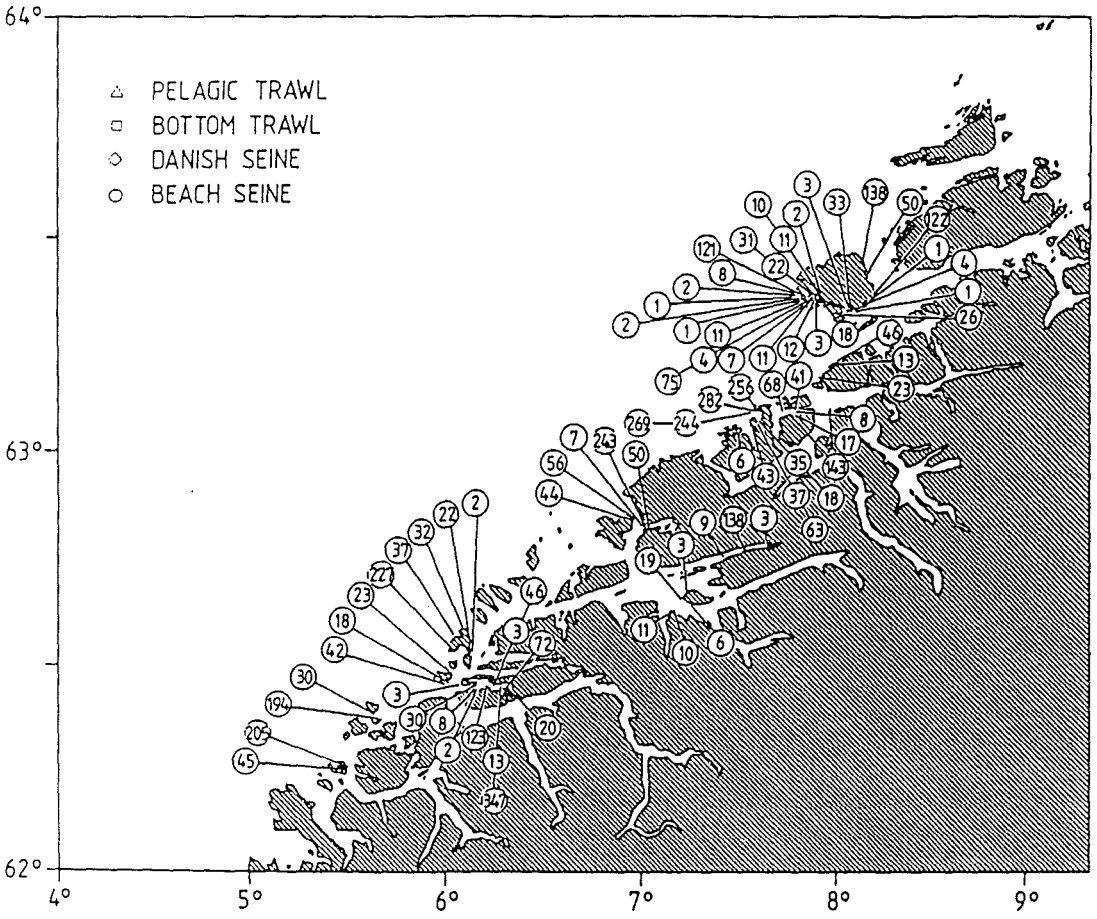


Fig. 9. Catches of saithe in numbers taken by the different sampling gears in 1981 - 1983.

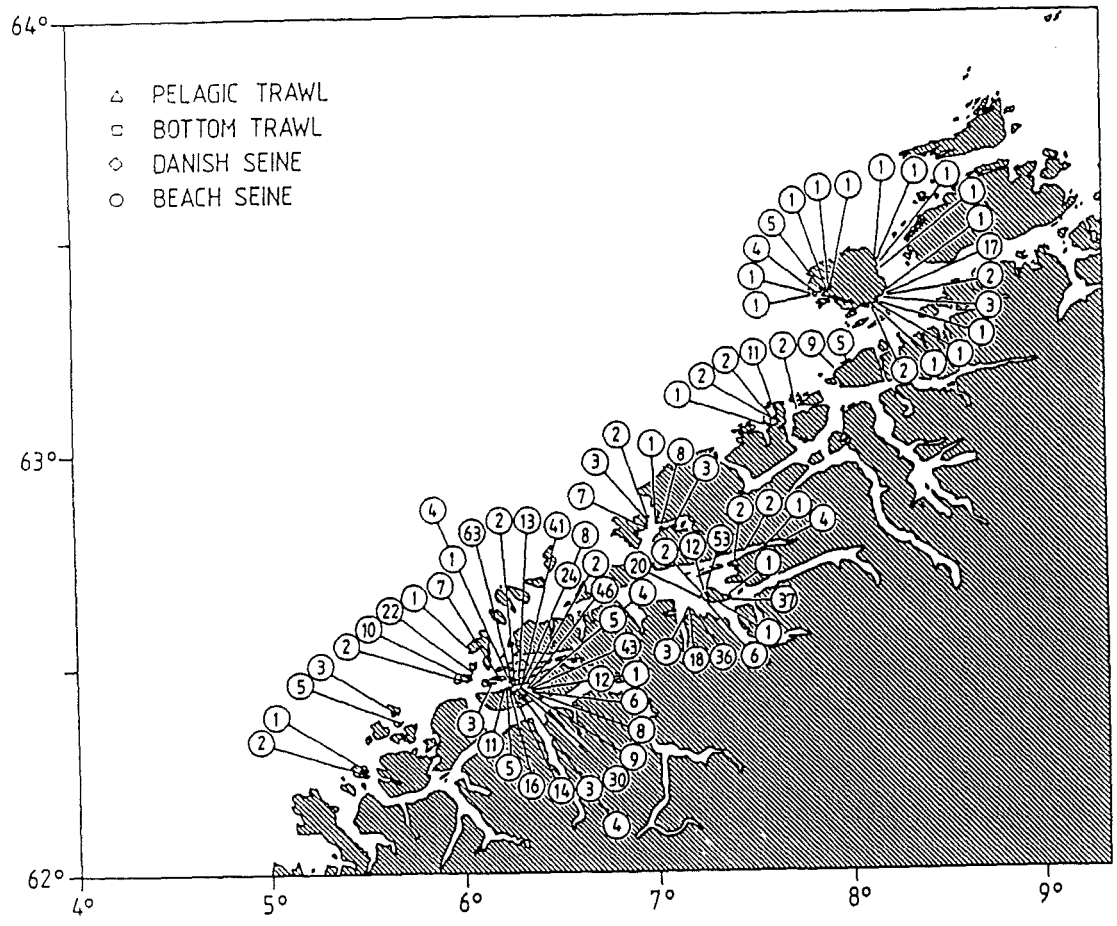
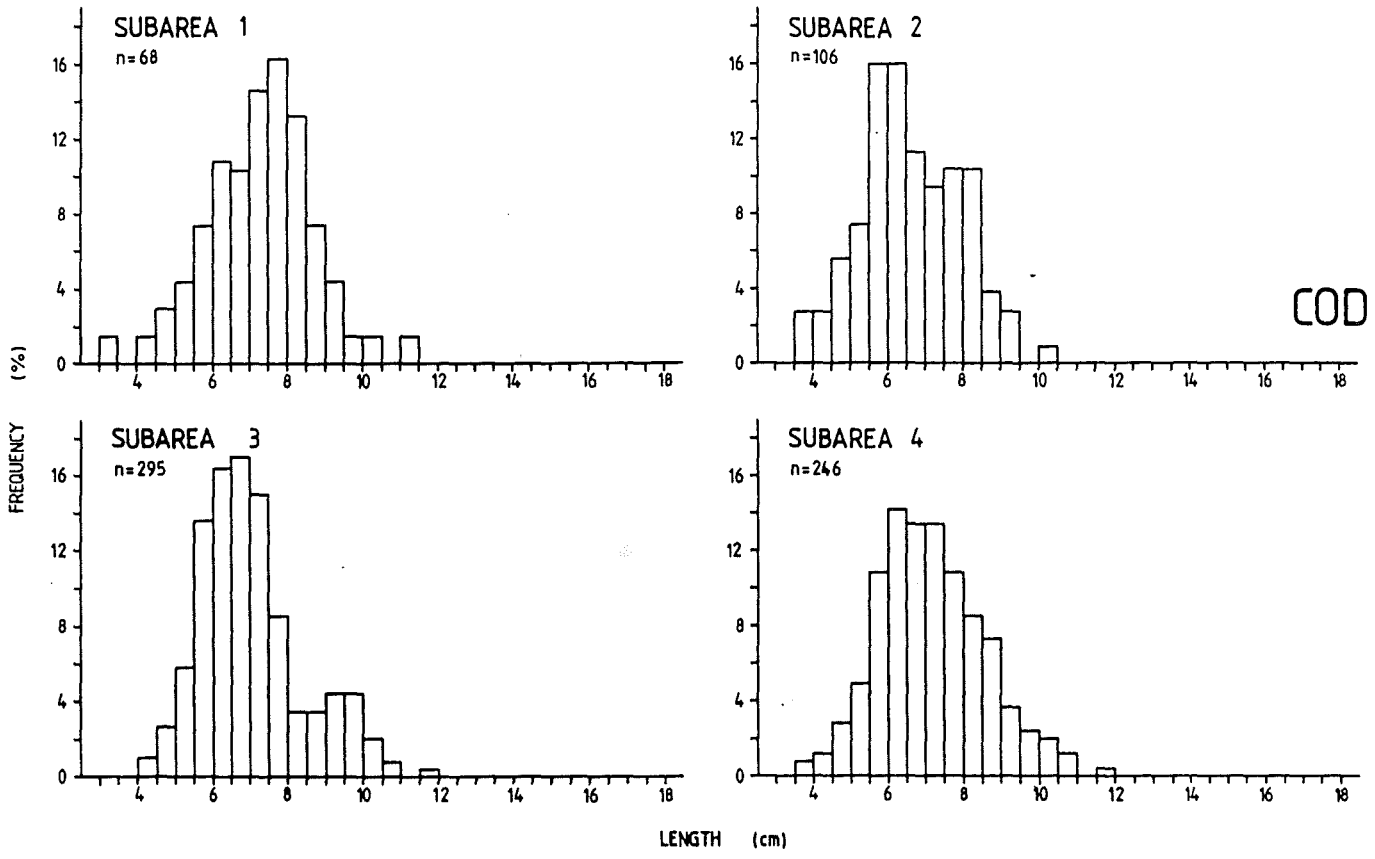


Fig. 10. Catches of pollock in numbers taken by the different sampling gears in 1981 - 1983.



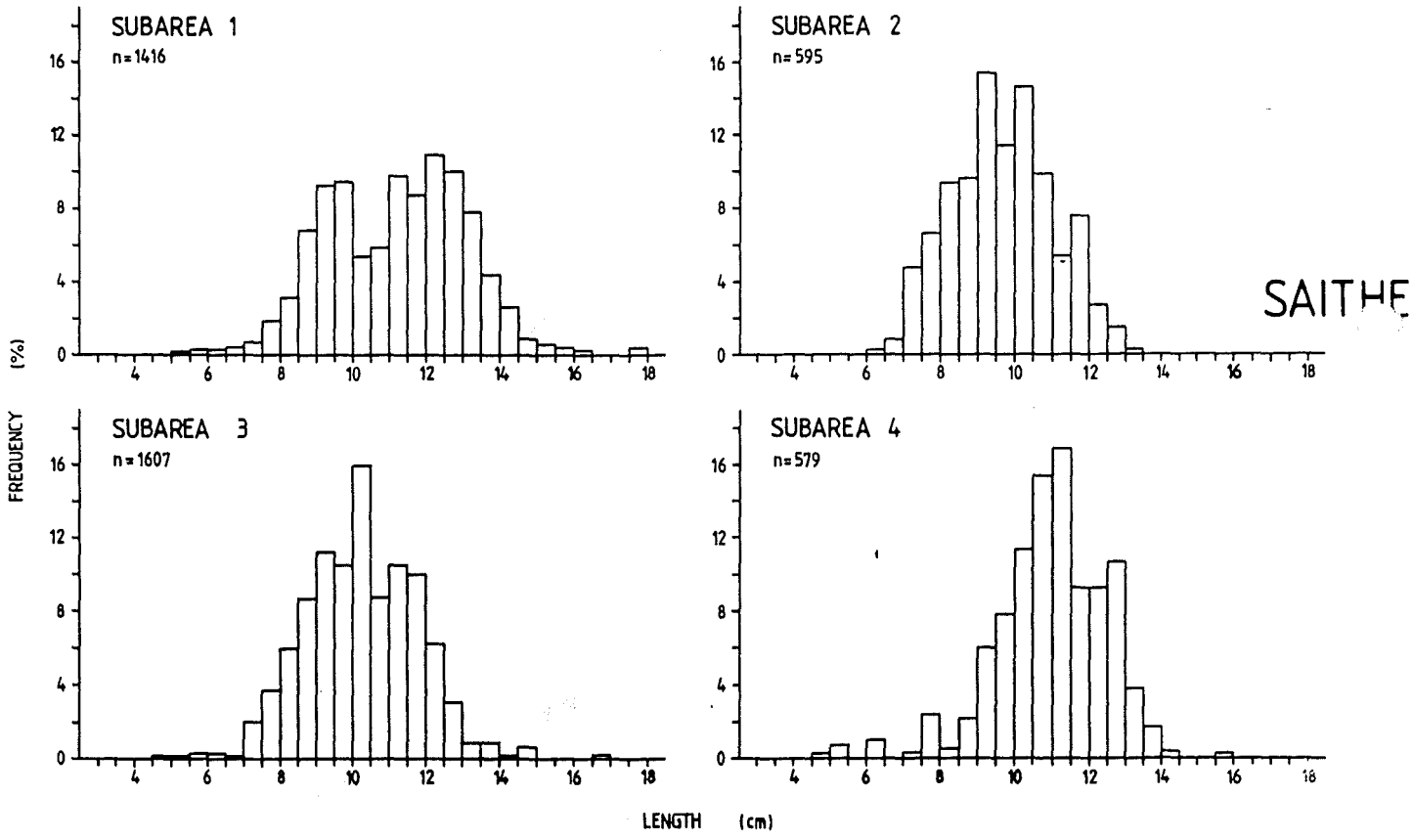


Fig. 11. Length distribution by subarea for cod and saithe caught by beach seine. For explanation see text.

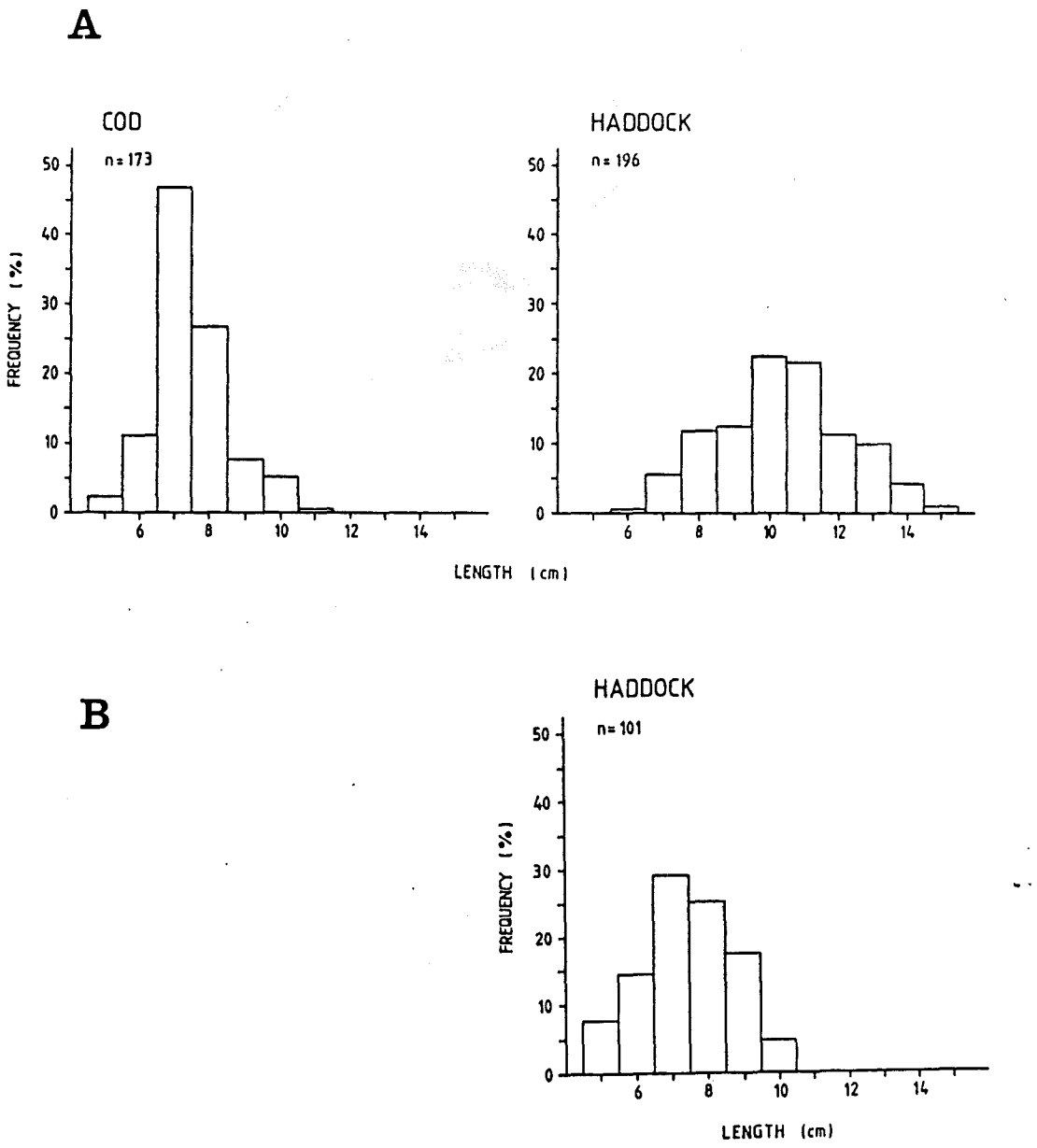


Fig. 12. Length distribution for cod and haddock caught by Danish seine a) and pelagic trawl b) in 1983.

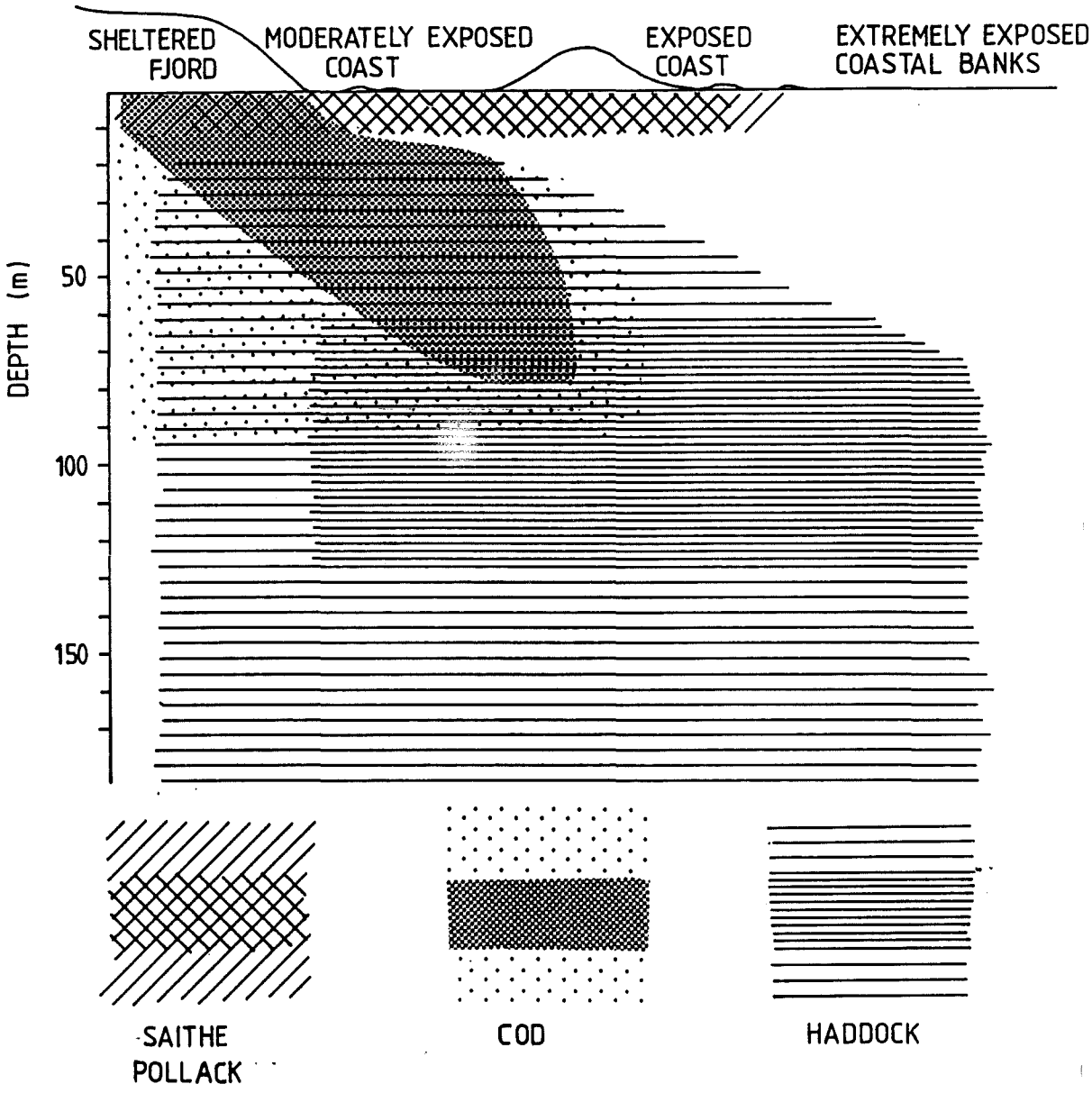


Fig. 13. Schematic presentation of the distribution of 0-group gadids in an exposure to depth coordinate system.