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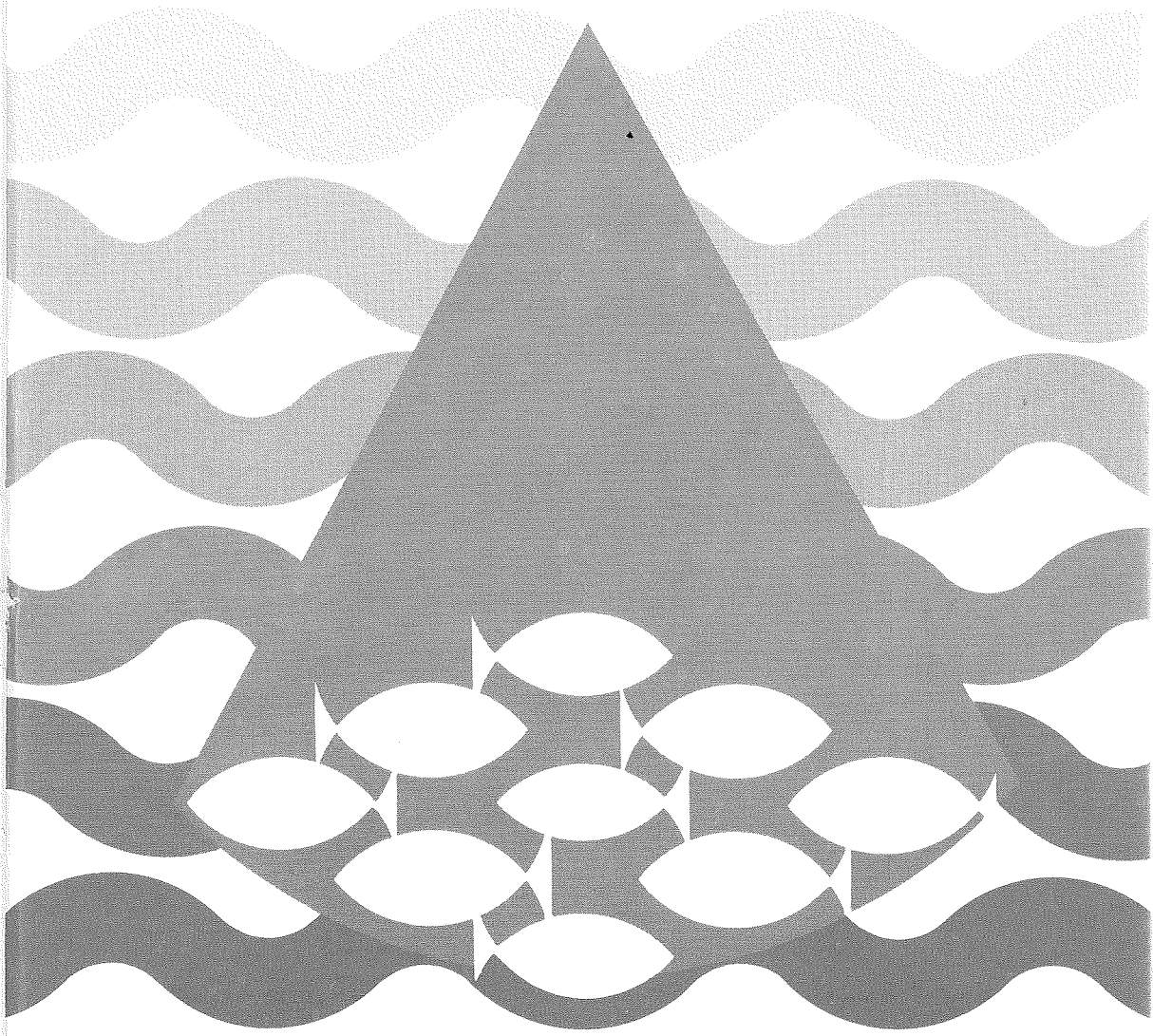

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FOOD AND FEEDING HABITS OF YOUNG SAITHE, *POLLACHIUS VIRENS* (L.), ON THE COAST OF WESTERN NORWAY

By

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ABSTRACT

NEDREAAS, K. 1987. Food and feeding habits of young saithe, *Pollachius virens* (L.), on the coast of western Norway. *FiskDir. Skr. Ser. HavUnders.*, *18*: 263–301.

The stomach contents of young saithe (both I– and II-group, but mainly II-group) from two areas, denoted A and B, on the western coast of Norway have been analysed. When these juvenile saithe become two or more often three years old, they migrate from the coastal shallows to the North Sea. Nutrition may be an important factor governing or influencing this migration.

In area A, the saithe had preyed almost exclusively upon plankton in the pelagic environment. The appendicularian *Oikopleura dioica*, the copepod *Calanus finmarchicus*, and the krill *Thysanoessa inermis* each dominated the nutrition at times. In the winter, when 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 and hyperbenthos, consisting of isopods and amphipods attached to bottom vegetation, seemed to play an important role, especially when typical 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 are indicative of a gradual migration of the largest fish, mostly two-year-olds, away from the coast. In July-August almost all two-year-olds 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 investigated areas. 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 February, but before June) when the saithe are three years old. In the beginning of March, the saithe seemed to have preyed mostly on krill, and the observed transport of krill with the water masses away from the coast may have led the saithe to follow.

INTRODUCTION

Feeding and searching for food are factors which regulate or at least influence the distribution, migration, and growth of fish. According to food availability fish can change both their behaviour and migration patterns.

The saithe was in 1984 the third most important commercial fish species to Norway both in quantity and in value. Preliminary results show that Norwegian fishermen caught respectively 51% and 96% of the total landings of saithe from the North Sea and Norwegian coast north of 62°N (ANON. 1985). The International Council for the Exploration of the Sea operates as though there are two stocks of saithe, one in the North Sea and one along the Norwegian coast north of 62°N. This border between the stocks is not biologically distinct, migrations between the areas do occur (JAKOBSEN 1981, ANON. 1983).

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

What causes the massive annual 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 was related to the age and length of the saithe. The timing of the saithe migration differed from year to year. An explanation might be found in the feeding and prey preferences of the saithe (JAKOBSEN 1978a).

The main task of this work was to identify on the basis of stomach content analyses what the juvenile saithe in the coastal shallows prey upon before they migrate to deeper water in the North Sea. It was therefore decided to study 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.

Little has 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. LIE (1961) published a taxonomic and quantitative analysis on the feeding of O-group saithe. LIE (1962) has also studied the feeding of a few I-group saithe. From the North Sea some data on the feeding of saithe are available, e.g., GOLUBJATNIKOVA and MALYSHEV 1980, ANON. 1982, GISLASON 1983, but these were on saithe that had already migrated from the coast. It is because of this lack of knowledge about the feeding of young saithe that a closer examination has been made of the feeding of I- and II-group saithe prior to migration. Three subjects are emphasized:

1 Age-length composition of the saithe
2 Stomach-content analyses
3 Sampling of plankton from the actual area for comparison with the diet of the saithe

MATERIALS AND METHODS

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

The stomach contents of all fish, up to a maximum of 20, 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 each saithe in the catch was measured. Within two hours of the saithe being 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,

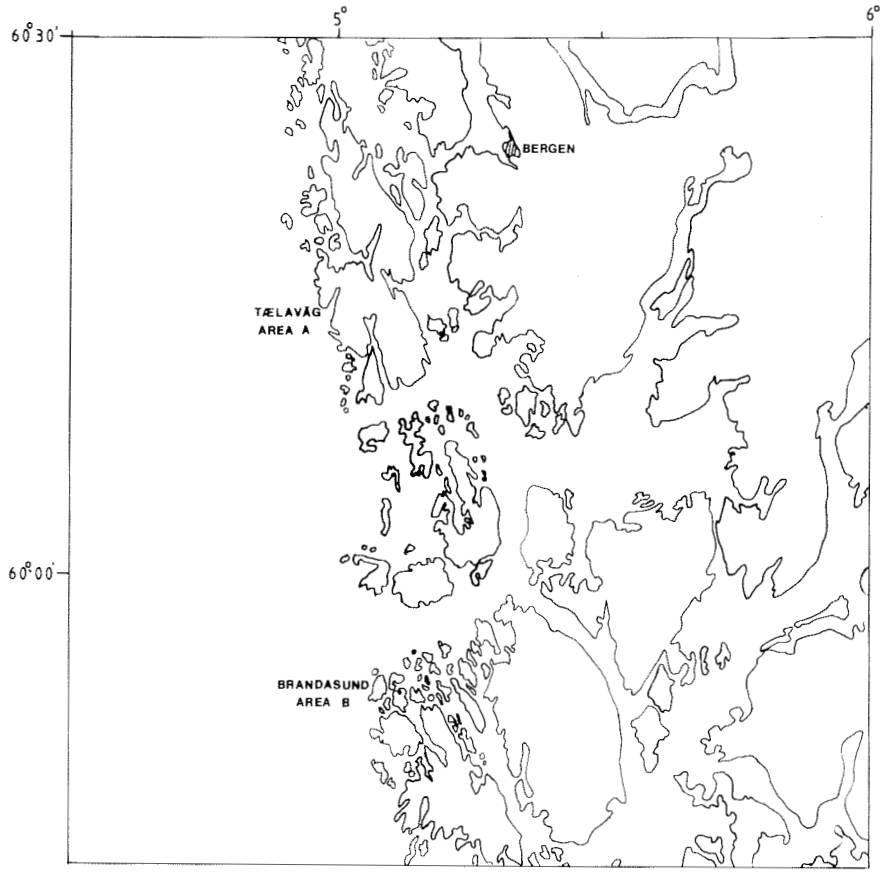

Fig. 1. Part of the coast and the outer areas of Hordaland, western Norway. The two sampling areas are indicated.

but the results have been summarized and presented for each 5 cm length-group of the predator.

The total wet weight of the stomach content was found. All fish prey and other larger prey organisms were sorted out, weighed and subtracted from the total. From the remaining, more homogeneous content, a subsample was taken. The size of the subsample was determined according to the diversity of the content. This subsample generally comprised about 25% of the homogeneous content.

The weights of the prey organisms are all fresh weights. These were partly taken from the literature (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 sum of constituent weights gave an *estimated* total wet weight. Relative amounts of different prey categories are referred in the text to this estimated weight.

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

The nematodes and trematodes 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 by numbers and by weight. For some essential prey types values for the «frequency of occurence» (%F) have also been calculated. For analysing the stomach content data, computer programmes 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 at 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.

RESULTS

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 (Fig. 2). In March 1983 the same year class, now three years old, dominated, but some two-year-old saithe began to appear. One-year-old fish never occurred in the samples from this area.

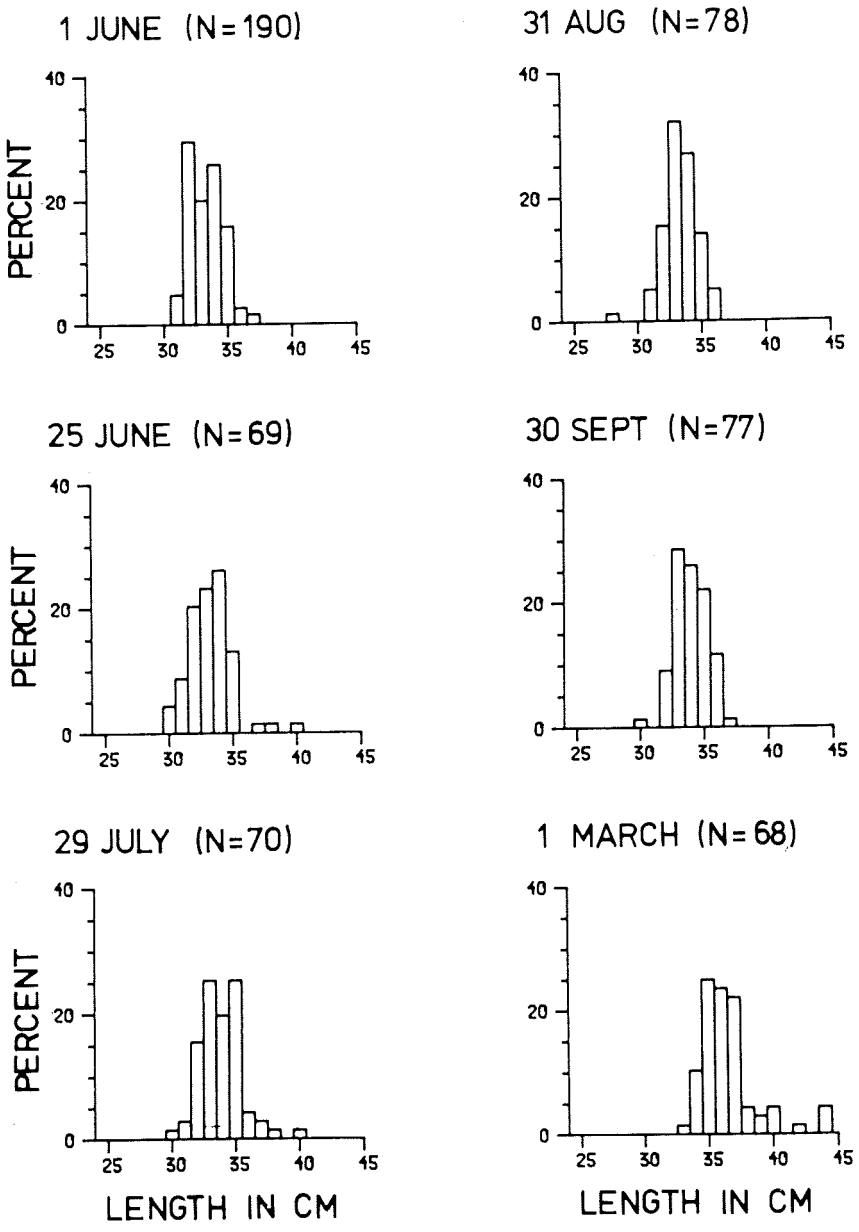

Fig. 2. *AREA A*. Length distribution of the saithe split into 1 cm length-groups.

In area B, the length composition was more variable (Fig. 3). The samples contained at times much one-year-old fish, with a maximum occurence in July of about 56%. This may be due to having fished closer to the shore than in area A. Throughout most of the sampling period two-year-old fish were dominant in area B.

Fig. 2 and Fig. 3 show that there was very little growth of the saithe in the two areas during the sampling period. In area A the mean length of the 1980 year class (two-year-olds) increased by 3.1 cm from 1 June 1982 to 1 March 1983. In area B the mean length of the same year class showed an increase of about 1.3 cm during 3 1/2 months.

STOMACH FILLING

Only 0.6% of the stomachs were empty. Fish which had regurgitated were not observed.

There was no significant difference in the amount of food in the stomachs

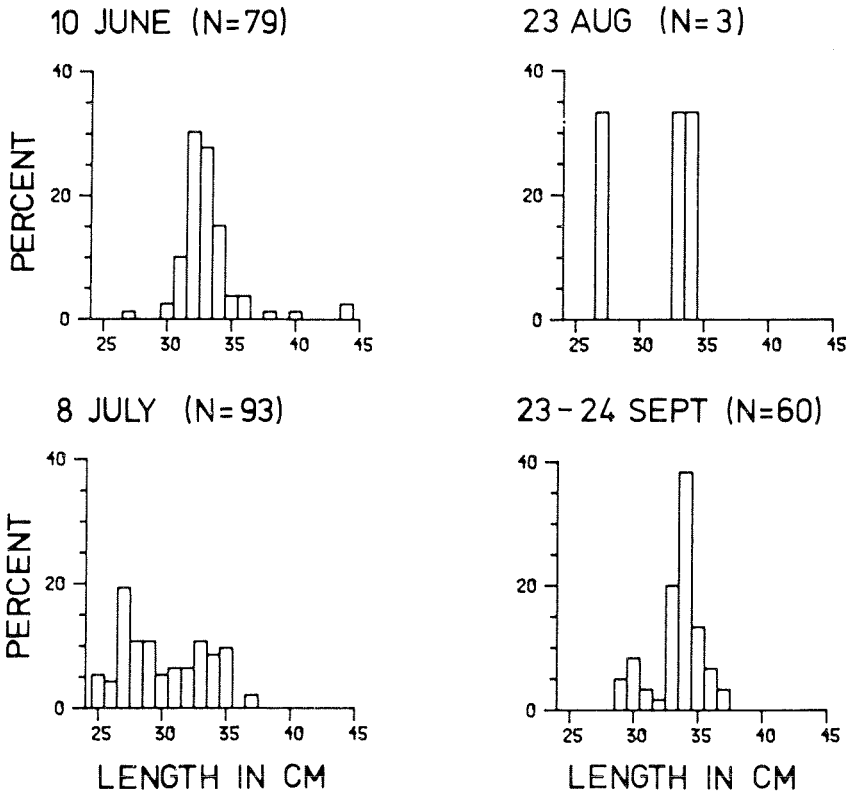

Fig. 3. *AREA B.* Length distribution of the saithe split into 1 cm length-groups.

among the major length-groups. The total wet weight of the stomach content was therefore used as a measure of stomach filling (Fig. 4).

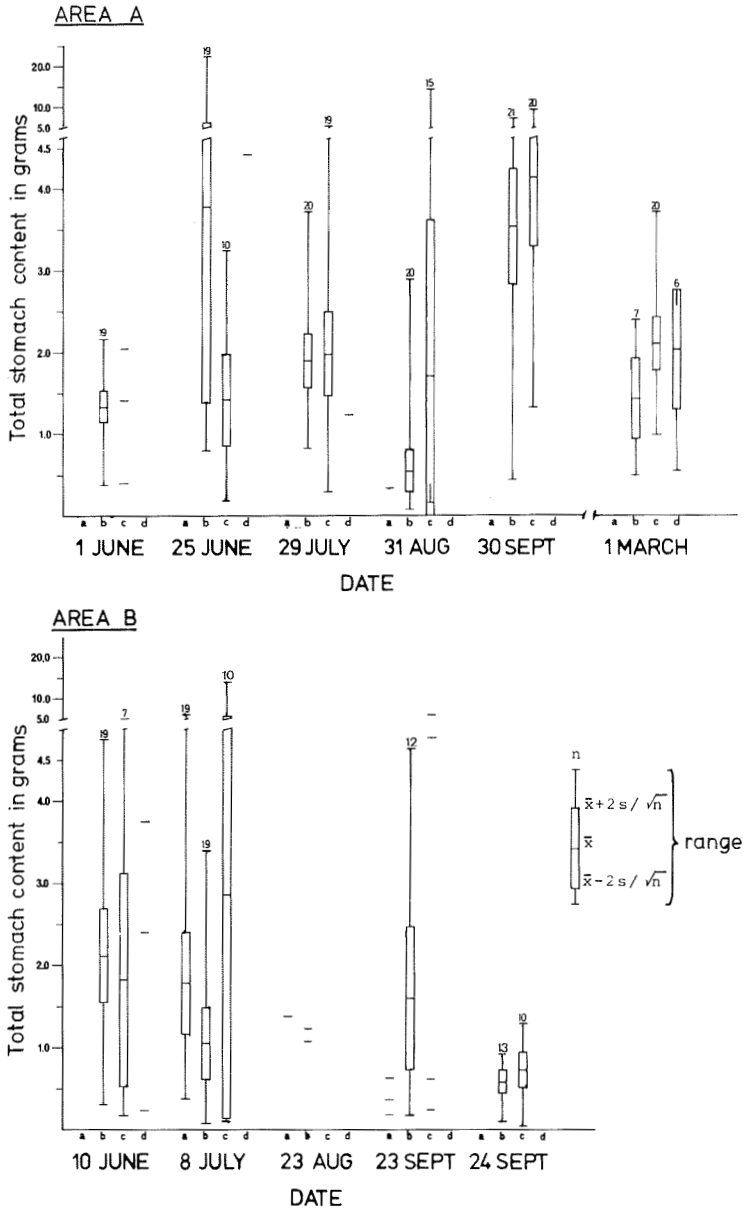

Fig. 4. Stomach filling expressed by the total wet weight of the stomach content, including unidentified fragments, gastric juices, and small parasites. Length-groups: (a)25–29 cm, (b)30–34 cm, (c)35–39 cm, (d)40–44 cm. n: number of saithe, $\bar{x}$: mean, $s/\sqrt{n}$: standard error of mean.

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 among the length-groups. Fig. 4 shows that the variation within the same length-group from time to time was great.

In area B, as in area A, a clear relationship between the amount of food in the stomachs and the length of the fish was not observed. In the only sample taken in the morning (24 September) there was remarkably less food in the stomachs.

The stomach content expressed as grams of food per kilogram of saithe was not significantly related to the predator. The mean weight of the prey organisms generally increased with increasing length of the saithe (Table 1).

By summing the weights of all prey organisms counted in one stomach, the total weight of the stomach content was estimated. This estimate was less than the observed total weight of the content before the analysis. Fragments of organisms, digestive fluids, and gastric parasites, which were not taken into consideration, are possible reasons for this difference. Table 2 may therefore suggest the degree of digestion of the stomach content. The time lapse from catching to fixation was more or less the same for each sample.

Table 1. Mean weight (mg) per prey organism for each length-group: (a) 25–29 cm, (b) 30–34cm, (c) 35–39 cm, (d) 40–44 cm and main prey at each sampling time.

Area and date	Length-group				Mean	Main prey
	a	b	c	d		
A						
1June 82		1.35	1.37		1.36	Calanus finmarchicus
25 June 82		10.63	2.91	19.96	11.17	Fish (cod & sand lances)
29 July 82		0.75	0.89	0.66	0.77	Oikopleura sp.
31 Aug 82	0.62	1.33	8.00		3.32	Oikopleura, C. finmarch., Fish (horse mackerel)
30 Sept 82		0.66	0.74		0.70	Oikopleura sp.
1 March 83		6.87	9.33	10.76	8.99	Krill
Mean	0.62	3.60	3.87	10.46		
B						
10 June 82		1.52	2.31	4.17	2.67	C. finmarchicus, krill
8 July 82	1.68	1.67	9.67		4.34	C.finm., fish (gadoids)
23 Aug 82	1.34	2.17			1.76	C.finm., hyperbenthos
23 Sept 82	1.00	2.35	2.31		1.89	Oikopl., fish (whiting, sand lances, horse mackerel)
24 Sept 82		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 a percentage of the total weight of the complete stomach content before the analysis; (a) 25–29 cm, (b) 30–34 cm, (c) 35–39 cm, (d) 40–44 cm.

Area and date	Time (local)	Length-group			
		a	b	c	d
A					
1 June 82	1800–2000		45	51	
25 June 82	1800–1900		64	41	63
29 July 82	1830–2000		47	51	46
31 Aug 82	1800–1900	77	61	94	
30 Sept 82	1500–1530		46	45	
1 March 83	1400–1445		59	69	39
B					
10 June 82	2000–2200		53	42	36
8 July 82	2000–2210	54	49	70	
23 Aug 82	2000–2200	62	60		
23 Sept 82	2000–2030	42	53	50	
24 Sept 82	0815–0845		35	26	

A GENERAL OVERVIEW OF THE FOOD FOUND IN THE SAITHE STOMACHS

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

Fig. 5 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 fed almost exclusively 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 observed chaetognath.

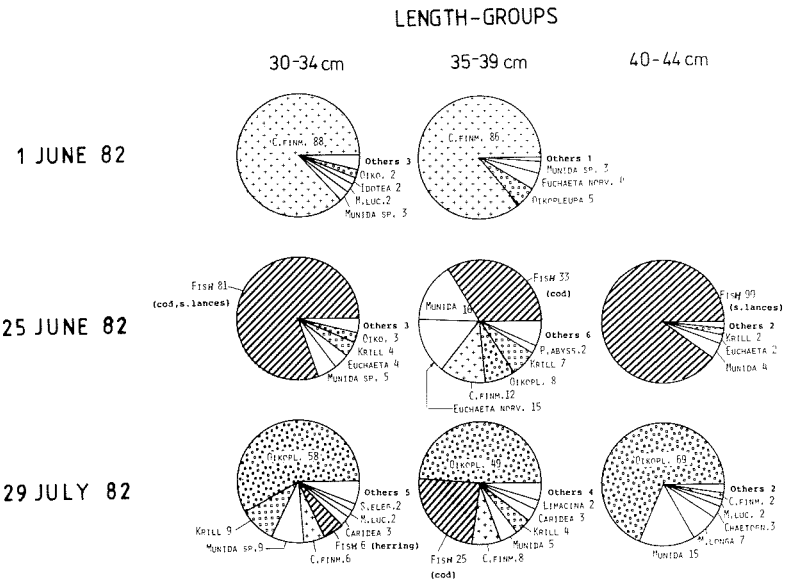

Fig. 5. *AREA A*. A general overview of the nutrition of the saithe given in relative amounts by weight (%). The apparently most important categories are emphasized by specific symbols.

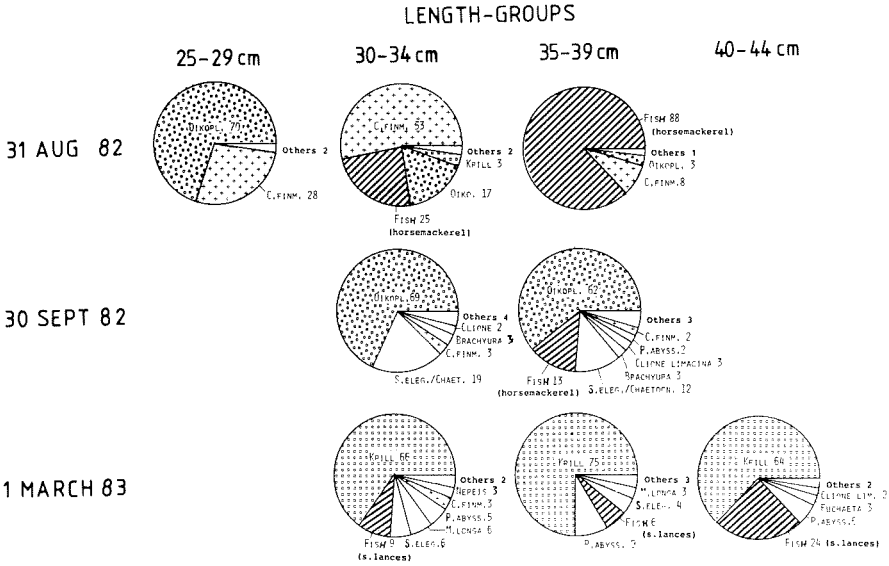

Fig. 5 cont.

In area B, there were greater differences among length-groups with respect to prey (Fig. 6). 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, different species of amphipods occurred. It is reasonable to conclude that the saithe used different strategies to catch true pelagic prey, prey attached to algae or prey 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 and hyperbenthos	9.2	1.2
Krill	7.0	4.9
Oikopleura spp.	5.1	22.1

Cod, and other unspecified gadoids, were the most important fish prey by weight. By number, herring and sand lances were the most important fish prey. *Thysanoessa inermis* was the dominant krill species.

QUANTITATIVE ANALYSIS OF THE MOST IMPORTANT PREY ORGANISMS IN THE SAITHE STOMACH

Calanus finmarchicus (Gunnerus)

AREA A (Table 3)

Calanus finmarchicus was the most important prey for the saithe in the samples taken in the beginning of June, constituting almost 87 % of the total amount of nutrition by weight. Already by the end of this month the importance of *C. finmarchicus* was remarkably reduced. Not before the end of August did the amount of *C.finmarchicus* in the stomach content again increase, but only to a level of about 30 % of the amount on 1 June. During autumn and winter *C. finmarchicus* seemed to constitute a minor part of the saithe nutrition.

Taking the total sampling period into account, there was a significant differende between length-groups 30–34 cm and 35–39 cm in regard to the number of preyed *C.finmarchius*. Generally the smallest fish had preyed the greatest number.

The mean weight of the saithe in length-groups 30–34 cm and 35–39 cm was respectively 0.30 kg and 0.38 kg ($W = 0.0085L^3$, where W is in grams and L in centimeters). Based on this, the quantity of *C.finmarchicus* in milligrams per kilogram saithe in length-group 35–39 cm amounted to about 40 % of that in length-group 30–34 cm.

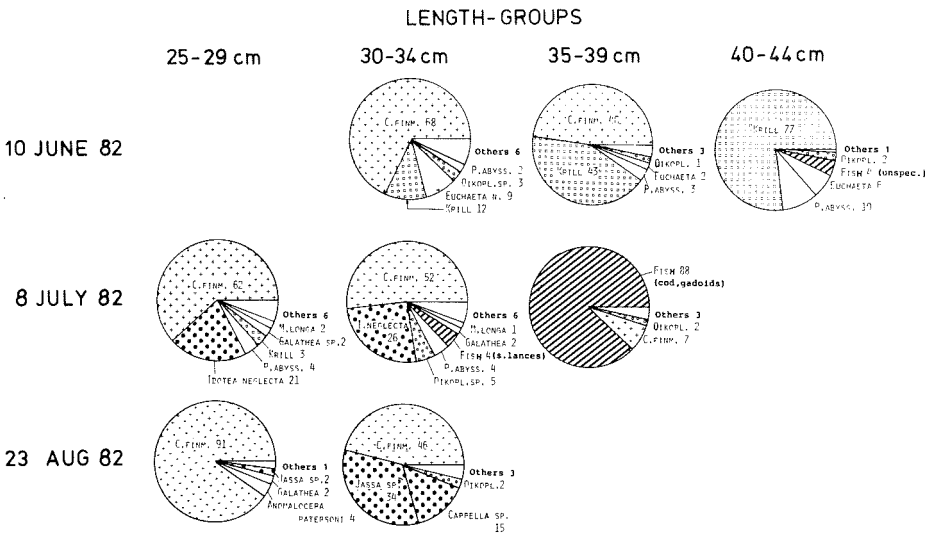

Fig. 6. *AREA B.* A general overview of the nutrition of the saithe given in relative amounts by weight (%). The apparently most important categories are emphasized by specific symbols.

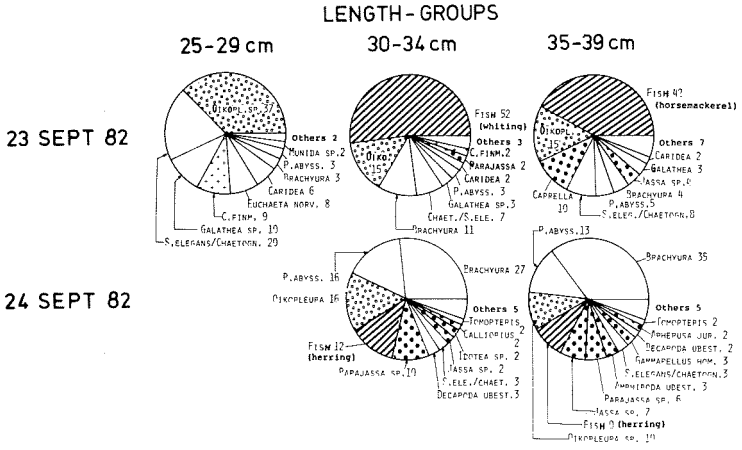

Fig. 6 cont.

Table 3. The feeding of different length-groups of saithe upon *Calanus finmarchicus* (Gunnerus). 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	522.9	87.5	390	88.2	3	567.6	86.4	391	81.8					
25 June 82						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 July 82						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 Aug 82	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 Sept 82						21	48.7	3.0	35	1.4	20	40.1	2.2	30	1.2					
1 March 83						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 June 82						19	762.4	68.0	546	73.8	7	365.7	47.9	252	76.1	3	+	+	0	0
8 July 82	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 Aug 82	1	770.0	90.5	576	90.4	2	316.0	45.9	236	74.3										
23 Sept 82	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 Sept 82						14	0.7	0.4	1	0.5	10	0.4	0.2	0.3	0.3					

AREA B (Table 3)

In area B *Calanus finmarchicus* seemed to be the most important organism during a longer period than in the other area, extending from the beginning of June and to the end of August. The sampling in September showed a remarkable decrease in the amount of *C.finmarchicus* in the saithe diet.

Table 4 shows how uniform the preying upon *C.finmarchicus* was in both areas. *C.finmarchicus* seemed to occur at least as frequently 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, shows however that the amount by weight of this copepod per predator for length-groups 30–34 cm and 35–39 cm in area A was respectively 53% and 75% of the corresponding amounts in area B.

Also in area B, the smallest saithe preyed most upon this copepod. The mean weight of saithe in length-groups 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. The quantity of *C.finmarchicus* in milligrams per kilogram of saithe in length-group 35–39 cm was 34% and 12% of the amounts in length-groups 30–34 cm and 25–29 cm, respectively.

Table 3 shows a very low percentage of *C.finmarchicus* in 35–39 cm saithe taken in July. Two out of eleven fish had preyed upon cod, and these two fish were the cause of this low percentage. Cod contributed to the group by as much as 86 % 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 upon by 30–34 cm and 35–39 cm saithe was only 0.04 mg, and in area B the difference between copepods preyed by 25–29 cm and 35–39 cm saithe was 0.11 mg. In determing this, the length of the copepods was computed according to the length–weight relationship found by BOGOROV (1959).

Oikopleura spp.

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

AREA A (Table 6)

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 appendicularians were present in the plankton, most saithe preyed this food source (Table 5).

Table 4. Percentage of all saithe at each sampling time that had preyed upon *Calanus finmarchicus*.

A:

Date	1 June 82	25 June 82	29 July 82	31 Aug 82	30 Sept 82	1 March 83
Percentage	100	87	78	94	76	58

B:

Date	10 June 82	8 July 82	23 Aug 82	23 Sept 82	24 Sept 82
Percentage	86	98	67	60	33

Table 5. Percentage of all saithe at each sampling time that had preyed upon *Oikopleura* spp.

A:

Date	1 June 82	25 June 82	29 July 82	31 Aug 82	30 Sept 82	1 March 83
Percentage	64	100	98	89	100	0

B:

Date	10 June 82	8 July 82	23 Aug 82	23 Sept 82	24 Sept 82
Percentage	72	96	100	90	71

The differences between the two length-groups in regard to the amount of *Oikopleura* spp. in the diet were small, although statistically significant (common levels of significance). The quantity in milligrams per kilogram of saithe in the length-group 30–34 cm was about 94 % of that in the length-group 35–39 cm.

AREA B (Table 6)

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 as important in this area as in area A. In September *Oikopleura* spp. made up only about 15% by weight of the total amount of nutrition. The quantity in milligrams per kilogram of saithe in the length-group 30–34 cm and 35–39 cm made up only 13% and 9%, respectively, of the amounts for the corresponding length-groups in area A.

There were small differences among the length-groups in regard to the number and weight of *Oikopleura* spp.. Table 5 shows how frequently specimens of this genus occurred in the stomachs.

Table 6. The feeding of different length-groups of saithe upon *Oikopleura* spp. 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	12.0	2.0	24	5.4	3	35.0	5.3	70	14.7					
25 June 82						19	61.3	2.5	123	53.8	10	47.2	8.0	94	46.8	1	18.0	0.6	36	25.9
29 July 82						20	520.0	58.4	1037	87.4	19	497.7	48.8	995	86.8	1	398.5	69.2	797	91.9
31 Aug 82	1	185.5	70.0	371	86.5	20	56.5	17.0	113	45.0	15	47.6	3.0	95	47.4					
30 Sept 82						21	1128.5	68.9	2260	91.4	20	1140.0	61.8	2282	91.8					
1 March 83						7	0.0	0.0	0	0.0	20	0.0	0.0	0	0.0	6	0.0	0.0	0	0.0
B																				
10 June 82						19	33.3	3.0	66	9.0	7	11.2	1.5	22	6.8	3	16.6	2.2	33	18.1
8 July 82	19	13.7	1.4	27	4.8	19	26.4	5.2	53	17.3	11	31.2	1.5	62	30.0					
23 Aug 82	1	0.0	0.0	0	0.0	2	16.0	2.3	32	9.9										
23 Sept 82	3	62.5	37.2	125	74.3	13	125.4	14.8	251	69.6	4	223.6	15.4	447	71.0					
24 Sept 82						14	32.5	16.0	65	52.1	10	19.4	10.2	39	36.9					

Euphausiacea – Krill

AREA A (Table 7)

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

In winter, however, krill semed to be the most important prey. In samples taken in March, krill made up about 70% of the estimated total weight of the stomach content. Almost all of the krill were adults. *Thysanoessa inermis* was the most frequently occurring species. In March more saithe in the length-group 35–39 cm preyed upon krill than did saithe in the length-group 30–34 cm. During the sampling period the size of the krill found in the stomach varied from 1.2 mg on 1 June to 11.8 mg on 1 March.

AREA B (Table 7)

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

Epifauna and hyperbenthos

Some isopods and amphipods live on or just above the bottom, or attached to various algae. Only isopods of the genus *Idotea* were found in the saithe diet. All species of *Idotea*, because of their mode of living, were placed in this fauna group. The observed amphipods, except *Parathemisto abyssorum*, also belong to this group.

AREA A (Table 8)

The saithe in this area seemed to prey only meagerly upon epifauna and hyperbenthos. Only at the beginning of June did such prey make up more than 1% of the estimated total weight.

AREA B (Table 8)

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

Table 7. The feeding of different length-groups of saithe upon euphausiacea – krill. 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	0.3	0.1	0.3	0.1	3	1.6	0.3	1	0.3					
25 June 82						19	99.1	4.1	17	7.4	10	39.3	6.7	7	3.3	1	51.5	1.9	31	22.3
29 July 82						20	82.5	9.3	29	2.4	19	41.6	4.1	13	1.1	1	4.0	0.7	2	0.2
31 Aug 82	1	0.0	0.0	0	0.0	20	10.5	3.1	4	1.7	15	13.1	0.8	5	2.5					
30 Sept 82						21	3.2	0.2	1	+	20	0.9	+	0.3	+					
1 March 83						7	558.0	65.9	47	38.3	20	1095.8	75.3	90	57.4	6	549.0	63.6	54	70.9
B																				
10 June 82						19	128.1	11.4	67	9.0	7	325.0	42.6	34	10.4	3	591.0	77.1	121	65.9
8 July 82	19	30.3	3.2	19	3.4	19	9.2	1.8	5	1.6	11	5.6	0.3	3	1.4					
23 Aug 82	1	0.0	0.0	0	0.0	2	0.0	0.0	0	0.0										
23 SEpt 82	3	0.0	0.0	0	0.0	13	0.9	0.1	0.4	0.1	4	4.5	0.3	2	0.3					
24 Sept 82						14	1.8	0.9	0.2	0.2	10	1.2	0.6	+	0.1					

Table 8. The feeding of different length-groups of saithe upon epifauna and hyperbenthos. 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	12.6	2.1	0.3	0.1	3	0.6	0.0	0	0.0					
25 June 82						19	0.5	+	0.2	+	10	0.0	0.0	0	0.0	1	0.0	0.0	0	0.0
29 July 82						20	1.5	0.2	0.1	+	19	+	+	+	+	1	0.0	0.0	0	0.0
31 Aug 82	1	0.0	0.0	0	0.0	20	0.0	0.0	0.0	0.0	15	1.0	0.1	+	+					
30 Sept 82						21	0.0	0.0	0.0	0.0	20	1.2	0.1	0.2	+					
1 March 83						7	0.0	0.1	0.3	0.2	20	0.3	+	+	+	6	3.0	0.4	0.1	0.2
B																				
10 June 82						19	0.8	0.1	0.3	+	7	1.4	0.2	1	0.2	3	3.0	0.4	1	0.5
8 July 82	19	210.5	21.9	6	0.9	19	136.6	26.8	5	1.8	11	22.0	1.1	4	1.7					
23 Aug 82	1	30.0	3.6	8	1.2	2	342.0	49.7	27	8.5										
23 Sept 82	3	1.3	0.8	1	0.6	13	19.0	2.2	3	1.0	4	229.2	15.7	25	3.9					
24 Sept 82						14	37.8	18.7	8	6.5	10	43.3	22.8	9	8.9					

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

Teleostei – Fish (Larvae and yearlings)

AREA A (Table 9)

Especially at the end of June and end of 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 during most of the other sample periods (Table 10), but the fish prey consisted of rather big yearlings of horse mackerel (*Trachurus trachurus*), which contributed significantly to the total amount by weight.

The number of fish per saithe did not seem to vary very much among the length-groups (Table 9), but because of a relatively large range in size of the fish prey there were differences among the length-groups at times in the absolute and relative amounts by weight. A Mann–Whitney test was performed to show eventual differences in the number of fish prey per saithe with respect to predator length. The results from the combined samples showed no significant differences.

AREA B (Table 9)

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

The fish prey consisted of different species at different times. Table 11 shows what species the saithe preyed upon, and the relative amount of all fish prey by weight. The most common fish larvae and yearlings in the diet are the following:

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 also found in July, but in September a greater quantity appeared in the diet (about 20 mm).

COD. Yearlings of cod, *Gadus morhua*, (35–70 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 relatively great size (up to 75 mm), they contributed significantly 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 of

Table 9. The feeding of different length-groups of saithe upon fish. 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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																				
1June 82						19	0.0	0.0	0	0.0	3	0.0	0.0	0	0.0					
25 June 82						19	1949.9	80.4	2	0.9	10	196.3	33.4	1	0.2	1	2500.0	90.1	4	2.9
29 July 82						20	50.4	5.7	4	0.3	19	255.0	25.0	1	+	1	0.0	0.0	0	0.0
31 Aug 82	1	0.0	0.0	0	0.0	20	82.0	24.6	+	+	15	1409.3	87.6	0.4	0.2					
30 Sept 82						21	9.3	0.6	0.4	+	20	241.6	13.1	1	+					
1 March 83						7	71.4	8.5	1	0.7	20	89.0	6.1	1	0.8	6	141.6	17.8	3	4.5
B																				
10 June 82						19	10.2	0.9	0.2	+	7	0.0	0.0	0	0.0	3	33.3	4.3	1	0.4
8 July 82	19	0.4	0.0	0.1	+	19	21.8	4.3	0.2	0.1	11	1775.6	88.1	1	0.5					
23 Aug 82	1	0.0	0.0	0	0.0	2	0.0	0.0	0	0.0										
23 Sept 82	3	0.0	0.0	0	0.0	13	442.5	52.3	2	0.3	4	606.2	41.5	1	0.1					
24 Sept 82						14	25.0	12.3	1	0.8	10	17.6	9.2	1	1.0					

Table 10. Percentage of all saithe that had preyed upon fish larvae and yearlings at each sampling time for the two length-groups b–30–34 cm and c–35–39 cm.

Date	1 June 82		25 June 82		29 July 82		31 Aug 82		30 Sept 82		1 March 83	
A:												
Length-group	b	c	b	c	b	c	b	c	b	c	b	c
Percentage	0	0	79	46	50	32	5	20	29	50	43	60

Date	10 June 82		8 July 82		23 Aug 82		23 Sept 82		24 Sept 82	
B:										
Length-group	b	c	b	c	b	c	b	c	b	c
Percentage	21	0	26	70	0	–	42	75	39	40

25–65 mm size in June and of 20–35 mm size in March. In area B the greatest number of sand lances (22–29 mm) per saithe occurred in September, but the sand lances were very unevenly distributed among the predators.

DRAGONET. Small larvae (5–7 mm) of dragonet, *Callionymus* sp., *Scomber scombrus*, (5–13 mm), were common in the saithe diet.

Other prey

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

Parathemisto abyssorum, the most frequently 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, was more frequently observed in the diet in September than in other sampling periods, without regard to areas (Table 15).

Larvae of crabs are difficult to identify, especially in the different zoea stages. The megalopa stages contain more characteristics, which made it possible to identify these stages in *Hyas araneus* and *Cancer pagurus*. *H.araneus* only occurred in the saithe stomachs in June and July. Crab larvae were most important as food for the saithe in September, especially in area B. In area A

Table 11. Species composition of the fish that saithe preyed upon given in number per 100 saithe. Large numbers are underlined. (+) less than 1% by weight. Length-groupe: (a) 25–29 cm, (b) 30–34 cm, (c) 35–39 cm, (d) 40–44 cm.

AREA A	Date																							
	1 June 82				25 June 82				29 July 82				31 Aug 82				30 Sept 82				1 March 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 weight (%)		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 spp.																		33	20					
Scomber scombrus						47	40			125	47													
Limanda limanda																			5					
Microstomus kitt																		5	5					
Fish, unspecified						37	10	100											35			114		

Table 11. cont.

AREA B	Date																			
	10 June 82				8 July 82				23 Aug 82				23 Sept 82				24 Sept 82			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Fish, weight (%)		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 gunelus		16																		
Ammodytidae, fam.						5	10							100					10	
Callionymus spp.														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-group of saithe upon *Euchaeta norvegica,* Boeck. p: number of saithe stomachs, w/p: absolutte 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	9.3	1.6	2	0.3	3	27.3	4.2	4	0.8					
25 June 82						19	102.6	4.2	17	7.5	10	89.8	15.3	14	6.7	1	66.0	2.4	10	7.2
29 July 82						20	6.9	0.8	1	0.1	19	5.4	0.5	1	0.1	1	0.0	0.0	0	0.0
31 Aug 82	1	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 Sept 82						21	12.3	0.8	2	0.1	20	13.0	0.7	2	0.1					
1 March 83						7	7.3	0.9	1	0.9	20	12.5	0.9	2	1.2	6	22.3	2.6	3	3.7
B:																				
10 June 82						19	100.3	8.9	22	3.0	7	13.7	1.8	2	0.7	3	48.7	6.3	8	4.2
8 July 82	19	+	+	0.3	0.1	19	+	+	+	+	11	+	+	+	+					
23 Aug 82	1	0.0	0.0	0	0.0	2	0.0	0.0	0	0.0										
23 Sept 82	3	13.3	7.9	2	1.2	13	3.5	0.4	1	0.1	4	9.5	0.7	2	0.3					
24 Sept 82						14	0.0	0.0	0	0.0	10	0.0	0.0	0	0.0					

Table 13. The feeding of different length-groups of saithe upon *Metridia longa* (Lubbock). 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	11.1	1.9	7	1.7	3	3.5	0.5	2	0.5					
25 June 82						19	17.2	0.7	11	4.9	10	3.6	0.6	2	1.2	1	+	+	6	4.3
29 July 82						20	6.4	0.7	4	0.3	19	4.7	0.5	3	0.2	1	42.5	7.4	25	2.9
31 Aug 82	1	0.0	0.0	0	0.0	20	0.3	0.1	0.2	0.1	15	1.1	0.1	1	0.3					
30 Sept 82						21	0.0	0.0	0	0.0	20	0.0	0.0	0	0.0					
1 March 83						7	47.7	5.6	29	23.3	20	41.3	2.8	25	15.9	6	5.7	0.7	3	4.4
B																				
10 June 82						19	18.4	1.6	12	1.7	7	0.0	0.0	0	0.0	3	0.0	0.0	0	0.0
8 July 82	19	18.2	1.9	12	2.0	19	6.9	1.4	4	1.4	11	8.9	0.4	5	2.5					
23 Aug 82	1	0.0	0.0	0	0.0	2	+	+	1	0.3										
23 Sept 82	3	0.0	0.0	0	0.0	13	0.0	0.0	0	0.0	4	18.6	1.3	12	1.9					
24 Sept 82						14	0.0	0.0	0	0.0	10	0.0	0.0	0	0.0					

Table 14. The feeding of different length-groups of saithe upon *Parathemisto abyssorum*, Boeck. 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	3.2	0.5	1	0.2	3	0.0	0.0	0	0.0					
25 June 82						19	13.8	0.6	3	1.2	10	12.5	2.1	3	1.2	1	+	+	1	0.7
29 July 82						20	10.9	1.2	3	0.2	19	6.9	0.7	2	0.2	1	0.0	0.0	0	0.0
31 Aug 82	1	0.0	0.0	0	0.0	20	0.7	0.2	0.3	0.1	15	2.2	0.1	1	0.3					
30 Sept 82						21	26.3	1.6	12	0.5	20	42.4	2.3	28	1.1					
1 March 83						7	45.5	5.4	2	1.7	20	126.4	8.7	4	2.6	6	50.0	5.8	3	4.4
B																				
10 June 82						19	26.2	2.3	5	0.6	7	24.4	3.2	5	1.5	3	73.3	9.6	15	8.0
8 July 82	19	37.5	3.9	12	2.1	19	22.3	4.4	7	2.3	11	19.0	0.9	5	2.4					
23 Aug 82	1	0.0	0.0	0	0.0	2	0.0	0.0	0	0.0										
23 Sept 82	3	5.0	3.0	1	0.6	13	23.1	2.7	4	1.2	4	71.2	4.9	11	1.8					
24 Sept 82						14	33.5	16.4	10	7.8	10	24.1	12.7	7	6.6					

Table 15. The feeding of different length-groups of saithe upon *Sagitta elegans*, Verill. 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	+	+	0.2	+	3	0.0	0.0	0	0.0					
25 June 82						19	15.3	0.6	6	2.6	10	11.4	1.9	4	2.2	1	+	+	2	1.4
29 July 82						20	16.1	1.8	6	0.5	19	16.1	1.6	6	0.5	1	5.0	0.9	2	0.2
31 Aug 82	1	0.0	0.0	0	0.0	20	0.0	0.0	0	0.0	15	0.0	0.0	0	0.0					
30 Sept 82						21	270.1	16.5	104	4.2	20	217.2	11.8	84	3.4					
1 March 83						7	50.1	5.9	19	15.7	20	60.4	4.2	23	14.9	6	3.0	0.3	1	1.5
B																				
10 June 82						19	7.1	0.6	3	0.4	7	5.9	0.8	2	0.7	3	0.0	0.0	0	0.0
8 July 82	19	+	+	0.1	+	19	+	+	+	+	11	0.0	0.0	0	0.0	0				
23 Aug 82	1	0.0	0.0	0	0.0	2	0.0	0.0	0	0.0										
23 Sept 82	3	21.6	12.9	8	5.0	13	30.7	3.6	12	3.3	4	78.6	5.4	30	4.8					
24 Sept 82						14	4.6	2.3	2	1.4	10	2.8	1.5	1	1.0					

at this time crab larvae made up about 3 % of the estimated total weight, while in area B they comprised, as a mean, up to above 20 % (Table 16).

Other decapodalarvae also occurred in the saithe diet. In area A this was only in June and July, but in area B this occurred during the entire sampling period. The prey consisted 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* occurred in greatest quantities. In area B there was a greater mixture of different decapodalarvae in the diet.

Clione limacina, a carnivarous pteropod, was found in the stomach only in area A. This species seemed to occur only in autumn and winter, as it was only identified in the diet in September and March. The largest fish seemed to prey most upon *C.limacina*, which in September composed up to 2.6 % of the estimated total weight.

Spiratella(Limacina) retroversa, a herbivorous pteropod, was found in area A in the diet samples taken from the end of June until the end of September. The greatest quantity was found in July, when it composed up to 2.4 % of the estimated total weight (Table 17). In area B scattered registrations of *S.retroversa* were found in the diet of saithe during the entire sampling period. However, the quantities were never as great as in the other area.

Of other apparently minor 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 was, the more common it also was for them to prey upon sea goosberries.

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

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* all made up a minor part of the diet at times. The copepods *Candacia armata*, *Anomalocera patersoni*, and *Acartia* sp. were rarely found in the saithe diet.

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 regularly; in area B, only in connection with the sampling of saithe in June.

Table 16. The feeding of different length-group of saithe upon brachyura (crab larvae). 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

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	+	+	+	+	3	0.0	0.0	0	0.0					
25 June 82						19	2.6	0.1	1	0.6	10	+	+	0.8	0.4	1	0.0	0.0	0	0.0
29 July 82						20	2.1	0.2	1	0.1	19	2.6	0.2	1	+	1	0.0	0.0	0	0.0
31 Aug 82	1	0.0	0.0	0	0.0	20	0.0	0.0	0	0.0	15	0.0	0.0	0	0.0					
30 Sept 82						21	48.9	3.0	17	0.7	20	47.6	2.6	17	0.7					
1 March 83						7	0.0	0.0	0	0.0	20	0.0	0.0	0	0.0	6	0.0	0.0	0	0.0
B																				
10 June 82						19	5.9	0.5	4	0.5	7	+	+	1	0.3	3	0.0	0.0	0	0.0
8 July 82	19	1.4	0.2	2	0.4	19	3.1	0.6	2	0.7	11	1.0	+	1	0.5					
23 Aug 82	1	+	+	2	0.3	2	0.0	0.0	0	0.0										
23 Sept 82	3	5.0	3.0	2	1.2	13	89.2	10.6	33	9.3	4	62.7	4.3	25	3.9					
24 Sept 82						14	54.9	26.9	20	16.1	10	67.1	35.3	25	23.3					

Table 17. The feeding of different length-groups of saithe upon *Spiratella* (= *Limacina) retroversa* (Flem.). 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.

Area and date	Length-group																			
	25 – 29 cm					30 – 34 cm					35 – 39 cm					40 – 44 cm				
	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 June 82						19	0.0	0.0	0	0.0	3	0.0	0.0	0	0.0					
25 June 82						19	+	+	0.4	0.2	10	0.5	0.1	1	0.5	1	0.0	0.0	0	0.0
29 July 82						20	11.7	1.3	23	2.0	19	24.3	2.4	49	4.2	1	0.0	0.0	0	0.0
31 Aug 82	1	0.0	0.0	0	0.0	20	+	+	1	0.3	15	+	+	1	0.3					
30 Sept 82						21	5.0	0.3	10	0.4	20	4.3	0.2	9	0.3					
1 March 83						7	0.0	0.0	0	0.0	20	0.0	0.0	0	0.0	6	0.0	0.0	0	0.0
B																				
10 June 82						19	0.0	0.0	0	0.0	7	+	+	1	0.2	3	0.0	0.0	0	0.0
8 July 82	19	1.3	0.1	3	0.5	19	1.3	0.3	3	0.8	11	+	+	1	0.2					
23 Aug 82	1	0.0	0.0	0	0.0	2	+	+	3	0.8										
23 Sept 82	3	0.0	0.0	0	0.0	13	+	+	1	0.4	4	0.0	0.0	0	0.0					
24 Sept 82						14	1.8	0.9	4	3.0	10	1.2	0.6	2	2.2					

Table 18. Percentage compositions of sampled zooplankton. +: less than 1%.

Area and date 1982-1983	A 1 June 82	A 2 June	B 10 June	A 25 June	A 29 July	A 31 Aug	A 30 Sept	A 1 March 83
time (local)	2300	0500	2200	1900	2000	1900	1545	1445
Depth (meter)	30–3	30–3	35–18	30–5	20–0	35–0	20–12	30–0
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
Barnacles, cypris			8.0	+				
Gnathia sp.			+					
Amphipoda				+	+			
Krill, egg	+	4.1	+					4.2
krill, 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						

Nauplii were almost never encountered in the diet. The copepod *Microcalanus pusillus* was completely absent. Despite the observation of a great number of *Pseudocalanus* and *Paracalanus* in the plankton at certain times, the saithe preyed very little upon these copepods. *Acartia* sp. was found in relatively 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 relatively great numbers. However, *O.similis* never appeared in the saithe diet. 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 % of all *Calanus finmarchicus* preyed upon by the saithe were greater than 2.5 mm total length. Among the plankton a great number of *C.finmarchicus* were less than 2.5 mm, especially in June. The relatively large carnivorous copepod *Euchaeta norvegia*, found in small amounts in the diet, never occured in the plankton samples. *Metridia longa*, a relatively common copepod in the diet, was only identified a few 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, however, *Fritillaria borealis*, was found in the plankton samples, but never in the stomach. Krill and decapodalarvae were very scarce in the plankton samples, although the saithe had very often preyed upon these.

DISCUSSION

The age distribution showed that the length-groups between 30 and 40 cm were mainly dominated by one year class (two-year-old saithe). Differences in the diet of saithe within this length interval cannot therefore be explained by varying ages of the saithe. The stomach content analyses of an opportunistic predator, such as saithe, can easily give apparently significant results which, however, deviate from the general pattern of nutrition. Thus the saithe were considered 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 a single prey category. The most important prey at the beginning of June was *Calanus finmarchicus*, in July and September *Oikopleura* spp., and during winter krill, *Thysanoessa inermis*. At the end of June and August there was a greater variation in the diet, and fish prey was now an important component. This agrees with the observations by BERTELSEN (1942) on the feeding of O- and I-group saithe in the Faroe Islands: when a suitable prey organism for the saithe dominated 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. Fish prey seemed to be an important food item in July and September. From July epifauna and hyperbenthos was an important component, and particularly in September, several species made up the bulk of the diet.

The generally higher 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 did not dominate the diet, there were greater differences among individual 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 planktonic food became scarce, the saithe preyed upon different bottom organisms, including hydroids.

Most of the samples showed that the saithe 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 it is most likely that the saithe begin searching for other food (fish prey, epifauna and hyperbenthos) when the planktonic offering, especially copepods, is poor.

The samples of zooplankton were taken in broken vertical hauls from the same depth interval where the saithe were caught. This may lead to an overestimation of the plankton on which the saithe preferred to prey on. However, nothing from the analysis seems to support such a possibility. Furthermore, it is not entirely correct to compare the whole stomach content with the planktonic offering as observed only at a certain time and place. 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 preferences in the feeding. Although the results fron the sampling of plankton showed a different composition from that found in the diet, a plankton sample cannot 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 appear odd that *Euchaeta norvegica* never occurred in a plankton sample, and that *Metridia longa* and *Thysanoessa inermis* did not appear in the plankton sample in March, when these species were frequent in the diet. 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, 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 of the saithe for *Oikopleura*. Throughout the sampling period the saithe seemed to prefer the oldest and largest stages of *Calanus finmarchicus*. In June nauplii and specimens less than 2.5 mm of this copepod dominated the plankton. Nevertheless, the saithe had mainly preyed upon specimens greater than 2.5 mm. LIE (1961) showed that already O-group saithe preferred larger copepods than smaller species such as *Paracalanus parvus, Temora longicornis, Acartia* spp. or *Oithona similis*.

In area B a relatively large number of one-year- old saithe occurred in the samples. A possible explanation for this is that the samples were taken closer to the shore than in area A. Remarkably, almost all the the saithe disappeared from the shallows in area B from the end of July to nearly the end of August. During their absence only mackerel were left in the shallows. This is consistent with the sampling of only three saithe in August in this area. Fishermen fishing for mackerel with their drift nets in the open sea caught rather a lot of saithe. Reports from the east coast of USA (e.g., GROSSLEIN, LANGTON and SISSENWEIN 1980) showed a relatively great overlap in the diet between saithe and mackerel. A few mackerel stomachs analysed from both area A and area 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, JAKOBSEN (1978a) indicated that a possible explanation of the migration of commercial-sized saithe (above 32 cm) away from the coast might be an intraspecific competition from younger saithe migrating from the littoral zones outwards to the shallows. Many one-year-old saithe appeared in the investigated area a few weeks before the migration of older saithe. In area A in 1983 (the year after the observed migration in area B) fishermen again observed a large quantity 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 two-year-old saithe grow about 10 cm in reaching the size of a three-year-old (ANON. 1983). The length distribution of saithe in sampling areas 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 year class during summer and autumn.

It is difficult to generalize from the behaviour observed during the sampling months to the arbitrary time period. Nevertheless, based on the data from area A, it seems likely that the greatest migration of saithe from the shallow

waters occurs during spring when the saithe are three years old. This observation is an agreement with marking results and age samples from trawl catches in the North Sea (JAKOBSEN 1978a).

In March the saithe showed clear signs of starvation, resembling those of cod (LOVE 1980). The particular symptoms were the following: the liver had become small and reddish because of loss of fat, the gall bladder had increased in volume, and the colour of the gall had become darker. Larvae of the gastric parasite *Anisakis simplex* were found in great quantities in the tiny liver and in areas 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 occurs yearly, it may explain the main migration of saithe away from the coast some time after February but before June. By 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) demonstrated an extensive migration of young saithe (35–40 cm, 3–4 years) to the North Sea during the following spring (May–June).

While seeking reasons for the migration of saithe to the North Sea, it might be useful to consider the saithe food habits there. Table 19 shows that fish and krill make up the main part of the diet. Norway pout, haddock, and sand lances seem to be, in the same order, the most important species. Sand lances, which were the most important fish prey for the saithe in the shallow waters in areas A and B, also seem to be an important food for the smallest saithe in the North Sea. The importance of sand lances seem 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, with saithe feeding mainly on adult krill and showing clear signs of starvation, may be a contributing reason for the main migration of saithe away from the coast. Table 19 shows that saithe above 40 cm length are feeding mostly on krill. These are mainly three-year-old saithe, thus with the same age as those observed to feed much upon krill in area A in March before leaving the coast. In the North Sea, krill seems to play the most important nutritive 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 Deeps in June, though it has been impossible to say anything about the origin of this krill. From June and throughout the sampling period in 1982, adult krill were almost never found in the saithe diet.

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

	Data source						
	Golubjatnikova and Malyshev (1980)				Gislason (1983)		
Length-group (cm)	31–50				30–39	40–49	50–69
Area	North of 59°30′		South of 59°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 (e.g., amphipoda)	20.1	0.0	6.6	0.0	6.9	5.5	3.7

Although the plankton net seemed unable to sample adult krill, it is plausible that the adult krill had left the area some time after the first part of March but before June.

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

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THE GREY SEAL, *HALICHOERUS GRYPUS* (FABRICIUS), IN ROGALAND, NORWAY

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ABSTRACT

WIIG, Ø, 1987. The grey seal, *Halichoerus grypus* (Fabricius), in Rogaland, Norway. *FiskDir. Skr. Ser. HavUnders.*, 18: 303–309.

Surveys of grey seals in Rogaland, southwestern Norway, are reviewed. The highest numbers of adult seals have been observed in the spring, while far less are generally observed during the breeding season in the autumn. Pupping has been recorded, but it is rare in relation to the number of seals observed in the spring. The nearest breeding site of grey seals in Norway is at Froan, about 680 km to the north. The southernmost recovery of pups tagged at Froan is about 300 km north of the pupping sites in Rogaland. There are many recoveries in western Norway of grey seal pups tagged in Great Britain. There is, however, no information suggesting that British seals are being recruited to Norwegian breeding stocks or are establishing new breeding colonies on the Norwegian coast. It is reasonable to assume that most of the grey seals found in Rogaland in the spring are British and return to Britain in the breeding season. It is not known whether the recorded breedings in Rogaland are stragglers from British colonies or relate to a local stock.

INTRODUCTION

The grey seal, *Halichoerus grypus*, and the common seal, *Phoca vitulina* L., are the only resident seals on the Norwegian coast. ØYNES (1964, 1966) surveyed the breeding colonies of both these species along the Norwegian coast and SUMMERS, BONNER, and van HAAFTEN (1978) estimated the total population of grey seals in Norway to be 2 000–3 000 seals.

A study of coastal seals and their interactions with inshore fisheries along the Norwegian coast from Stad (about 62°N)to Lofoten (about 68°N) was initiated by the Institute of Marine Research in 1974. The study was later extended to cover the larger part of the Norwegian coast. One result of this study is new information on the distribution and abundance of grey seals in Norway, summarized by WIIG (1986), who has also given a more detailed

account for Finnmark county (WIIG 1987). The surveys indicate a minimum stock of 3100 grey seals in Norway.

ØYNES (1966) was unable to verify any breeding of grey seals in southern Norway. The only reported breeding locality was at Kjør in Rogaland, where a couple of pups had been reported in some years.

Recent surveys indicate that more than 100 grey seals are found in Rogaland during parts of the year, and breeding has now been verified. There is, however, a disparity between the observed numbers of seals and the very few recorded births. This disparity may be related to an immigration of grey seals from Britain, which was recently reviewed by BJØRGE and MCCONNELL (1986).

The present paper gives a detailed account of recorded observations of grey seals in Rogaland, southwestern Norway, with a discussion of the status of the stock.

METHODS

The numbers of seals have been estimated from aerial and ground surveys carried out by the Sea Mammal Section of the Instititute of Marine Research. The aerial surveys were made from twin-engined fixed-wing aircraft. In addition to direct counts, seals were photographed by 35–mm hand-held reflex-cameras, using colour reversal film as recommended by VAUGHAN (1971). The ground surveys were made from 12′–15′ Zodiac inflatable boats, which are well suited for rapid landings on rocky shores and skerries, enabling the seals to be visually counted. In addition, observations have been reported by local fishermen.

In 1984 a culling program for seals in Rogaland permitted the killing of 25 grey seals. In fact, 15 were killed and the lower jaw, internal genitalia and stomach of each of 11 seals were sent to the Institute of Marine Research for further analysis. The animals were aged from tooth sections of the canine of the lower jaw, and their reproductive status were classified from the internal genitalia.

Three foetuses collected at Kjør in 1984 were weighed and their standard length (nose–tail) measured. Parturition dates were estimated from the relationship in Boyd (1984).

RESULTS

Seal observations in Rogaland are recorded in Table 1, and the localities are shown in Fig. 1. Surveys have been performed in February, March, May, June, October, November and December. Most of the grey seals were observed from February to June, and the largest aggregation was found at Kjør. Few adults and no pups have been observed during the surveys in the

Table 1. Results of grey seal surveys in Rogaland by the Institute of Marine Research.

Date	Method	Number of sales observed	
		Largest aggregation	Total
20 February 1984	Aircraft	16 at Kjør	30
1 March 1983	Boat	60 at Kjør	60
12 March 1984	Aircraft	80 at Kjør	90
30–31 May 1981	Boat	36 at Utsira	36a)
1–3 June 1981	Boat	60 at Kjør	75a)
11 October 1982	Aircraft		0
7 November 1981	Aircraft		0
29 November 1982	Aircraft		0
10 December 1985	Aircraft	10 at Kjør	10b)

a) BJØRGE et al. 1982
b) BERGFLØDT et al. 1985

breeding period from October to November. During the latest aerial survey (December 1985), only about 10 adult grey seals were observed at Kjør. In addition to these observations, surveys at Kjør were performed on several occasions by boat, during autumn 1985 (Table 2). Only a few adults and no pups were observed.

Most of the aged grey seals appeared to be young, and only two of eleven specimens were older than six years (Table 3). They were all shot in the autumn, but only two of the seven males were classified as mature. All four females, however, were pregnant or had given birth during the year of killing. Weight and standard length of the foetuses and the estimated parturition dates are given in Table 4.

In recent years, five white pups have been observed at Kjør (R. Roth pers. comm. to B. Bergfløtdt), in November/December 1983 one white pup was photographed at Higgilen near Kvitsøy (L. Reinertsen pers. comm.), one white pup was seen at Lausingen near Utsira on 22 August 1984. (O. Tørstad pers. comm. to T. Øritsland), one white pup was observed at Kjør on 13 November 1984 (T. Ølberg pers. comm.), and a large pup, with remnants of white hairs, was seen at Higgilen near on Kvitsøy 2 January 1985 (L. Reinertsen pers. comm.).

DISCUSSION

Grey seals lived in Rogaland several thousand years ago (WIIG 1986). Archaeological excavations at «Vistehålå», a Stone Age site near Stavanger, have disclosed more than 200 bone remains from grey seals (OLSEN 1976), which was the second most abundant species at the site. The site has been

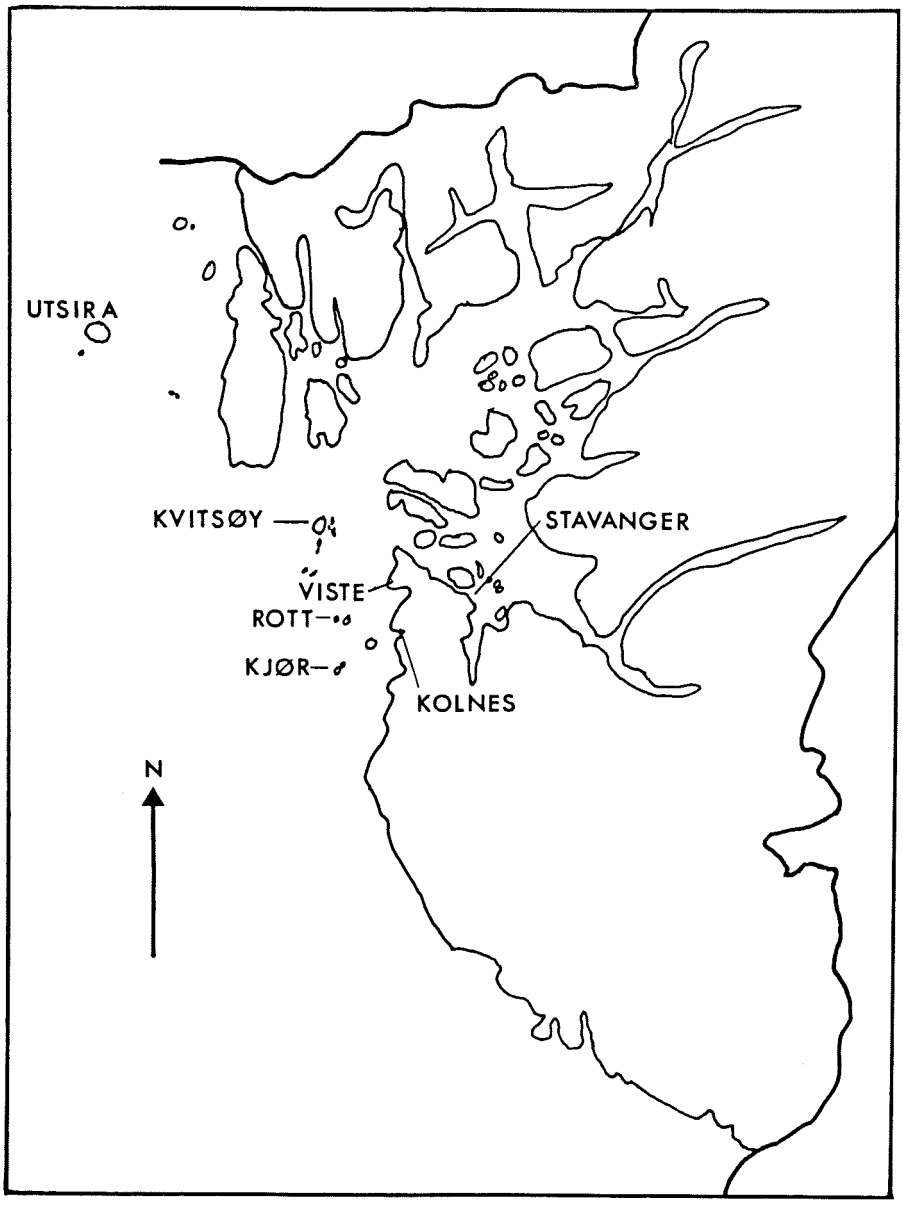

Fig. 1. Grey seal localities in Rogaland, Norway.

Table 2. Surveys of grey seals at Kjør in Rogaland in autumn 1985.

Date	Method	No. of seals observed	References
30 September	Boat	36	ELDØY pers. comm.
29 October	Boat	15	ELDØY pers. comm.
5 December	Aircraft	10	BERGFLØDT et al. 1985
9 December	Boat	11	MUNKJORDET pers. comm.

Table 3. Grey seals collected in Rogaland in 1984.

Locality	Date	Sex	Age	Mature
Rott	8 June	M	4	NO
Rott	2 September	F	4	YES (foetus)
Kjør	8 November	M	10	YES
Kolnes	13 November	F	6	YES (foetus)
Kjør	13 November	M	4	NO
Kjør	13 November	M	5	NO
Kjør	13 November	M	3	NO
Kjør	13 November	M	6	YES
Kjør	13 November	F	5	YES (foetus)
Kjør	13 November	F	17	YES
Kjør	13 November	M	4	NO

Table 4. Grey seal foetuses collected in Rogaland in 1984.

Location	Date	Weight (kg)	Length (cm)	Estimated parturition date
Rott	2 September	7.0	66	27 November
Kolnes	13 November	12.5	87	19 December
Kjør	13 November	11.5	90	13 December

dated to 8 000–6 000 B.P. by the Radiological Dating Laboratory, the Norwegian Institute of Technology, Trondheim, Norway (HUFTHAMMER pers. comm.). Pig (*Sus scrofa* L.) (49.5%) is the only species which has more abundant remains than the grey seal (13.0%). Only two other archaeological sites have grey seal remains of this abundance in Norway, these are the mesolithic sites «Kirkehelleren» at Træna and «Storbåthelleren» at Flakstadøy in Lofoten. According to DEGERBØL (1951) there is no doubt that grey seals bred in the neighbourhood of «Vistehålå». The site is situated only 2 km from Kjør, where grey seal pups have now been recorded.

The stock of grey seals in Rogaland was estimated to be 120 specimens in

1983 (ØRITSLAND 1983). A stock of that number would usually produce 20–30 pups. The few observations of pups indicate that the actual pup production is much lower.

Grey seals are not usually found at the breeding site throughout the year. After breeding they disperse and do not return until the next breeding season. Meanwhile they gather at moulting sites in the spring (e.g., HEWER 1974). Most grey seals probably return to breed at the rookery of their birth (BONNER 1981).

The nearest breeding site of grey seals on the Norwegian coast is at Froan, about 680 km north of Kjør. At this locality 576 pups were tagged in the period from 1975 to 1985. The southernmost recovery of these pups is at Florø, about 300 km north of Kjør (WIIG and ØIEN in prep.).

Since tagging of grey seals in Great Britain was initiated in 1951, a total of 61 seals have been recovered in Norwegian coastal waters (BJØRGE and MCCONNELL, 1986). Fifty-eight of these were recovered within six months of tagging. Most of the recoveries were made on the western coasts from Rogaland to Sogn og Fjordane. According to HICKLING, RASMUSSEN, and SMITH (1962) and HEWER (1974) this long distance dispersal is probably due to wind. The immigration from Great Britain is estimated to have been about 14300 seals in the period from 1960 to 1981, averaging about 650 grey seals pups per year (BJØRGE and MCCONNELL 1986). These correspond to a production of a stock of more than 2500 seals, which is more than 75% of the total Norwegian population of grey seals, according to the figures of WIIG (1986). There is, however, no information suggesting that British grey seals are being recruited to Norwegian breeding stocks or are establishing new breeding colonies on the Norwegian coast. The few records of breeding in western Norway during the last 25 years support this. It is therefore uncertain where these seals actually breed when they become mature. According to the results of Norwegian taggings, the mature grey seals seem to return to their place of birth for reproduction (WIIG and ØIEN in prep.). Some mixing between the stocks is, however, probable. This has been verified in Britain (HARWOOD et al. 1976) and in Canada (MANSFIELD and BECK 1977).

The numbers of grey seals observed in Rogaland in the spring is much higher than in the breeding season. It is resonable, therefore, to assume that the seals found in Rogaland in the spring are British and that these return to Britain in the breeding season as also suggested by BJØRGE and MCCONNELL (1986). However, some seals evidently do breed in Rogaland, but it is uncertain whether these constitute a local stock or are just occasional young stragglers from the British stocks. The dated records of foetuses and pups suggest a pupping time in November and December in most of the cases. This is later in the year than along most of the Norwegian coast, where breeding occurs between September and November (WIIG 1986).

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