International Council for
the Exploration of the Sea

C.M. 1985/G:22
Demersal Fish Committee

FOOD AND FEEDING HABITS OF YOUNG SAITHE, POLLACHIUS VIRENS (L.), ON THE COAST OF WESTERN NORWAY.

by

Kjell Nedreaas

Institute of Marine Research
P.O.Box 1870, N-5011 Bergen-Nordnes
NORWAY

ABSTRACT

The stomach contents of young saithe [Pollachius virens (L.)] (I- and II-group, mainly II-group) in two areas (A and B) on the western coast of Norway, has been analysed. When this juvenile saithe become two or mainly three years old, they migrate away from the shallows on the coast and towards the North Sea. The nutrition may play a role in connection with this migration.

In area A the saithe had almost exclusively preyed upon plankton in the pelagic environment. The appendicularian Oikopleura dioica, the copepod Calanus finmarchicus, and the krill Thysanoessa inermis each dominated the nutrition at their times. In the winter when the krill seemed to be the most important single food organism, the saithe showed clear signs of starvation.

In area B Calanus finmarchicus was the most common single prey. In this area the diversity of the stomach content was higher than in area A. Epifauna/hyperbenthos, consisting of isopods and amphipods attached to bottom vegetation, seemed to play an important role, especially when typical and suitable plankton organisms were scarce.

Larvae and yearlings of fish were at certain times important food for the saithe. Different species occurred in the diet at different times.

Small differences in the length distribution throughout the sampling period is an indication of a gradual migration of the greatest fish (mostly two-year-old) away from the coast. In July-August almost all two-year-old saithe disappeared from area B for a short time, while they were still present in area A. This behaviour did not seem to appear every year in the areas investigated. Intraspecific competition

from younger age groups may be an explanation.

The main migration of saithe away from the coast seems to take place during spring (after 1 March, but before 1 June) when the saithe are three years old. In the beginning of March, the saithe examined seem mostly to have been preyed on krill, and the observed transport of krill away from the coast may have led the saithe to follow.

1. INTRODUCTION

Feeding and searching for food are factors which regulate or at least have influence on the distribution, migration, and growth of fish. The fish can change behaviour and migration pattern according to food availability.

The saithe (Pollachius virens (L.)) was in 1984 the third most important commercial fish species to Norway both in quantity and value. Preliminary results show that Norwegian fishermen caught 51 % and 96 % of the total landings of saithe from the North Sea and the Norwegian coast north of 62^0 N respectively (Anon. 1985). ICES operates with two stocks of saithe, one in the North Sea and one outside and along the Norwegian coast north of 62^0 N. This border between the stocks is biologically not clear and strictly defined, migrations between the areas do occur (Jakobsen 1981, Anon. 1983).

When the saithe along the coast of western Norway (south of 62^0 N) are 2-4 years old, they migrate towards the banks in the North Sea, mainly to the eastern part north of 57^0 N (Jakobsen 1981). Fishing of young saithe with purse seine along this part of the Norwegian coast is for many people an important fishery. The disappearance of the saithe when they reach a certain size or age therefore has consequences for the fishery.

What causes this massive and every year occurring migration of juvenile saithe away from the coast? Tagging experiments in 1972-1974 (Jakobsen 1978a) and 1975-1977 (Jakobsen 1981) showed a gradual migration of fish away from the coast which had connection with the age and length of the saithe. The timing of migration of saithe differed from year to year, and a possible explanation of this migration could be the feeding and prey preferences of the saithe (Jakobsen 1978a).

Based on stomach content analyses the main task of this work was to identify what the juvenile saithe on the shallows along the coast prey upon before they migrate towards deeper water in the North Sea. Therefore it was decided to look at the nutrition of the saithe in connection with the variable catches in the area, with the aim of finding possible explanations to the gradual migration away from the coast.

Very few works have been published about the feeding of young saithe along the coast of Norway. Nordgaard (1902) studied the species composition in saithe stomachs, but this was not a quantitative analysis. About the feeding of 0-group saithe Lie (1961) has published a taxonomic and quantitative analysis. Lie (1962) also looked upon the feeding of a few I-group saithe. From the North Sea some data on the feeding of saithe are available (e.g. Golubjatnikova & Malyshev 1980, Anon. 1982, Gislason 1983), but this is on saithe that already have migrated from the coast. Because of this lack of knowledge about the feeding of young saithe, a closer look was taken at the feeding of I- and II-group saithe before the migration took place.

The work was concentrated on following three subjects:

i) Age-length composition of the saithe
ii) Stomach content analyses
iii) Sampling of plankton from the actual area to compare with the diet of the saithe

2. MATERIAL AND METHODS

The saithe used in this work were fished in two important saithe-fishing areas in western Norway, Tælavåg and Brandasund (in this article respectively called area A and area B) (Figure 1). For fishing young saithe the fishermen use purse seines. The saithe in this research were taken with purse seine (1 June only) or handline from the beginning of June to the end of September 1982. To look at the feeding of the saithe in the winter a sample was taken 1 March 1983.

The stomach contents of all or maximum 20 fish in each 5 cm length-group were analysed. The same fish were further used for age-length and sex composition studies. The total length of all the saithe in the catch was measured. Within two hours after the saithe had been fished, the stomachs were fixed and preserved in 4% formalin (40% formaldehyde in sea water). Stomach contents from each of a total of 328 saithe were analysed separately, but the results have been summed and presented for each 5 cm length-group of the predator.

The weight of the total stomach content was found (total wet weight). All fish prey and other larger prey organisms were sorted out, weighed and subtracted from the total. Left now was a more homogeneous content, from which a subsample was taken . The size of the subsample was determined after how diverse the content looked out to be, generally about 25% of the homogeneous content. The weights of the prey organisms are all fresh weights. These weights were partly taken from the litterature (Bogorov 1959) and partly from the present study. Weights of all fish prey were based on fish in its actual condition in the stomachs. By using these individual weights, the weight-sum of the content gave an <u>estimated</u> total wet weight. Relative amounts of

different prey categories are in the text referred to this estimated weight.

Fragments of animals were excluded in the countings except in the cases where it was possible to find out from what and how many individuals these fragments originated. Fragments of algae have been recorded as 'detected in the stomach' (number=1) or 'not detected' (number=0).

All nemetodes and trematodes found were undamaged by digestion, and have therefore been regarded only as gastric parasites. Nematodes have been excluded in all calculations of food composition. Trematodes have been included in the total weight of the stomach content because these parasites were too small to be properly sorted out before weighing.

The composition of the diet has been presented both in numbers and by weight. For some essential prey types there have also been calculated values for the "frequency of occurrence" (%F). For handling and analysis of all the stomach content data, computer programs have been used (Westgård 1982). In order to show differences between length-groups of saithe in feeding on a certain prey, a nonparametric and blocked Mann-Whitney test was used (Lehmann 1975). To compare the filling of the stomachs (total wet weight) in different predator length-groups, an ordinary Mann-Whitney test was used (Zar 1974).

Sampling of zooplankton was done on most stations. All the samples were taken in broken vertical hauls with a Juday-net (diameter 36 cm, mesh size 0.18 mm) from the depth interval where the saithe were staying.

3. RESULTS

3.1 Age-length composition of the saithe

In area A almost all the saithe were two years old, and mainly 30-34 cm throughout the sampling period in 1982 (Figure 2). In March 1983 the same yearclass dominated (now three years old), but some two years old saithe now began to appear. One year old fish never occurred in the catches from this area.

In area B the age-length composition was more variable (Figure 3). The catches contained at times much one year old fish (A maximum in July of about 56 percent). This may have to do with fishing closer to the shore than in area A. All over the sampling period two years old fish dominated this area, too.

Figure 4 shows that there was very little growth of the saithe in both areas during the sampling period. In area A the mean length of the 1980-yearclass (two-year-old) increased by 3.1 cm from 1 June 1982 until 1 March 1983. In area B the mean length of the same yearclass

only showed an increase of about 1.3 cm during three and a half months.

3.2 Stomach filling

Only 0.6 percent of the stomachs were empty. Fishes who had regurgitated were not observed in the current study.

There was no significant difference in the amount of food in the stomachs analysed from the major length-groups. The total wet weight of the stomach content was therefore used as a measure of stomach filling (Figure 5).

The majority of the samples in area A showed that the largest saithe had most food in their stomachs, but there were no statistically significant differences between the length-groups. Figure 5 shows that the variation within one length-group at time was great.

Nor in area B a clear relation between the amount of food in the stomachs and the length of the fish was observed. In the only sample taken in the morning (24 September) there was remarkably less food in the stomachs.

The stomach content expressed as gram food per kilo saithe was not significantly related to the predator length. Mean weight of the prey organisms generally increased with increase in length of the saithe (Table 1).

By summing the weights of all prey organisms counted in one stomach, an estimated total weight of the stomach content was found. This estimated total weight was less than the observed total weight of the content before the analysis. Fragments of organisms, which were not taken into consideration, digestion fluids, and gastric parasites are possible reasons for this difference. Table 2 may therefore give a picture of the degree of digestion of the stomach content. The time lapse from catching to fixation was approximately constant from sampling to sampling.

3.3 A general view upon the food found in the saithe stomachs

This view is based on the contribution by weight of different prey to the nutrition.

Figure 6 shows that the diet of the saithe in area A at most sampled times was dominated by a certain prey group, regardless of the size of the predator. In this area the saithe were almost exclusively feeding upon pelagic prey. The complete sampling period in area A showed the following most important prey categories:

	Weight %	Number %
Fish prey	31.8	0.0014
Oikopleura spp.	28.5	79.9
Krill	13.9	2.1
Calanus finmarchicus	9.3	9.6
Chaetognatha	5.7	3.0

In weight the most important fish species preyed upon were cod, Gadus morhua, and horse-mackerel, Trachurus trachurus. In numbers postlarvae of sand lances, fam. Ammodytidae , herring, Clupea harengus, and mackerel, Scomber scombrus dominated. Thysanoessa inermis was the most important krill species, and Sagitta elegans was the only occurring chaetognath.

In area B there were greater differences between length-groups with regard to what the saithe fed upon (Figure 7). In this area prey items belonging to epifauna and hyperbenthos were found in the stomachs. Of such prey the isopod Idotea neglecta was the only species found in the first samples, later on different species of amphipods occurred. It is reasonable to believe that the saithe used different strategies to catch either true pelagic prey or prey attached to algae or living near or on the bottom. Nevertheless, it was not unusual to detect both pelagic species and epifauna in the same stomach.

The complete sampling period in area B showed the following most important prey categories:

	Weight %	Number %
Calanus finmarchicus	35.5	56.5
Fish prey	28.1	0.2
Epifauna/hyperbenthos	9.2	1.2
Krill	7.0	4.9
Oikopleura spp.	5.1	22.1

Cod, and other not specified gadoids, were in weight the most important fish prey. In numbers herring and sand lances were the most frequent occurring fish species preyed upon. Thysanoessa inermis was also here the most important krill species.

3.4 Absolute and relative quantity of the most important prey organisms in the saithe stomachs

3.4.1 Calanus finmarchicus (Gunn.)

AREA A (Table 3 and Figure 8)

Calanus finmarchicus was the most important prey for the saithe in the samples taken in the beginning of June, almost 87 percent of the total amount nutrition (by weight). Already at the end of this month the importance of C.finmarchicus was reduced remarkably. Not before the end of August the amount of C.finmarchicus in the stomach content

increased again, but only to a level of about 30 % of the amount at 1 June. During autumn and winter C.finmarchicus seemed to have played a minor part of the saithe nutrition.

Taking the total sampling period into account there was a significant difference between length-group 30-34 cm and 35-39 cm with regard to how many C.finmarchicus the saithe in these length-groups had preyed. Generally the smallest fish had preyed the greatest number.

The mean weight of the saithe in length-group 30-34 cm and 35-39 cm was respectively 0.30 kg and 0.38 kg ($W=0.0085.L^3$, where W is in grams and L in cm). Based on this, milligram C.finmarchicus per kilo saithe in l.group 35-39 cm amounted to about 40 percent of milligram C.finmarchicus per kilo saithe in l.group 30-34 cm.

AREA B (Table 3 and Figure 8)

In area B Calanus finmarchicus seemed to be the most important food organism during a longer period than in the other area: from the beginning of June and until the end of August. The sampling in September showed a remarkably decrease in the amount of C.finmarchicus as food for the saithe.

Table 4 shows how uniform the preying upon C.finmarchicus was in both areas, or by other words in how many percent of all the saithe stomachs this copepod occurred (frequency of occurrence). C.finmarchicus seemed to be at least as frequent occurring in the diet in area A as in area B. Comparison of the two areas over the same time (excluding 1 March in area A) showed however that the amount of this copepod per predator for length-group 30-34 cm and 35-39 cm in area A respectively was by weight 53 percent and 75 percent of the amount in the corresponding l.groups in area B.

Also in area B the smallest saithe preyed significantly most upon this copepod . The mean weight of saithe in l.group 25-29 cm, 30-34 cm, and 35-39 cm in area B was 0.18 kg, 0.30 kg, and 0.38 kg respectively. Milligram C.finmarchicus per kilo saithe in l.group 35-39 cm was 34 and 12 percent of the amount in l.group 30-34 cm and 25-29 cm respectively.

Figure 8 shows a very low percentage of C.finmarchicus in 35-39 cm saithe taken in July. Two out of elleven fish had preyed upon cod, and these two fishes were the cause for this low percentage. Cod contributed to the group with as much as 86 percent, by weight.

The mean size of the copepods seemed to be largest in the stomachs of the largest fish. In area A the difference between copepods preyed by 30-34 cm and 35-39 cm saithe was only 0.04 milligram, in area B the difference between copepods preyed by 25-29 cm and 35-39 cm saithe was 0.11 milligram (the length of the copepods was found and the length-weight relationship found by Bogorov (1959) was used).

3.4.2 Oikopleura spp.

It is very difficult to identify different species belonging to this genus, especially in the stomach content. Nevertheless, the dominating species in both areas during the entire sampling period was Oikopleura dioica.

AREA A (Table 6 and Figure 9)

The amount of Oikopleura spp. in the saithe diet was characterized by two distinct modes, the first at the end of July and the second and largest at the end of September. The diet of the saithe in winter (March) did not contain Oikopleura spp. at all. When these appendicularian were present in the plankton, a great deal of the saithe utilized this food source (Table 5).

The differences between the two length-groups with regard to the amount of Oikopleura spp. in the diet were small but although statistically significant (common levels of significance). Milligram per kilo saithe in 1.group 30-34 cm was as a mean about 94 percent of the amount per kilo saithe in 1.group 35-39 cm.

AREA B (Table 6 and Figure 9)

In this area Oikopleura spp. was the most important food item for the saithe in samples taken at the end of September. These organisms did not seem to be that important in this area compared to area A. In September Oikopleura spp. made up only about 15 percent by weight of the total amount nutrition. Milligram per kilo saithe in 1.group 30-34 cm and 35-39 cm made up only 13 and 9 percent respectively of the amount for the corresponding length-groups in area A.

There were small differences between the length-groups with regard to the number and weight of Oikopleura spp.. In the diet, it also varied what length-group had preyed the most.

Table 5 shows how frequent specimens of this genus occurred in the stomachs.

3.4.3 Euphausiacea - Krill

AREA A (Table 7 and Figure 10)

During summer and autumn the saithe preyed upon the furcilia stages of the krill. The amounts were small, the highest absolute and relative values were found at the end of June and July.

In winter however, krill seemed to be the most important prey. In

samples taken in March krill made up about 70 percent of the estimated total weight of the stomach content. Almost all the krill were adults. Thysanoessa inermis was the most frequently occurring species. In March saithe in l.group 35-39 cm preyed more krill than did saithe in l.group 30-34 cm. During the sampling period the size of the krill found in the stomach content varied (inserted table in Figure 10).

AREA B (Table 7)

During the sampling period only in June krill was an important component in the saithe diet. The saithe had preyed both upon furcilia and adult stages. In June krill seemed to be most important as food for the largest saithe, both numerically and by weight.

3.4.4 Epifauna and hyperbenthos

Some isopods and amphipods are living on or just above the bottom, or attached to different algae. Only isopods of the genus Idotea were found in the saithe diet, and all species of this genus were because of their mode of living placed in this fauna group. All the amphipods found, except Parathemisto abyssorum, did also belong to this kind of animals.

AREA A (Table 8)

The saithe in this area seemed to prey very little upon epifauna/hyperbenthos, almost nothing at all. Only at the beginning of June such prey made up more than 1 percent of the estimated total weight.

AREA B (Table 8 and Figure 11)

As a contrast to the other area epifauna/hyperbenthos played an important role as food for the saithe in this area. From the beginning of July and during the entire sampling period the saithe preyed upon these organisms. Isopods and amphipods dominated this faunagroup at different times. In July the isopod Idotea neglecta was the most common species. In August and September four to five genera of amphipods were dominating. The most important genera were Jassa, Caprella, Parajassa, and Gammarellus.

There was no clear relationship between the size of the saithe and the amount of epifauna/hyperbenthos in the diet. However, in September the largest saithe seemed to have fed most upon such prey.

3.4.5 Teleostei - Fish (larvae and yearlings)

AREA A (Table 9 and Figure 12)

Especially at the end of June and August fish prey made up a great part of the saithe nutrition. In August, however, the fish prey was not evenly distributed among the saithe. Fewer saithe had preyed upon fish than in most of the other sample periods (Table 10), but the fish prey consisted of rather big yearlings of horse-mackerel (Trachurus trachurus) which contributed quite a lot to the total amount by weight. From Figure 12 it seems as if the smallest saithe (l.group 30-34 cm) preyed most upon fish in June, but the stomach content of one saithe in l.group 40-44 cm (not presented in the figure) almost exclusively contained sand lances (fam. Ammodytidae).

Figure 12 shows that there were differences between the length-groups at times, but it only shows the absolute and relative amounts. Because of a relative great variance of the size of the fish prey, the number of fish per saithe did not seem to differ that much between the length-groups (Table 9). A Mann-Whitney test was performed to show eventual differences in the number of fish prey per saithe with regard to predator length. The results from all the samples combined showed no significant differences.

AREA B (Table 9 and Figure 12)

In July and September different fish species were quite frequent in the diet. Only three saithe were available in August and the data is too little to base any general conclusions . From July onwards as in area A, it seems to be more common among the largest saithe to feed on fish prey (Table 10).

::::::::::::::::::::::::::::::::::::

Different species made up the fish prey at different times. Table 11 shows what species and how many fish the saithe as a mean preyed upon. The most common fish larvae and yearlings found in the diet were:

HERRING. In area A larvae of herring (Clupea harengus) (16-22 mm) were found in the saithe diet in July. In area B a few small ones were found in July too, but in September a greater amount appeared in the diet (about 20 mm).

COD. Yearlings of cod (Gadus morhua) (up to above 70 mm) were never numerous in the diet, but because of their size, they made up an important part of the stomach contents in June and July. The saithe had also preyed upon yearlings of other gadoids.

HORSE-MACKEREL. Yearlings of horse-mackerel (Trachurus trachurus) did not appear in the diet until August and September. Because of their relative great size (up to 75 mm), they contributed quite a lot to the diet.

SAND LANCES. Species of the family Ammodytidae seemed to be popular food for the saithe. In area A several saithe had preyed upon sand lances in June (up to 65 mm) and in March (up to 35 mm). In area B there were most sand lances (22-29 mm) per saithe in September, but here the sand lances were very unevenly distributed among the predators.

DRAGONET. Small larvae (up to 7 mm) of dragonet (Callionymus sp.) were found regulary in the stomach content in September in both areas.

MACKEREL. At the end of June and in July larvae of mackerel (Scomber scombrus), 5 to 13 mm, were common in the saithe diet.

3.4.6 Other prey

Euchaeta norvegica, a carnivore copepod, was found throughout the entire sampling period in the stomachs of saithe in area A. The greatest amounts were found in June, up to 15 percent of the estimated total weight (Table 12). In area B this copepod also occurred in greatest amounts in June (Table 12).

Metridia longa, another copepod, made up a small part of the diet in area A except in September. The greatest amounts of M.longa were found in March (Table 13). In area B there were greater variances in the occurrence of this copepod in the diet, but the greatest amounts were found in June/July.

Parathemisto abyssorum, the most frequent found amphipod in the saithe diet, seemed to be most important for the saithe in autumn and winter. The sampling in September in both areas, and in March in area A, indicated this (Table 14).

Sagitta elegans, the only occurring chaetognath in the saithe stomachs. This prey item was more frequently observed in the diet in September than in other sampling periods in both areas (Table 15).

Larvae of crabs are difficult to identify especially the different zoea stages. The megalopa stages contain more characteristics, and this made it possible to identify these stages of at least Hyas araneus and Cancer pagurus. H.araneus only occurred in the saithe stomachs in June and July. The great importance of crab larvae as food for the saithe was in September, and especially in area B. In area A crab larvae at this time made up about 3 percent of estimated total weight, in area B up to above 30 percent (Table 16).

Other decapoda larvae did also occur in the saithe diet. In area A only in June and July, in area B during the entire sampling period. This prey cosisted of larvae of different shrimps (Caridea), hermit crabs (fam. Paguridae), and squat lobsters (Munida spp. and Galathea spp.). In area A specimens of the genus Munida were in greatest amounts. In area B there was a greater mixture of different decapoda

larvae in the diet.

Clione limacina, a carnivore pteropod, was found in the stomach content only in area A. This species seem to occurr only in autumn and in winter, it was only identified in the diet in September and in March. The largest fish seemed to prey most upon C.limacina, in September up to 2.6 percent of estimated total weight.

Spiratella(=Limacina) retroversa, a herbivore pteropod, was in area A found in the diet of samples taken from the end of June and until the end of September. The greatest amount was found in July and made up to 2.4 percent of estimated total weight (Table 17). In area B scattered registrations of S.retroversa in the diet of saithe were done, during the entire sampling period. However, the amounts were never as great as in the other area.

Of other apparently minor important prey the following can be mentioned:

Fragments of algae, especially of the red algae Ceramium rubrum.

Hydroids. Polyps, especially Obelia sp., were occasionally found in the saithe diet in area B.

The sea gooseberry Pleurobrachia pileus was encountered in the diet from September onwards. The largest fish had preyed most upon P.pileus (up to a number of 16 per saithe in area B), and the larger the saithe were the more common it also was for them to prey upon sea gooseberries.

The holoplanktonic polychaete Tomopteris helgolandica was not found in the diet of saithe taken before September, as in the case of P.pileus. In area A up to a number of 4.7 per saithe.

The cladoceran Evadne nordmanni occurred in the diet in a very small numbers in June and July.

The copepods Calanus hyperboreus, Pseudocalanus elongatus (including some Paracalanus parvus because of difficulties in distinguishing these species), Metridia lucens, Centropages typicus, C.hamatus, and Temora longicornis made all up a minor part of the diet at certain times. The copepods Candacia armata, Anomalocera patersoni, and Acartia sp. were seldom species in the saithe diet.

3.5 Sampling of plankton for comparison with the diet of the saithe

The results from the sampling of zooplankton are shown in Table 18. In area A samples of zooplankton were taken regulary, in area B only in connection with the sampling of saithe in June.

As a summary or conclusion of the observations the following can be

said:

Nauplii of all categories were almost never encountered in the diet. The copepod Microcalanus pusillus was never found in the diet of the saithe. Despite the observation of a great number of Pseudocalanus/Paracalanus in the plankton at certain times, the saithe preyed very little upon these copepods. Acartia sp. was found in relative great numbers in the plankton in July, but only very few specimens were found in the diet. The cyclopoid copepod Oithona similis was a very frequently occurring organism in the plankton. It also occurred in relative great numbers. However, in the saithe nutrition O.similis never occurred. In March nauplii of barnacles seemed to be the most important component of the plankton. In the diet, however, these planktonic larval stages were scarce.

During the entire sampling period 90-100 percent of all Calanus finmarchicus preyed by the saithe were greater than 2.5 mm (total length). In plankton a great number of C.finmarchicus were less than 2.5 mm, especially in June. The relatively large carnivore copepod Euchaeta norvegica, found in small amounts in the diet, did never occur in the plankton samples. Metridia longa, a relatively frequent occurring copepod in the diet, was only identified a couple of times in the plankton. Oikopleura spp., very important prey organisms for the saithe, were either missing or very scarce in the plankton samples. Another appendicularian, Fritillaria borealis, was found in the plankton samples but never in the stomach content. Krill and decapoda larvae were very scarce in the plankton samples, but, nevertheless, the saithe had preyed very often upon these categories.

4. DISCUSSION

The age distribution showed that the length-groups between 30 and 40 cm mainly were dominated by one yearclass (two-year-old saithe). Differences in the diet of saithe within this length interval therefore cannot be explained by different age of the saithe. The stomach content analyses of an opportunistic predator, as it is natural to expect the saithe to be, can easily give apparently significant results but which deviate from the general nutrition of the fish. The saithe were therefore placed in 5 cm length-groups, a finer partition (e.g. 1 cm length-groups) would have demanded a greater number of fish.

In most of the samplings in area A the saithe had mainly concentrated their feeding on one prey category. At the beginning of June Calanus finmarchicus was the most important prey, in July and September Oikopleura spp., and during winter krill (Thysanoessa inermis) seemed to be the most important prey. At the end of June and August there was a greater variation in the diet, fish prey was now an important component. This is in agreement with the observations done by Bertelsen (1942) on the feeding of 0- and I-group saithe in the Faroe

Islands: When a prey organism was at its maximum in the plankton, this prey was the most important food to almost all the saithe.

In area B no single species except Calanus finmarchicus dominated the diet. This is also confirmed by a general higher diversity in the stomach content in this area. Fish prey seemed to be an important food item in July and September. From July on epifauna/hyperbenthos was an important component, and in September, particulary, several species together made up the bulk of the diet.

A most often higher and regular diversity (based on number of prey categories and the number of specimens within each category) in the saithe diet in area B compared with area A, can be a result of lower prey densities in area B (e.g. Charnov 1976, Eggers 1977). The diversity will vary with the degree of digestion of the stomach content, and different digestion rates of different prey may therefore cause a change in the diversity as the digestion proceeds.

At those times when a single species was not dominating the diet, there were greater differences between single saithe in the composition of the diet. In area B the saithe had also grazed on different isopods and amphipods attached to the vegetation on the bottom. Nordgaard (1902) observed the same phenomenon, when there became lack of planktonic food, the saithe had to prey upon different bottom organisms, also hydroids.

Most of the samples showed that the saithe had preyed upon other fish larvae and yearlings. The fish prey did not make up any regular part of the nutrition, but appeared in the diet in greater amounts at certain times. It is difficult to tell whether the saithe prefer fish prey or ordinary planktonic food, but most probably the saithe begin to search for other food (fish prey, epifauna/hyperbenthos) when the offer of plankton (esp. copepods) is poor.

The samples of zooplankton were taken in broken vertical hauls from the depth interval where the saithe were found and taken. This may have lead to an overestimation of the plankton the saithe preferred to prey on. However, nothing from the analysis seemed to support such a possibility. Furthermore, it is not directly correct to compare the entire stomach content with just a spot check of the offer of plankton taken at a certain time. The content in a fish stomach is often a result of feeding over a time period, which is important to take into consideration when looking at selection or preferances in the feeding. Although the results from the sampling of plankton showed a different composition (both qualitative and quantitative) from what was found in the nutrition, nor a plankton sample can give unequivocal estimates of the total plankton composition in the environment. It can only give a good estimate of that part of the plankton spectrum which the gear is able to collect (Wickstead 1976).

It may look conspicious that Euchaeta norvegica never occurred in a plankton sample, and that Metridia longa and Thysanoessa inermis in March, when these species were frequent in the diet, did not appear in the plankton sample. The size of these species made them perhaps

capable of escaping the sampling gear. Oikopleura spp., one of the main components in the saithe diet, just barely appeared in the plankton samples. Oikopleura spp. are known to be very patchily distributed, so it is possible that the sampling gear could have missed the patches. If not there has been a clear preference by the saithe for Oikopleura. Throughout the sampling period the saithe seemed to prefer the oldest and largest stages of Calanus finmarchicus. In June when this copepod was at its maximum in the plankton, nauplii and specimens less than 2.5 mm were dominating. Nevertheless, the saithe had mainly preyed upon specimens greater than 2.5 mm. Lie (1961) showed that already 0-group saithe preferred larger copepods rather than smaller species as Paracalanus parvus, Temora longicornis, Acartia spp. or Oithona similis.

In area B a relative great number of one year old saithe was in the samples. An explanation for this can be that the samples in this area were taken a bit closer to the shore. In this area a remarkable thing happened at the end of July and lasted throughout August. Almost all the saithe disappeared from the shallows for in the end of August/beginning of September to return. Back on the shallows, only mackerel were left. This might be a possible explanation why only three saithe were sampled in August in this area. Fishermen fishing for mackerel with their drifting nets in the open sea caught a lot of saithe. Reports from the east coast of USA (e.g. Grosslein, Langton & Sissenwine 1980) showed a relative great overlap in the diet between saithe and mackerel. A few mackerel stomachs analysed from both area A and B indicated a similar overlap. In area A, at the same time, saithe and mackerel were both present. Competition with mackerel may therefore be an uncertain explanation for this short time migration.

Marking experiments done by Jakobsen (1978a) in the 1970s did not indicate any direct connection between year class strength and time for the migration of saithe away from the coast. Nevertheless, this research indicated that a possible explanation of the migration of commercial sized (above 32 cm) saithe away from the coast might be an intraspecific competition from younger saithe migrating outwards to the shallows. A lot of one year old saithe appeared in the investigated area a couple of weeks before the migration of older saithe. In area A in 1983 (the year after the observed migration in area B) fishermen observed at the same time of the year a lot of one year old saithe in the shallow waters after the disappearance of the older fish.

Age-length samples of saithe in the North Sea show that the 2 year old saithe to reach the size of a 3 year old, had a mean growth of about 10 cm (Anon. 1983). The length distribution of saithe in sampling area A and B showed no corresponding growth during the sampling period, and this may therefore be taken as an indication of a gradual migration away from the coast of the largest fish in the yearclass during summer and autumn.

It is difficult to generalize an observed behaviour during some sampling months and to say what reliable picture it will give for all time periods. Nevertheless, based on the data from area A it seems

right to say that the greatest part of the saithe disappear from the shallow waters during the spring as three-year-old saithe. This observation is in agreement with marking results and age samples from trawl catches in the North Sea (Jakobsen 1978a).

In March the saithe gave clear impressions of starvation. By starvation the cod liver becomes small and reddish, and loss of fat causes the red colour (Love 1980). The gall bladder increases in volume and the colour of the gall becomes darker. All these starvation symptoms were present in the saithe. Larvae of the gastric parasite Anisakis simplex were found in great amounts in the tiny liver and in arêas between the liver and stomach. An earlier larval stage of this nematode has been identified in krill (Berland pers.comm.), krill was the main food for the saithe at this time.

If the starvation is occurring yearly it may be an explanation of the main migration of saithe away from the coast sometimes between March and June . In June there were very few three-year-old saithe left in the coastal shallow waters. Marking experiments with saithe at Sunnmøre (just north of 62° N) in November- December 1974 (Jakobsen 1978b) showed an extensive migration of young saithe (35-40 cm, 3-4 years) to the North Sea during spring (May-June) the year after.

While looking for reasons for the migration of saithe to the North Sea, it may be useful to take a look at the saithe food habits there. Table 19 shows that fish and krill made up the main part of the diet. Norway pout, haddock, and sand lances seem in the mentioned order to be the most important species. Sand lances which were the most important fish prey for the saithe in the shallow waters in area A and B, also seem to be an important food for the smallest saithe in the North Sea. The importance of sand lances seems to decrease with increasing length of the saithe. Norway pout, a very important fish prey in the North Sea, only occurred in one saithe taken in the shallow waters close to the shore (25 June in area A).

The special situation in March: Saithe feeding mainly on adult krill, and clear evidence of starvation, may be contributory reasons for the main migration of saithe away from the coast. Table 19 shows that saithe above 40 cm are feeding mostly upon krill. This is mainly three-year-old saithe, saithe of the same age which were observed to feed much upon krill in area A in March before leaving the coast. In the North Sea, krill seem to play the most important nutrititative role for the saithe during winter and spring (Table 19).

Observations have shown that krill disappear from the fjord systems in February-March (J.B.L. Matthews pers.comm.). It is uncertain how far and in what direction the krill leave the coast, but great amounts of krill have been observed in the Norwegian Channel in June (though it has been impossible to say anything about the origin of this krill). From June and throughout the sampling period that year, adult krill were virtually never found in the saithe diet. Although the plankton net did not seem to be able to sample adult krill, it is reasonable to believe that the adult krill had left the area once between 1 March and 1 June.

An explanation of the great migration of saithe away from the coast during spring (after 1 March but before 1 June) can therefore be the distribution of krill. If the krill are transported away from the coast, the saithe probably follow similar migration pattern.

5. REFERENCES

Anon. 1982. Report of the meeting of the coordinators of the North Sea stomach sampling project 1981. Coun. Meet. int. Coun. Explor. Sea, 1982 (G:33): 1-39. [Mimeo.]

Anon. 1983. Report of the Saithe (Coalfish) Working Group. Coun. Meet. int. Coun. Explor. Sea, 1983 (Assess:16): 1-112. [Mimeo.]

Anon. 1985. Report of the Saithe (Coalfish) Working Group. Coun. Meet. int. Coun. Explor. Sea, 1985 (Assess:18): 1-119. [Mimeo.]

Bertelsen, E. 1942. Contributions to the biology of the coalfish (Gadus virens L.) in Faroe waters. Medd. Komm. Danm. Fiskeri og Havunders. Ser. Fiskeri, 11(2): 1-69.

Bogorov, B.G. 1959. On the standardisation of marine plankton investigations. Int. Revue ges. Hydrobiol. u. Hydrographie, 44: 621-642.

Charnov, E.L. 1976. Optimal foraging; the marginal value theorem. Theoretical Population Biology, 9: 129-136.

Eggers, D.M. 1977. The nature of prey selection by planktivorous fish. Ecology, 58: 46-59.

Gislason, H. 1983. A preliminary estimate of the yearly intake of fish by Saithe in the North Sea. Coun. Meet. int. Coun. Explor. Sea, 1983 (G:52): 1-10, 12 tab., 3 fig. [Mimeo.]

Golubjatnikova, I.P. & Malyshev, V.I. 1980. Growth and feeding of the North Sea saithe Pollachius virens (L.). Study in the Atlantic biological resources. Trudy AtlantNIRO, 1980: 74-80. [In Russian].

Grosslein, M.D., Langton, R.W. & Sissenwine, M.P. 1980. Recent fluctuations in pelagic fish stocks of the northwest Atlantic, Georges Bank region, in relation to species interactions. Rapp. P.-v. Reun. Cons. int. Explor. Mer, 177: 374-404.

Jakobsen, T. 1978a. Saithe tagging experiments on the Norwegian west coast south of 62°N, 1972-1974. Fisken Hav., 1978(3): 15-30.

——— 1978b. Saithe tagging experiments on the Norwegian coast at 62°30'N in November - December 1974. Fisken Hav., 1978(3): 57-68.

——— 1981. Preliminary results of saithe tagging experiments on the Norwegian coast 1975-77. Coun. Meet. int. Coun. Explor. Sea, 1981 (G:35): 1-6, 1 tab., 18 fig. [Mimeo.]

Lehmann, E.L. 1975. Nonparametrics: Statistical methods based on ranks. Holden-Day, inc., San Francisco. 457 pp.

Lie, U. 1961. On the growth and food of 0-group coalfish, Pollachius virens (L.), in Norwegian waters. Sarsia, 3: 1-36.

——— 1962. Om seiens ernæring. Fisken Hav., 1962(3): 6-9.

Love, R.M. 1980. The chemical biology of fishes, 2. Academic Press, London. 943 pp.

Nordgaard, O. 1902. Oplysninger om seiens vekst og aate. Bergens Mus. Aarb., 1901(3): 1-21.

Westgård, T. 1982. Programs for handling and analysis of stomach contents data. Coun. Meet. int. Coun. Explor. Sea, 1982 (H:21): 1-43. [Mimeo.]

Wickstead, J.H. 1976. Marine zooplankton. Studies in biology, 62. Edward Arnold (Publishers) Ltd., London. 60 pp.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J. 620 pp.

Table 1. Mean weight (mg) per prey organism for each lengthgroup (a=25-29 cm - d=40-44 cm) and main prey at each sampling.

Date	a	b	c	d	Mean	Main prey
Area A						
1.6		1.35	1.37		1.36	Calanus finmarchicus
25.6		10.63	2.91	19.96	11.17	Fish(cod & sand lances)
29.7		0.75	0.89	0.66	0.77	Oikopleura sp.
31.8	0.62	1.33	8.00		3.32	Oikopleura, C.finmarch., Fish (horsemackerel)
30.9		0.66	0.74		0.70	Oikopleura sp.
1.3		6.87	9.33	10.76	8.99	Krill
Mean	0.62	3.60	3.87	10.46		
Area B						
10.6		1.52	2.31	4.17	2.67	C.finmarchicus, krill
8.7	1.68	1.67	9.67		4.34	C.finm., fish (gadoids)
23.8	1.34	2.17			1.76	C.finm., hyperbenthos
23.9	1.00	2.35	2.31		1.89	Oikopl., fish (whiting, sand lances, horsemack.)
24.9		1.63	1.81		1.72	Brachyura, P.abyssorum, Oikopleura sp.
Mean	1.34	1.87	4.03	4.17		

Table 2. Estimated total weight (sum of all analysed organisms) as percent of the total weight of the complete stomach content before the analysis.

Date	Time (local)	a	b	c	d
Area A					
1.6	1800 - 2000		45	51	
25.6	1800 - 1900		64	41	63
29.7	1830 - 2000		47	51	46
31.8	1800 - 1900	77	61	94	
30.9	1500 - 1530		46	45	
1.3	1400 - 1445		59	69	39
Area B					
10.6	2000 - 2200		53	42	36
8.7	2000 - 2210	54	49	70	
23.8	2000 - 2200	62	60		
23.9	2000 - 2030	42	53	50	
24.9	0815 - 0845		35	26	

Table 3. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet. + : less than 0.1.

PREY: Calanus finmarchicus (Gunn.)

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 –44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	522.9	87.5	390	88.2	3	567.6	86.4	391	81.8					
25.6						19	22.6	0.9	15	6.7	10	69.6	11.9	47	23.4	1	24.0	0.9	20	14.4
29.7						20	53.7	6.0	40	3.3	19	77.3	7.6	57	5.0	1	10.5	1.8	7	0.8
31.8	1	74.0	27.9	55	12.8	20	178.0	53.4	131	52.1	15	130.4	8.1	95	47.3					
30.9						21	48.7	3.0	35	1.4	20	40.1	2.2	30	1.2					
1.3						7	28.1	3.3	20	16.1	20	10.7	0.7	7	4.7	6	1.5	0.2	1	1.5
B																				
10.6						19	762.4	68.0	546	73.8	7	365.7	47.9	252	76.1	3	+	+	0	0
8.7	19	592.6	61.9	439	77.2	19	265.4	52.0	209	68.3	11	145.1	7.2	110	52.7					
23.8	1	770.0	90.5	576	90.4	2	316.0	45.9	236	74.3										
23.9	3	15.3	9.1	12	6.9	13	14.0	1.7	11	3.0	4	13.5	0.9	10	1.6					
24.9						14	0.7	0.4	0.6	0.5	10	0.4	0.2	0.3	0.3					

Table 4. Percentage of all saithe at each sampling that had preyed upon Calanus finmarchicus (%F).

Area A:	Date	1.6	25.6	29.7	31.8	30.9	1.3
	%	100	87	78	94	76	58

Area B:	Date	10.6	8.7	23.8	23.9	24.9
	%	86	98	67	60	33

Table 5. Percentage of all saithe at each sampling that had preyed upon Oikopleura spp. (%F).

Area A: Date	1.6	25.6	29.7	31.8	30.9	1.3
%	64	100	98	89	100	0

Area B: Date	10.6	8.7	23.8	23.9	24.9
%	72	96	100	90	71

Table 6. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Oikopleura spp.

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	12.0	2.0	24.0	5.4	3	35.0	5.3	70.3	14.7					
25.6						19	61.3	2.5	122.6	53.8	10	47.2	8.0	94,4	46.8	1	18.0	0.6	36.0	25.9
29.7						20	520.0	58.4	1037.1	87.4	19	497.7	48.8	995.4	86,8	1	398.5	69.2	797.0	91.9
31.8	1	185.5	70.0	371.0	86.5	20	56.5	17.0	113.1	45.0	15	47.6	3.0	95.3	47,4					
30.9						21	1128.5	68.9	2260.1	91.4	20	1140.0	61,8	2282.2	91.8					
1.3						7	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0	6				
B																				
10.6						19	33.3	3.0	66.6	9.0	7	11.2	1.5	22.4	6.8	3	16.6	2.2	33.3	18.1
8.7	19	13.7	1.4	27.4	4.8	19	26.4	5.2	52.9	17.3	11	31.2	1.5	62.4	30.0					
23.8	1	0.0	0.0	0.0	0.0	2	16.0	2.3	31.5	9.9										
23.9	3	62.5	37.2	125.0	74.3	13	125.4	14.8	250.8	69.6	4	223.6	15.4	447,2	71.0					
24.9						14	32.5	16.0	65.1	52,1	10	19.4	10.2	38.8	36,9					

Table 7. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Euphausiacea - KRILL

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	0.3	0.1	0.3	0.1	3	1.6	0.3	1.3	0.3					
25.6						19	99.1	4.1	16.7	7.4	10	39.3	6.7	6.7	3.3	1	51.5	1.9	31.0	22.3
29.7						20	82.5	9.3	29.0	2.4	19	41.6	4.1	13.0	1.1	1	4.0	0.7	2.0	0.2
31.8	1	0.0	0.0	0.0	0.0	20	10.5	3.1	4.3	1.7	15	13.1	0.8	5.0	2.5					
30.9						21	3.2	0.2	0.9	0.0	20	0.9	0.0	0.3	0.0					
1.3						7	558.0	65.9	47.1	38.3	20	1095.8	75.3	89.5	57.4	6	549.0	63.6	53.6	70.9
B																				
10.6						19	128.1	11.4	66.5	9.0	7	325.0	42.6	34.4	10.4	3	591.0	77.1	121.3	65.9
8.7	19	30.3	3.2	19.1	3.4	19	9.2	1.8	4.8	1.6	11	5.6	0.3	3.0	1.4					
23.8	1	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0										
23.9	3	0.0	0.0	0.0	0.0	13	0.9	0.1	0.4	0.1	4	4.5	0.3	1.7	0.3					
24.9						14	1.8	0.9	0.2	0.2	10	1.2	0.6	0.1	0.1					

Table 8. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Epifauna/hyperbenthos.

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	12.6	2.1	0.3	0.1	3	0.0	0.0	0.0	0.0					
25.6						19	0.5	0.0	0.2	0.0	10	0.0	0.0	0.0	0.0	1	0.0	0.0	0.0	0.0
29.7						20	1.5	0.2	0.1	0.0	19	+	+	0.1	0.0	1	0.0	0.0	0.0	0.0
31.8	1	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0	15	1.0	0.1	0.07	0.0					
30.9						21	0.0	0.0	0.0	0.0	20	1.2	0.1	0.2	0.0					
1.3						7	0.8	0.1	0.3	0.2	20	0.3	0.0	0.1	0.1	6	3.0	0.4	0.1	0.2
B																				
10.6						19	0.8	0.1	0.3	0.0	7	1.4	0.2	0.7	0.2	3	3.0	0.4	1.0	0.5
8.7	19	210.5	21.9	5.7	0.9	19	136.6	26.8	5.4	1.8	11	22.0	1.1	3.9	1.7					
23.8	1	30.0	3.6	8.0	1.2	2	342.0	49.7	27.0	8.5										
23.9	3	1.3	0.8	1.0	0.6	13	19.0	2.2	3.3	1.0	4	229.2	15.7	24.7	3.9					
24.9						14	37.8	18.7	8.0	6.5	10	43.3	22.8	9.3	8.9					

Table 9. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Teleostei — fish

L.gr.	25 — 29 cm					30 — 34 cm					35 — 39 cm					40 — 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0					
25.6						19	1949.9	80.4	2.4	0.9	10	196.3	33.4	0.8	0.2	1	2500.0	90.1	4.0	2.9
29.7						20	50.4	5.7	3.7	0.3	19	255.0	25.0	0.5	0.0	1	0.0	0.0	0.0	0.0
31.8	1	0.0	0.0	0.0	0.0	20	82.0	24.6	0.05	0.0	15	1409.3	87.6	0.4	0.2					
30.9						21	9.3	0.6	0.4	0.0	20	241.6	13.1	0.8	0.0					
1.3						7	71.4	8.5	0.8	0.7	20	89.0	6.1	1.1	0.8	6	141.6	17.8	3.3	4.5
B																				
10.6						19	10.2	0.9	0.2	0.0	7	0.0	0.0	0.0	0.0	3	33.3	4.3	0.6	0.4
8.7	19	0.4	0.0	0.1	0.0	19	21.8	4.3	0.2	0.1	11	1775.6	88.1	1.4	0.5					
23.8	1	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0										
23.9	3	0.0	0.0	0.0	0.0	13	442.5	52.3	1.9	0.3	4	606.2	41.5	1.2	0,1					
24.9						14	25.0	12.3	1.0	0.8	10	17.6	9.2	1.0	1,0					

Table 10. Percentage of all saithe in two length-groups (b and c) at each sampling that had preyed upon fish larvae and yearlings (%F). b - 30-34 cm, c - 35-39 cm

Area A:	Date	1.6		25.6		29.7		31.8		30.9		1.3	
	L.gr.	b	c	b	c	b	c	b	c	b	c	b	c
	%	0	0	79	46	50	32	5	20	29	50	43	60

Area B:	Date	10.6		8.7		23.8		23.9		24.9	
	L.gr.	b	c	b	c	b	c	b	c	b	c
	%	21	0	26	70	0	-	42	75	39	40

Table 11. Species composition of the fish that the saithe preyed upon given in number per 100 saithe. Great numbers are underlined.
+ : only small amounts (less than 1% by weight).
a : length-group 25-29 cm -- d : length-group 40-44 cm.

AREA A	1.6				25.6				29.7				31.8				30.9				1.3 -83			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Fish, w%	0	0			81	33		90	6	25		0	0	25		88	1	13			9	6		24
Clupea harengus									270															
Gadus morhua					58	30				11														
Trisopterus esmarkii					5																			
Molva molva										5														
Triglidae, fam.																		15						
Trachurus trachurus														5		47		5						
Ammodytidae, fam.					105			300													71	115		500
Callionymus, fam.																		33		20				
Scomber scombrus					47	40			125	47														
Limanda limanda																		5						
Microstomus kitt																	5	5						
Fish (unspecified)					37	10		100										35			114			

AREA B	10.6				8.7				23.8				23.9				24.9			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Fish, w%		1	+	4	+	4		88	0	0			0	52		41		12		9
Clupea harengus						5												93		80
Gadidae, fam.							20							15					10	
Gadus morhua							60													
Pollachius pollachius							10													
Merlangius merlangus														8						
Gadiculus argenteus														8						
Trachurus trachurus															25					
Pholis gunellus	16																			
Ammodytidae, fam.						5	10							100					10	
Callionymus, fam.														38	25					
Gobiidae, fam.														8	25					
Scomber scombrus					16															
Limanda limanda														8						
Fish (unspecified)		129		67	37	42		130						8	50		7			

Table 12. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet. + : less than 0.1.

PREY: Euchaeta norvegica, Boeck.

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	9.3	1.6	1.5	0.3	3	27.3	4.2	3.7	0.8					
25.6						19	102.6	4.2	17.1	7.5	10	89.8	15.3	13.6	6.7	1	66.0	2.4	10.0	7.2
29.7						20	6.9	0.8	1.2	0.1	19	5.4	0.5	1.1	0.1	1	0.0	0.0	0.0	0.0
31.8	1	0.0	0.0	0.0	0.0	20	2.6	0.8	0.4	0.2	15	2.3	0.1	0.3	0.2					
30.9						21	12.3	0.8	2.0	0.1	20	13.0	0.7	2.4	0.1					
1.3						7	7.3	0.9	1.1	0.9	20	12.5	0.9	1.9	1.2	6	22.3	2.6	2.8	3.7
B																				
10.6						19	100.3	8.9	22.3	3.0	7	13.7	1.8	2.3	0.7	3	48.7	6.3	7.7	4.2
8.7	19	+	+	0.3	0.1	19	+	+	0.1	0.0	11	+	+	0.1	0.0					
23.8	1	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0										
23.9	3	13.3	7.9	2.0	1.2	13	3.5	0.4	0.5	0.1	4	9.5	0.7	1.8	0.3					
24.9						14	0.0	0.0	0.0	0.0	10	0.0	0.0	0.0	0.0					

Table 13. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet. + : less than 0.1.

PREY: Metridia longa (Lubbock).

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	11.1	1.9	7.4	1.7	3	3.5	0.5	2.3	0.5					
25.6						19	17.2	0.7	11.1	4.9	10	3.6	0.6	2.4	1.2	1	+	+	6.0	4.3
29.7						20	6.4	0.7	4.0	0.3	19	4.7	0.5	2.8	0.2	1	42.5	7.4	25.0	2.9
31.8	1	0.0	0.0	0.0	0.0	20	0.3	0.1	0.2	0.1	15	1.1	0.1	0.7	0.3					
30.9						21	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0					
1.3						7	47.7	5.6	28.7	23.3	20	41.3	2.8	24.8	15.9	6	5.7	0.7	3.3	4.4
B																				
10.6						19	18.4	1.6	12.3	1.7	7	0.0	0.0	0.0	0.0	3	0.0	0 0	0.0	0.0
8.7	19	18.2	1.9	11.5	2.0	19	6.9	1.4	4.3	1.4	11	8.9	0.4	5.3	2.5					
23.8	1	0.0	0.0	0.0	0.0	2	+	+	1.0	0.3										
23.9	3	0.0	0.0	0.0	0.0	13	0.0	0.0	0.0	0.0	4	18.6	1.3	12.0	1.9					
24.9						14	0.0	0.0	0.0	0.0	10	0.0	0.0	0.0	0.0					

Table 14. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Parathemisto abyssorum, Boeck

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	3.2	0.5	0.9	0,2	3	0.0	0.0	0.0	0.0					
25.6						19	13.8	0.6	2.7	1.2	10	12.5	2.1	2.5	1.2	1	+	+	1 0	0 7
29.7						20	10.9	1.2	2.8	0.2	19	6.9	0.7	2.0	0.2	1	0,0	0.0	0,0	0.0
31.8	1	0.0	0.0	0.0	0.0	20	0,7	0.2	0.3	0.1	15	2.2	0.1	0.6	0.3					
30.9						21	26.3	1.6	12.0	0.5	20	42.4	2.3	28.2	1.1					
1.3						7	45.5	5.4	2.1	1.7	20	126.4	8.7	4.1	2,6	6	50.0	5.8	3.3	4.4
B																				
10.6						19	26.2	2.3	4.7	0,6	7	24.4	3.2	5.0	1.5	3	73.3	9.6	14.6	8.0
8.7	19	37.5	3.9	11.6	2.1	19	22.3	4.4	7.0	2.3	11	19.0	0.9	5.0	2.4					
23.8	1	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0										
23.9	3	5.0	3.0	1.0	0,6	13	23.1	2.7	4.3	1.2	4	71.2	4.9	11.2	1.8					
24.9						14	33.5	16.4	9.8	7.8	10	24.1	12.7	6.9	6,6					

Table 15. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Sagitta elegans, Verrill

L.gr.	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	+	+	0,16	0.0	3	0.0	0.0	0.0	0.0					
25.6						19	15.3	0.6	5.9	2.6	10	11.4	1.9	4.4	2,2	1	+	+	2.0	1,4
29.7						20	16.1	1.8	6,2	0.5	19	16.1	1.6	6.2	0.5	1	5.0	0.9	2.0	0.2
31.8	1	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0	15	0.0	0.0	0.0	0.0					
30.9						21	270.1	16.5	103.9	4.2	20	217.2	11.8	83.5	3.4					
1.3						7	50.1	5.9	19.3	15.7	20	60.4	4.2	23.2	14.9	6	3.0	0.3	1.1	1.5
B																				
10.6						19	7.1	0.6	2,7	0.4	7	5.9	0.8	2,3	0.7	3	0.0	0.0	0.0	0.0
8.7	19	+	+	0.1	0.0	19	+	+	0.05	0.0	11	0.0	0.0	0.0	0.0					
23.8	1	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0										
23.9	3	21.6	12.9	8.3	5.0	13	30.7	3.6	11.8	3.3	4	78.6	5.4	30.2	4.8					
24.9						14	4,6	2.3	1,8	1,4	10	2.8	1.5	1.1	1.0					

Table 16. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Brachyura (crab larvae)

L.gr.	25 — 29 cm					30 — 34 cm					35 — 39 cm					40 — 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	+	+	0.05	0.0	3	0.0	0.0	0.0	0.0					
25.6						19	2.6	0.1	1.4	0.6	10	0.0	0.0	0.8	0.4	1	0.0	0.0	0.0	0.0
29.7						20	2.1	0.2	1.0	0.1	19	2.6	0.2	0.9	0.0	1	0.0	0.0	0.0	0.0
31.8	1	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0	15	0.0	0.0	0.0	0.0					
30.9						21	48.9	3.0	17.4	0.7	20	47.6	2.6	17.0	0.7					
1.3						7	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0	6	0.0	0.0	0.0	0.0
B																				
10.6						19	5.9	0.5	3.7	0.5	7	+	+	1.0	0.3	3	0.0	0.0	0.0	0.0
8.7	19	1.4	0.2	2.3	0.4	19	3.1	0.6	2.0	0.7	11	1.0	0.0	1.1	0.5					
23.8	1	+	+	2.0	0.3	2	0.0	0.0	0.0	0.0										
23.9	3	5.0	3.0	2.0	1.2	13	89.2	10.6	33.3	9.3	4	62.7	4.3	24.5	3.9					
24.9						14	54.9	26.9	20.1	16.1	10	67.1	35.3	24.5	23.3					

Table 17. The feeding of different length-groups of saithe upon a certain prey.
P - number of saithe stomachs, w/p - absolute weight (mg) of this prey per predator, w% - relative weight of this prey in the diet, n/p - absolute number per predator, n% - relative number in the diet, + : less than 0.1.

PREY: Spiratella (= Limacina) retroversa (Flem.)

L.gr.	25 — 29 cm					30 — 34 cm					35 — 39 cm					40 — 44 cm				
Area, date	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%	P	w/p	w%	n/p	n%
A																				
1.6						19	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0					
25.6						19	+	+	0.4	0.2	10	0.5	0.1	1.0	0.5	1	0.0	0.0	0.0	0.0
29.7						20	11.7	1.3	23.4	2.0	19	24.3	2.4	48.7	4.2	1	0.0	0.0	0.0	0.0
31.8	1	0.0	0.0	0.0	0.0	20	+	+	0.7	0.3	15	+	+	0.6	0.3					
30.9						21	5.0	0.3	10.0	0.4	20	4.3	0.2	8.5	0.3					
1.3						7	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0	6	0.0	0.0	0.0	0.0
B																				
10.6						19	0.0	0.0	0.0	0.0	7	+	+	0.7	0.2	3	0.0	0.0	0.0	0.0
8.7	19	1.3	0.1	2.6	0.5	19	1.3	0.3	2.6	0.8	11	+	+	0.5	0.2					
23.8	1	0.0	0.0	0.0	0.0	2	+	+	2.5	0.8										
23.9	3	0.0	0.0	0.0	0.0	13	+	+	1.4	0.4	4	0.0	0.0	0.0	0.0					
24.9						14	1.8	0.9	3.8	3.0	10	1.2	0.6	2.3	2.2					

Table 18. Results from the sampling of zooplankton. Percentage based on number. Dominating species or categories are underlined. + : less than 1 %.

Area and date 1982-1983	A 1.6-82	A 2.6	B 10.6	A 25.6	A 29.7	A 31.8	A 30.9	A 1.3-83
Time (local)	2300	0500	2200	1900	2000	1900	1545	1445
Depth (fathoms)	16-2	16-2	20-10	16-3	10-0	18-0	12-8	15-0
Copepoda, nauplii		34.4	4.7	1.7	1.2	4.2	3.8	4.9
Nauplii (unspecified)	11.8	+						
C.finmarchicus < 2.5mm	48.2	31.4	5.6	18.0	4.8	6.7	7.9	3.1
⩾ 2.5mm	7.2	1.8	7.0	16.2	8.0	7.0	7.9	15.8
Microcalanus pusillus			1.4	1.5	+	2.9	2.0	+
Pseudocal./Paracalanus	3.0	2.2	14.1	9.1	4.5	35.8	37.5	4.2
Metridia longa	+			+	+			
Centropages hamatus							+	
C.typicus			+			1.9	+	
Temora longicornis	1.2	1.4	3.8	3.8	+	+	+	1.4
Acartia sp.		+	+	2.3	24.0	2.2	+	1.2
Oithona similis	8.8	6.3	30.3	41.5	54.7	35.8	35.3	6.8
O.atlantica			+	+	+			
Harpacticoida				+	+			
Evadne nordmanni	+	+	12.1					
Barnacles, nauplii		1.8	+	+		+		56.2
, cypris			8.0	+				
Gnathia sp.			+					
Amphipoda				+	+			
Krill, egg	+	4.1	+					4.2
, nauplii		1.4	+	+	+			
Thysanoessa sp.	+	+	+	+				
Paguridae (zoea)			+					+
Hydromedusae	+	+	+	+			+	
Gastropoda & Bivalvia				+	+	+		
Spiratella retroversa		+					+	
Polychaeta(trocophora)	+	+	+					
Bryozoa(cyphonautes)				1.5	+	2.2	1.8	+
Asteroidea(brachiol.)	+	+	+					
Ophiuroidea(pluteus)	2.8	3.5				+		
Echinoidea(pluteus)		+						
Sagitta elegans	+		+	+			+	+
Oikopleura sp.	+		2.6	+	+		+	
Fritillaria borealis	14.9	13.6	2.7					+
Fish, egg					+			
Gadus morhua (2.4mm)		1 spec						

Table 19. Feeding of saithe in the North Sea. Russian data (Golubjatnikova & Malyshev 1980) and data from international researches in the North Sea, ICES (Gislason 1983). The results are given in relative weights (w%). s-summer, a-autumn, w-winter, sp-spring.

Data source	Russian data 1974-77				ICES-report 1983 1980-82		
Length-group (cm)	31-50				30-39	40-49	50-69
Area	N of $59^0 30'$		S of $59^0 30'$		Different areas		
Time of the year	s-a	w-sp	s-a	w-sp	Mean of the year		
Haddock	0.8		4.5		34.5	5.9	7.4
Sprat		0.3	3.3		0.2	3.5	
Sand lances	6.1	0.1	0.8		40.7	2.2	0.5
Norway pout	46.0	63.8	17.8	30.7	6.8	33.1	31.9
Blue whiting	10.8						0.1
Maurolicus sp.					1.4	5.3	19.1
Krill	16.2	35.8	67.0	69.3	9.5	44.5	37.3
Other prey	20.1	0.0	6.6	0.0	6.9	5.5	3.7

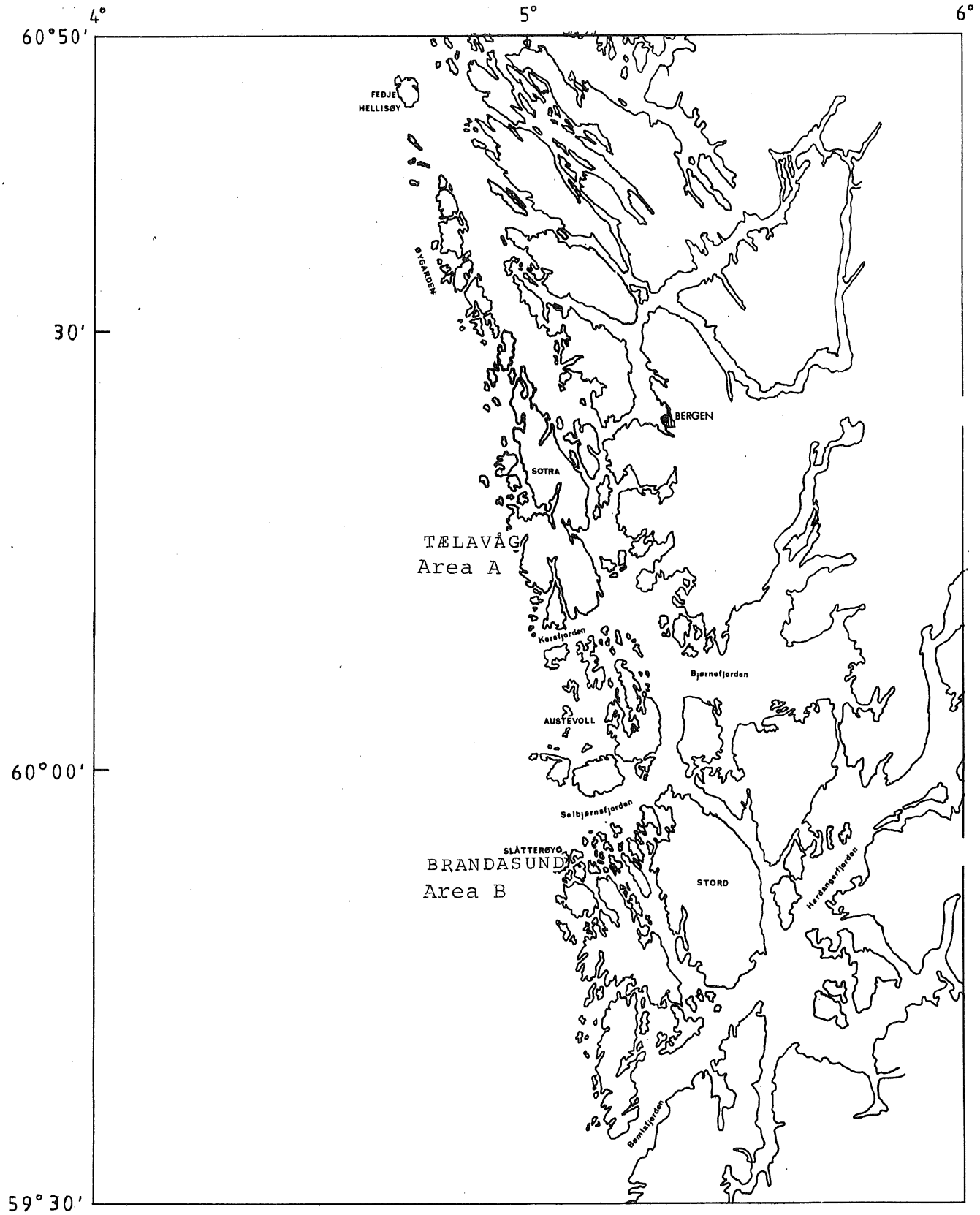

Figure 1. Part of the coast and the outer areas of Hordaland, western Norway. The two sampling areas are emphasized.

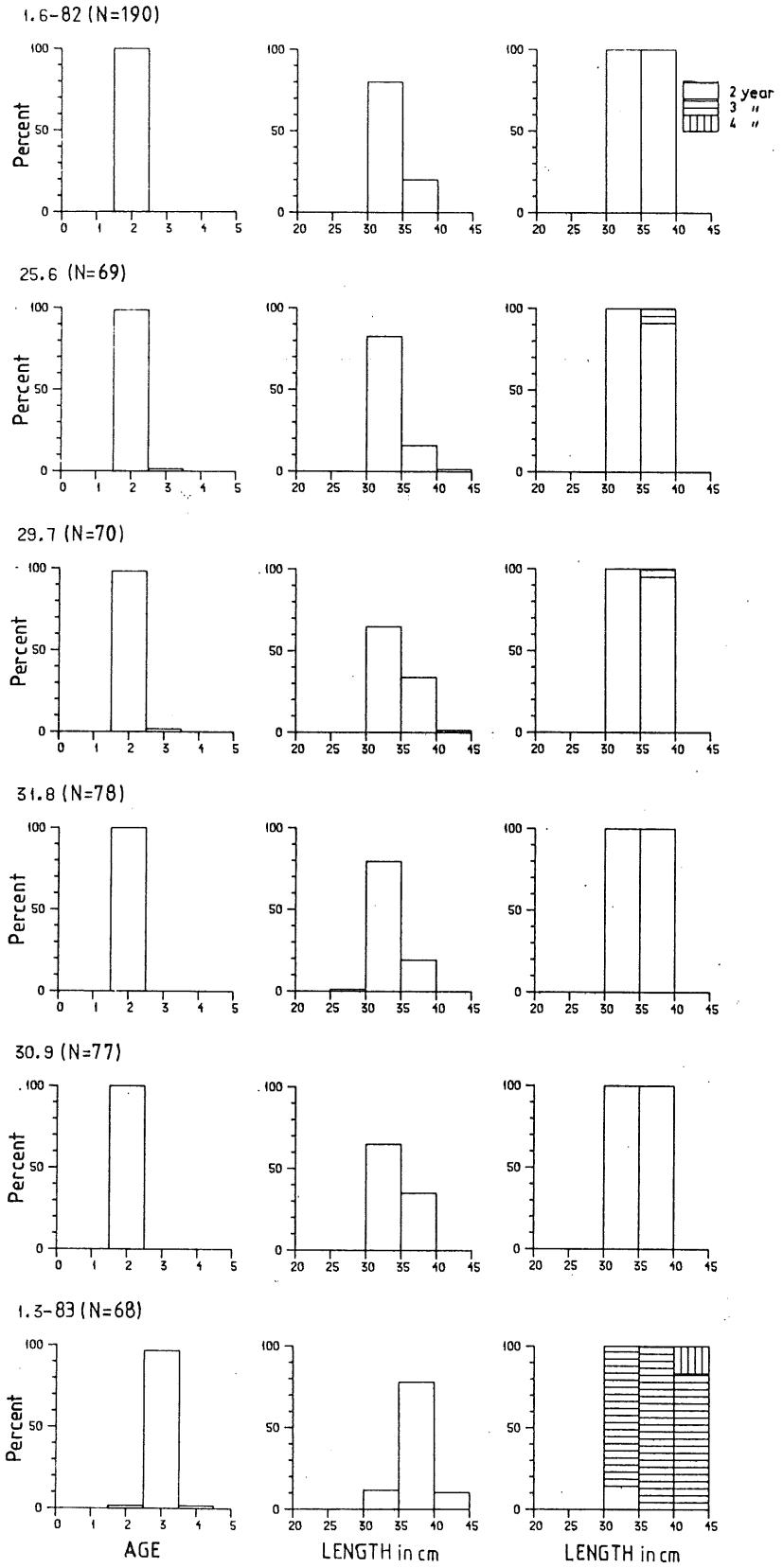

Figure 2. AREA A. Age (in the total catch and in each length-group) and length (5 cm groups) distribution of the saithe.

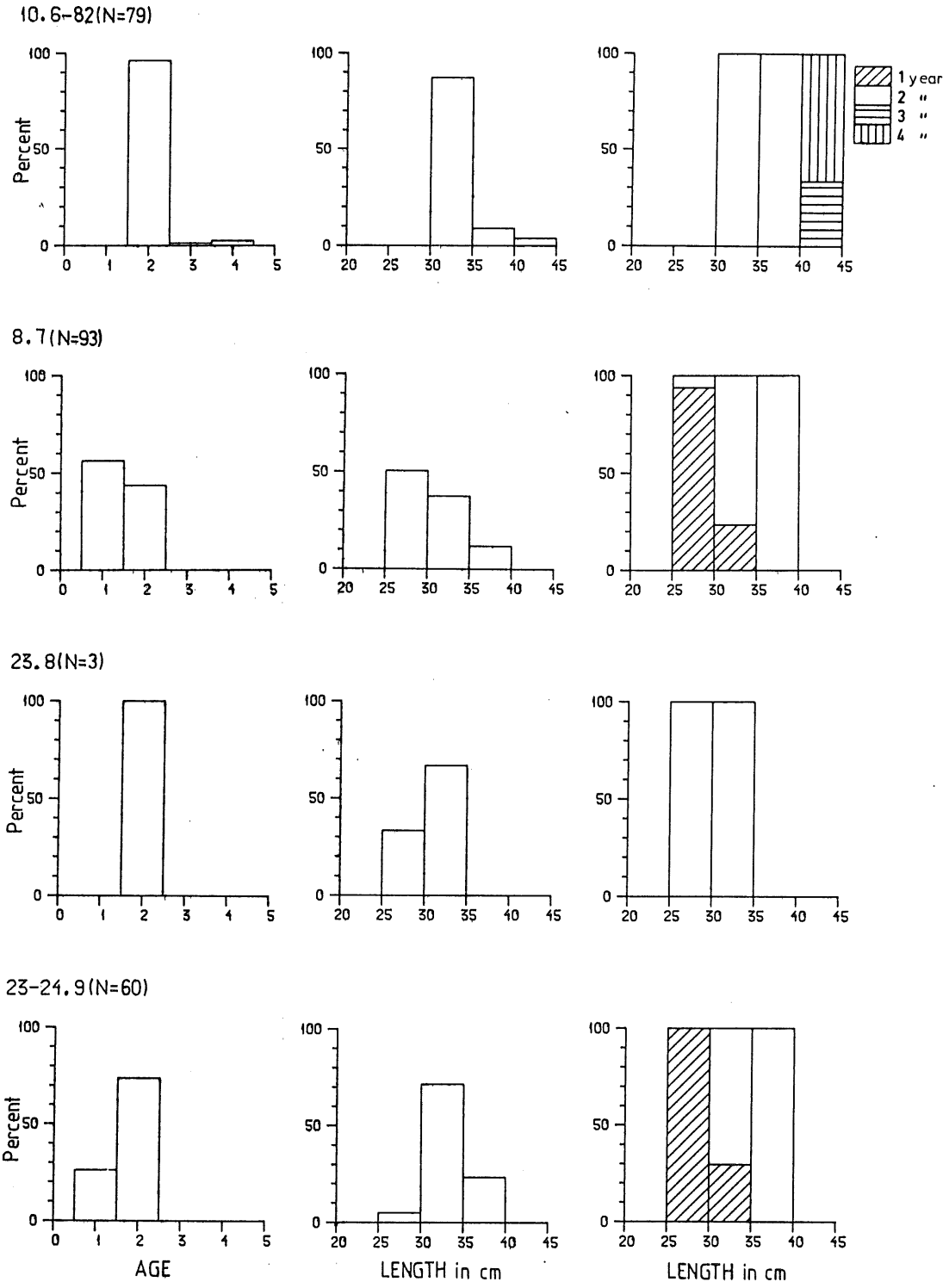

Figure 3. AREA B. Age (in the total catch and in each length-group) and length (5 cm groups) distribution of the saithe.

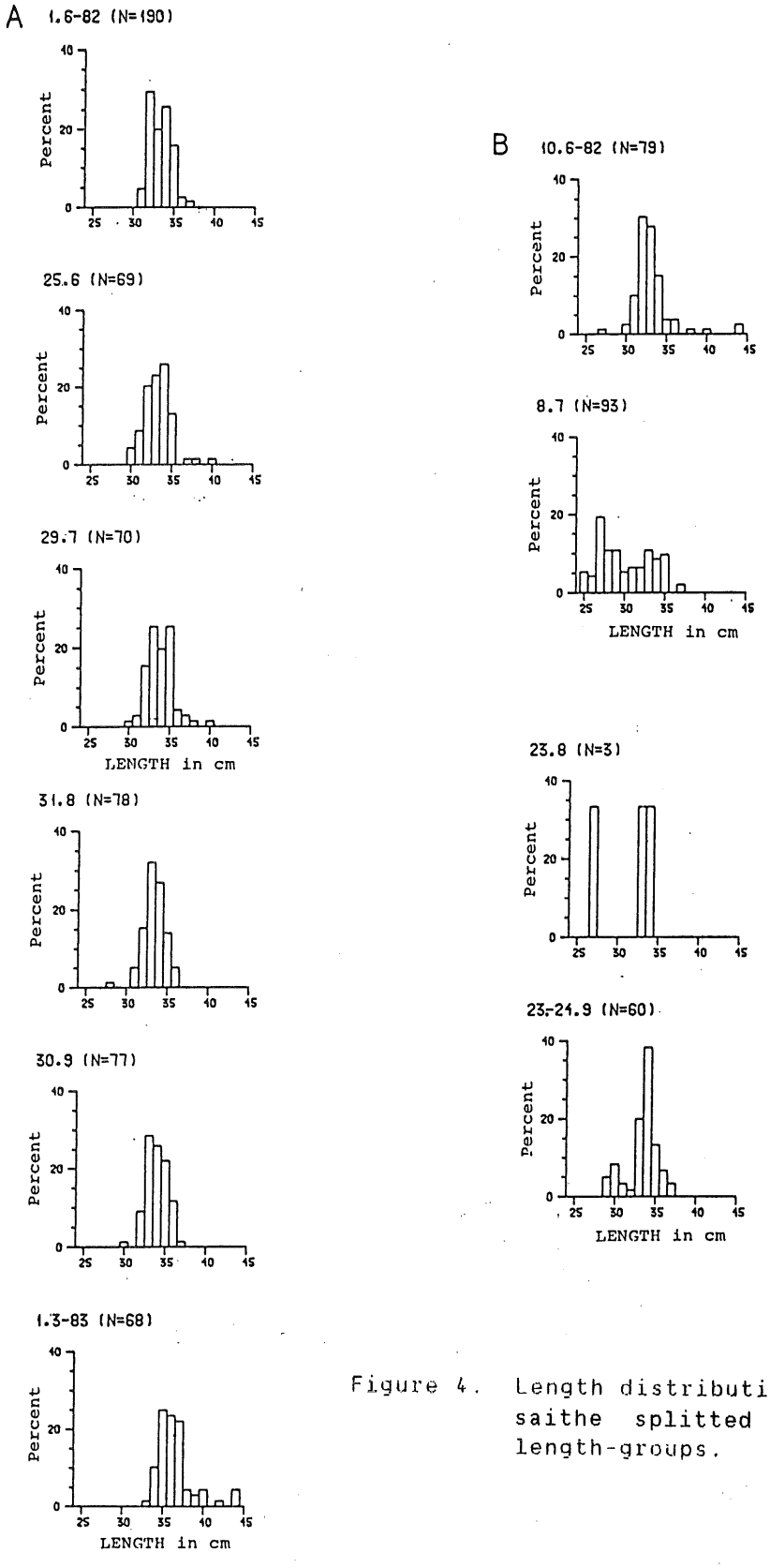

Figure 4. Length distribution of the saithe splitted in 1 cm length-groups.

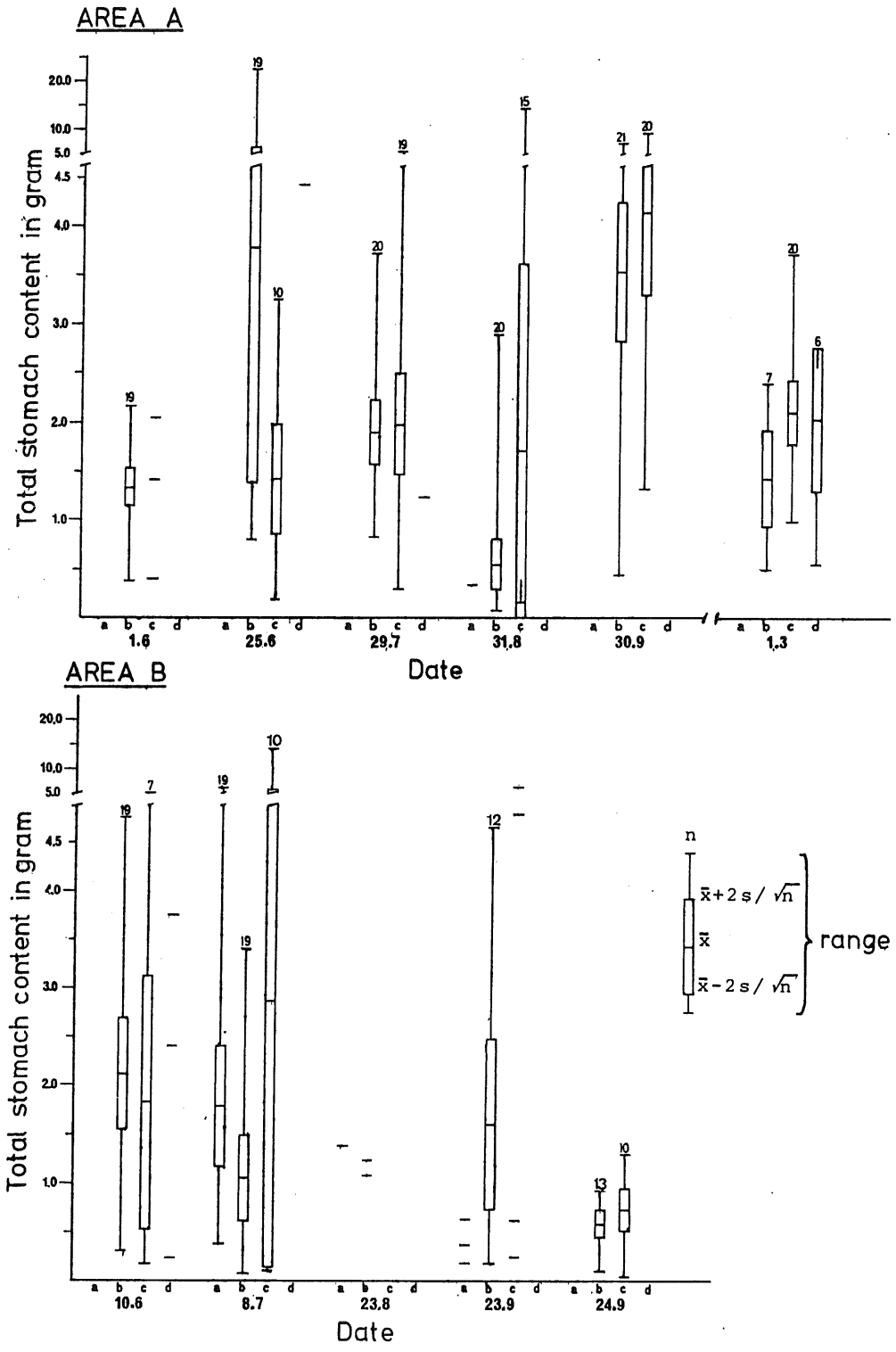

Figure 5. Stomach filling expressed by the total wet weight of the stomach content (incl. not identified fragments, gastric juices, and small parasites).
a: length-group 25-29 cm -- d: length-group 40-44 cm.
n: number of saithe, x: mean, s/√n: standard error of mean.

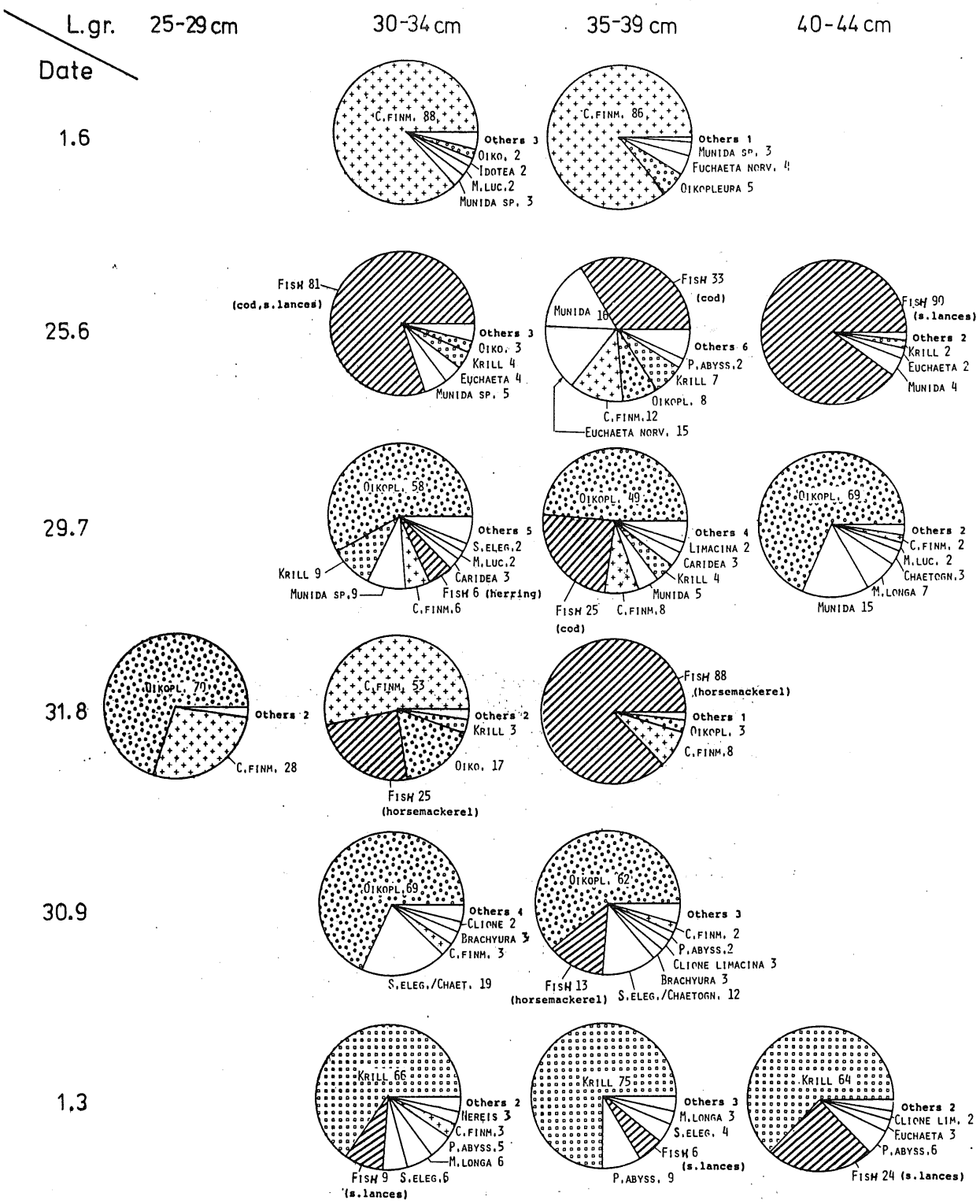

Figure 6. AREA A. A general view upon the nutrition of the saithe given in relative amounts (w %). The apparently most important categories are emphasized by symbols.

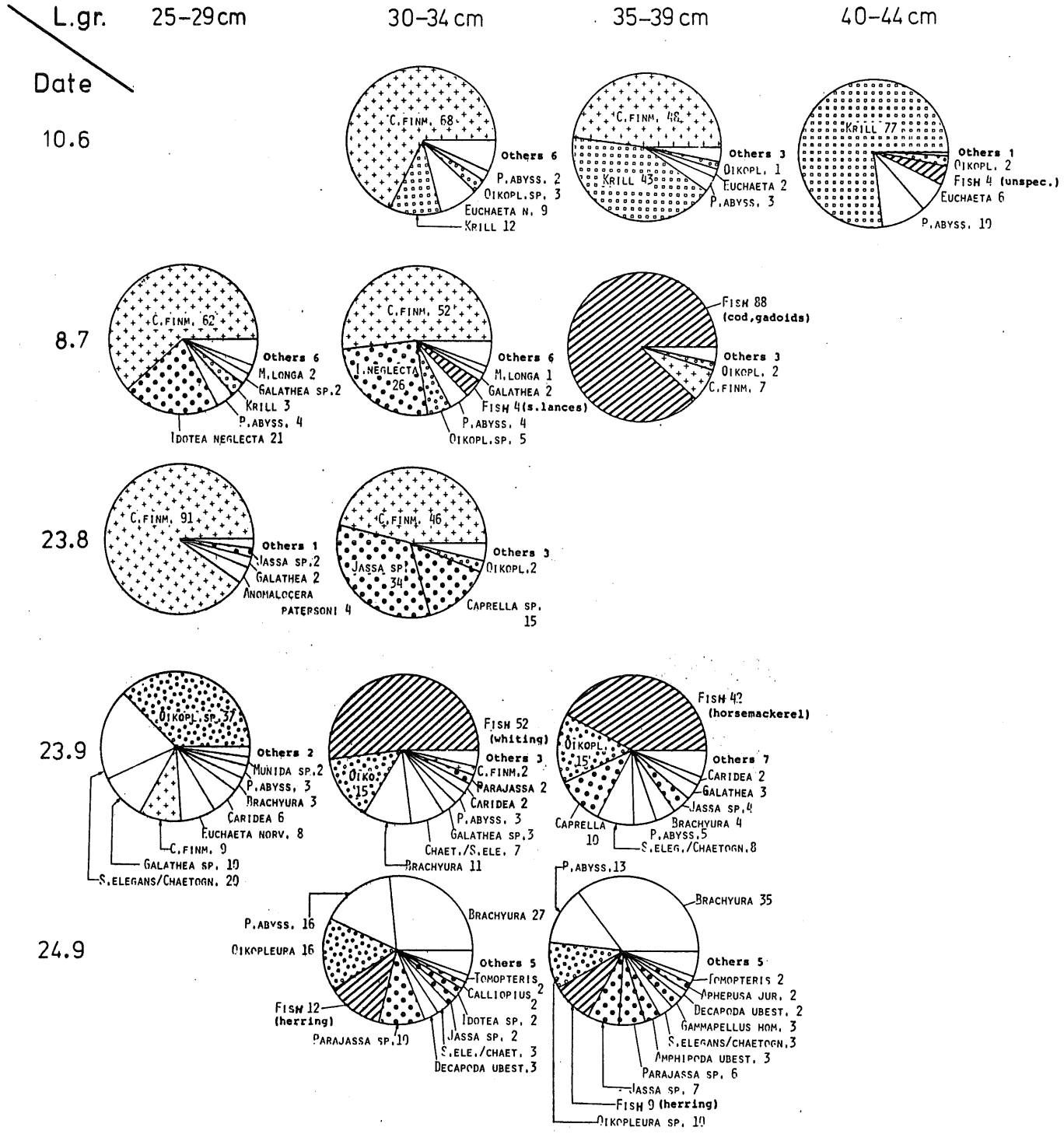

Figure 7. AREA B. A general view upon the nutrition of the saithe given in relative amounts (w %). The apparently most important categories are emphasized by symbols.

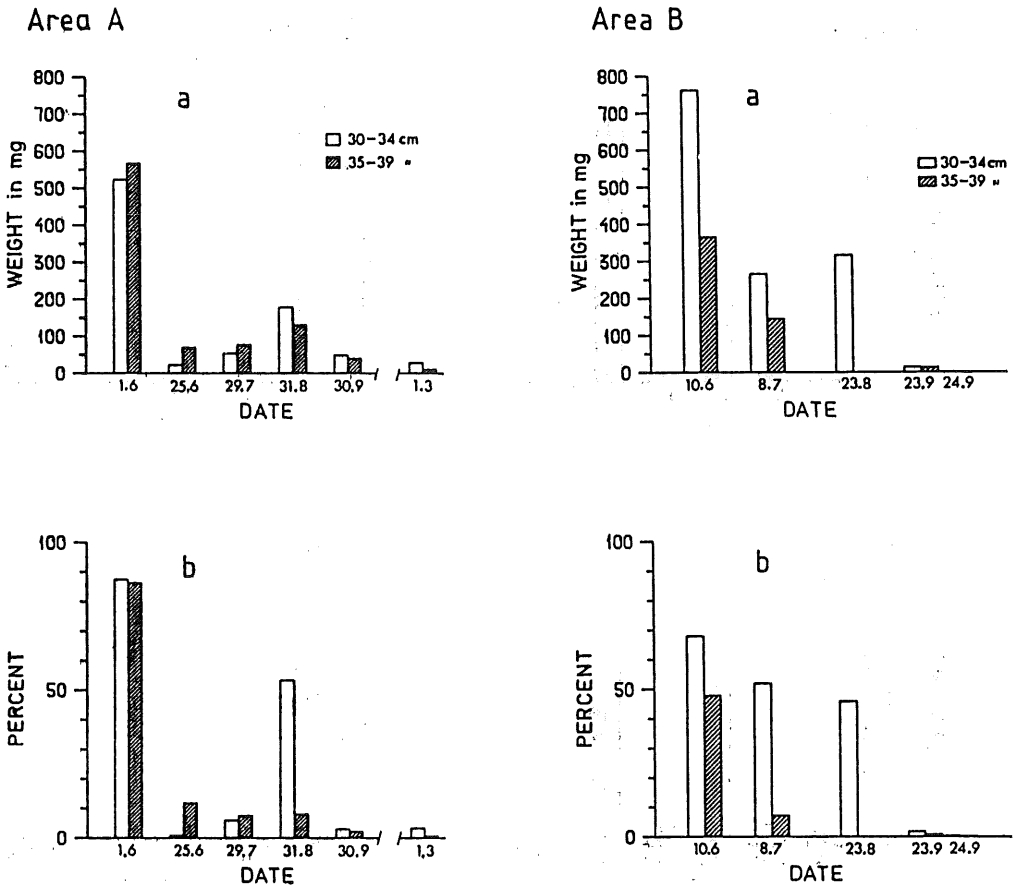

Figure 8. Calanus finmarchicus in the saithe diet from area A and B.
a: mean absolute weight of this prey per saithe (w/p).
b: relative amounts (by weight) of this prey (w %).

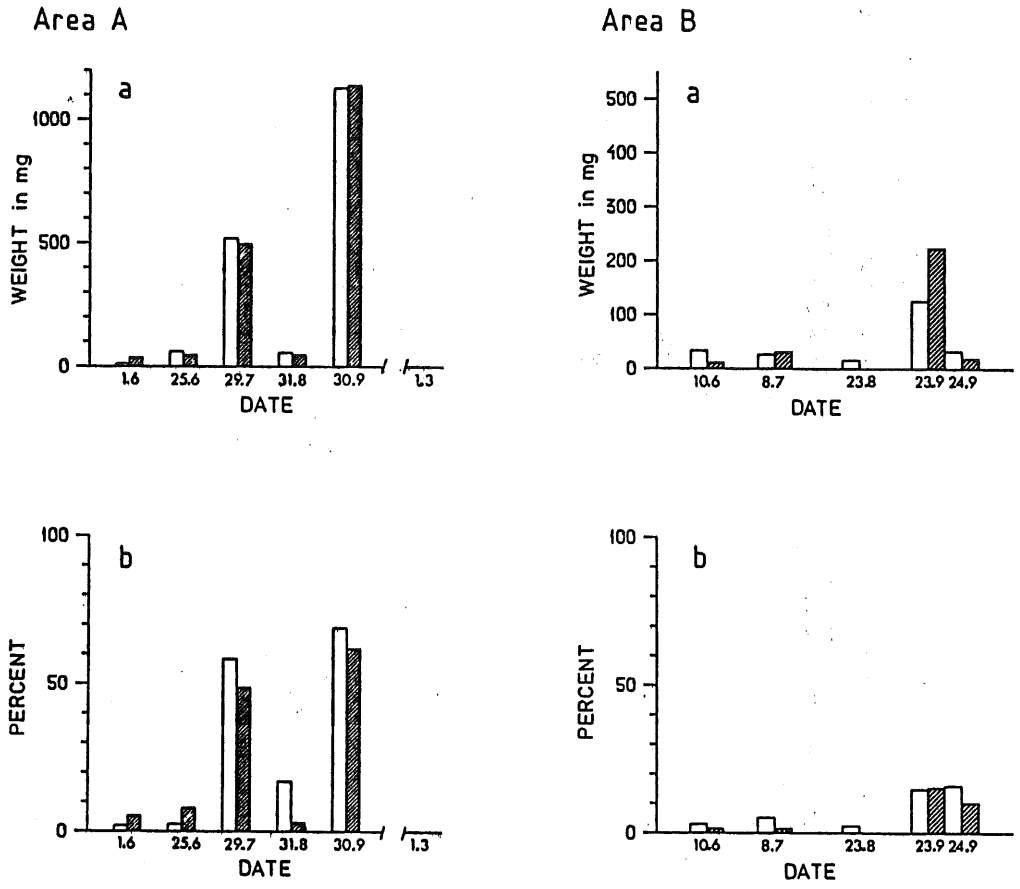

Figure 9. Oikopleura spp. in the saithe diet from area A and B.
a: mean absolute weight of this prey per saithe (w/p).
b: relative amounts (by weight) of this prey (w %).
Symbols for different length-groups as in Figure 8.

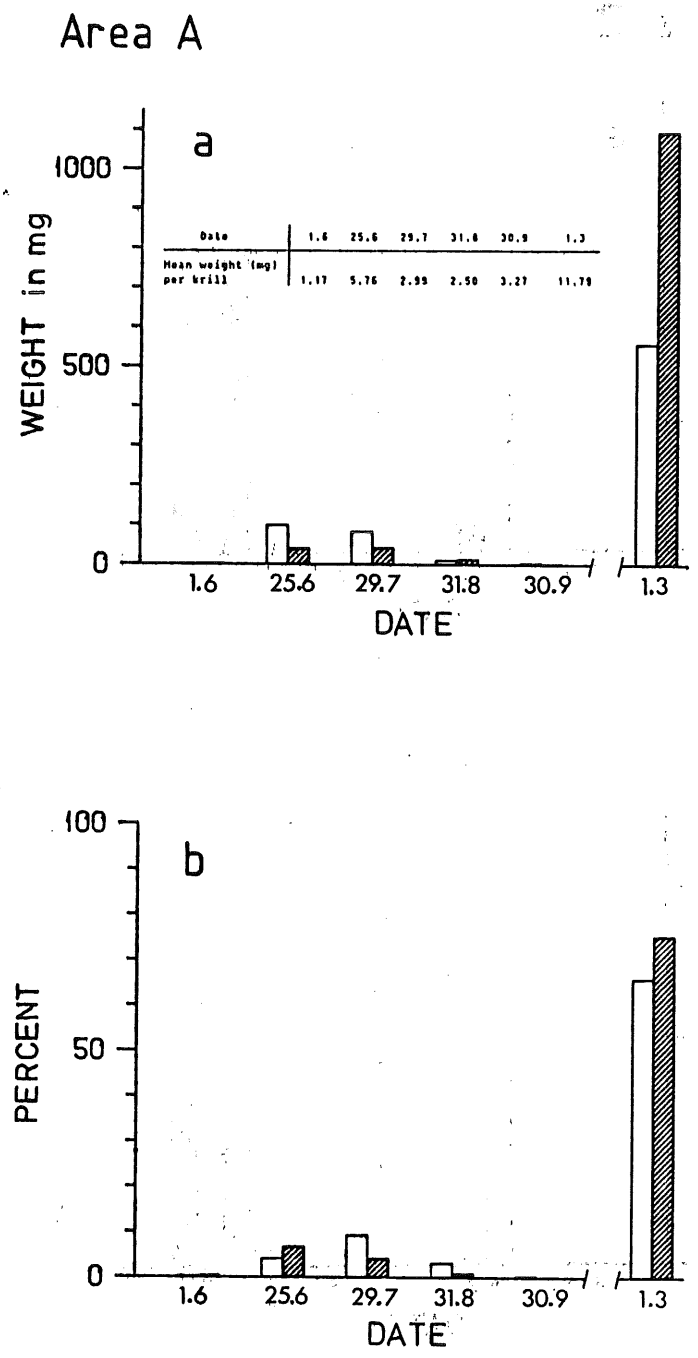

Figure 10. EUPHAUSIACEA - Krill in the saithe diet from area A .
a: mean absolute weight of this prey per saithe (w/p).
b: relative amounts (by weight) of this prey (w %).
Symbols for different length-groups as in Figure 8. Inserted table shows mean weight per krill at different sample periods.

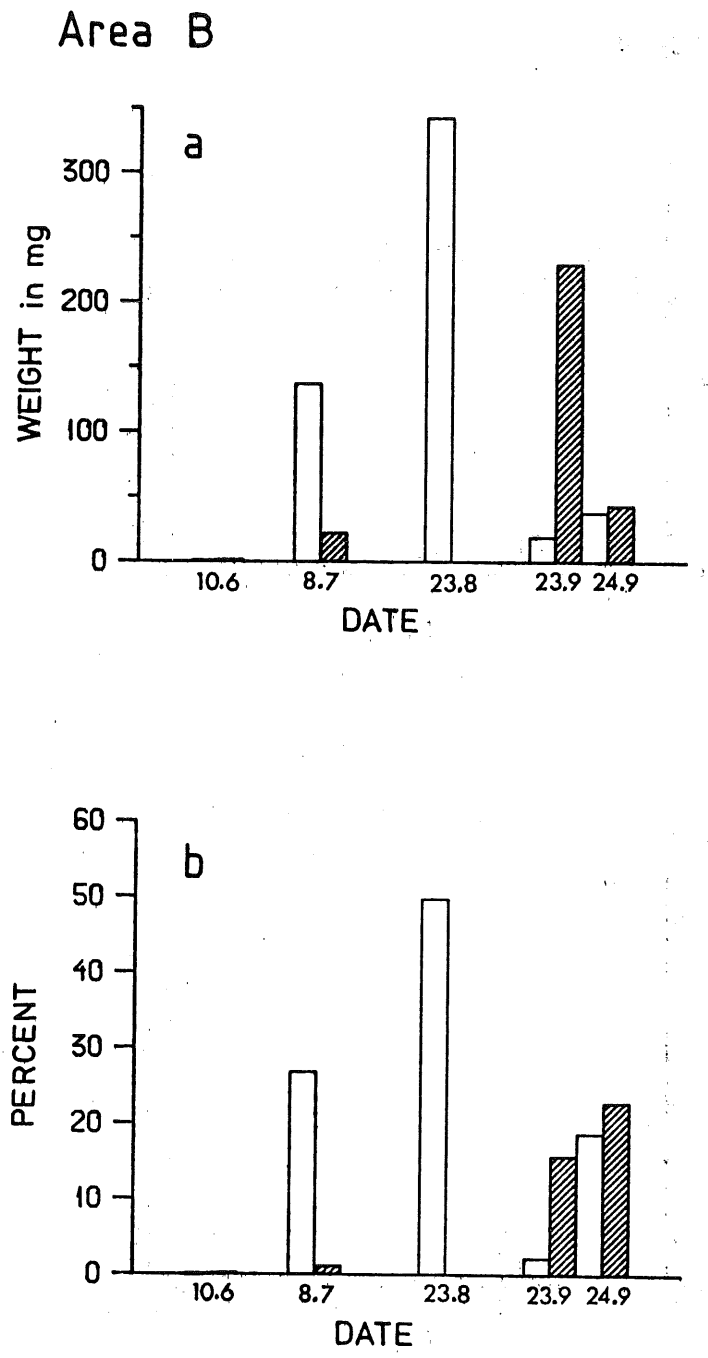

Figure 11. EPIFAUNA/HYPERBENTHOS in the saithe diet from area B.
a: mean absolute weight of this prey per saithe (w/p).
b: relative amounts (by weight) of this prey (w %).
Symbols for different length-groups as in Figure 8.

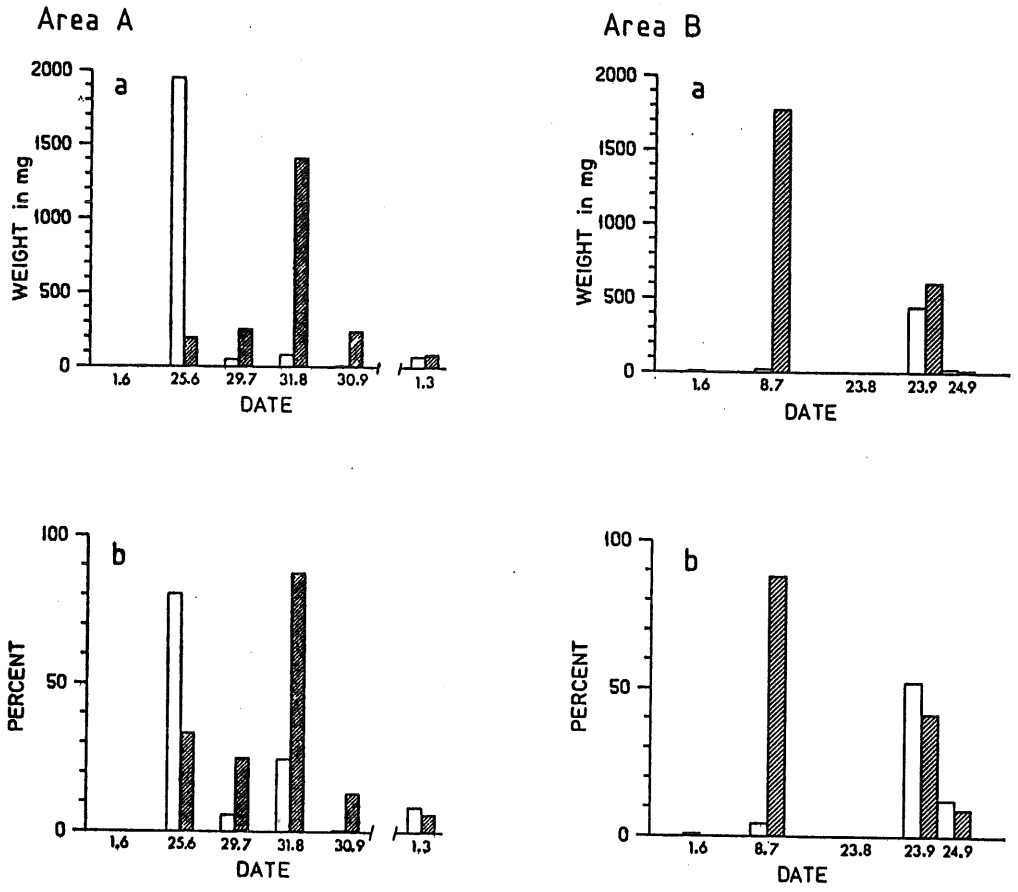

Figure 12. FISH (larvae and yearlings) in the saithe diet from area A and B.
a: mean absolute weight of this prey per saithe (w/p).
b: relative amounts (by weight) of this prey (w %).
Symbols for different length-groups as in Figure 8.

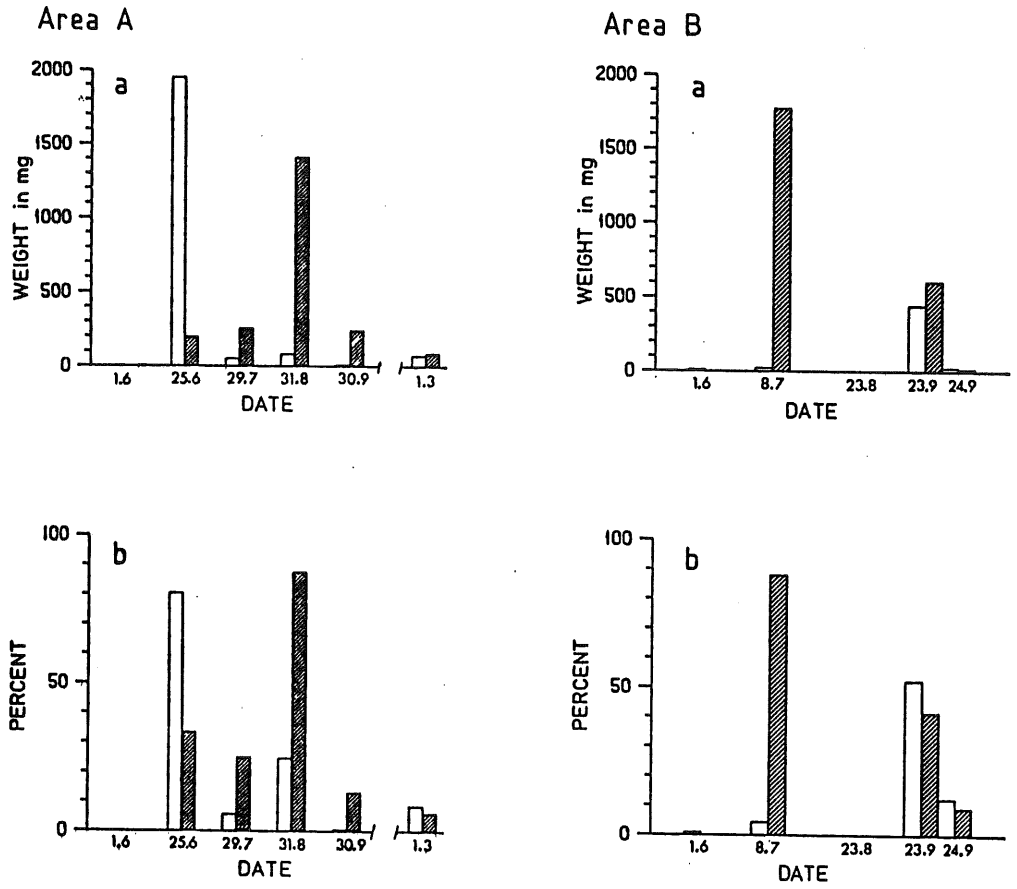

Figure 12. FISH (larvae and yearlings) in the saithe diet from area A and B.
a: mean absolute weight of this prey per saithe (w/p).
b: relative amounts (by weight) of this prey (w %).
Symbols for different length-groups as in Figure 8.