International Council for the Exploration of the Sea

CM 1995/M:12
Anacat Committee

POSTSMOLTS OF RANCHED ATLANTIC SALMON (*Salmo salar* L.) IN ICELAND: IV. Competitors and predators

by

Konrad Thorisson[1] and Johannes Sturlaugsson[2]

[1]*Marine Research Institute, Skulagata 4, 101 Reykjavik, Iceland*
[2]*Institute of Fisheries and Aquaculture research, Vagnhofdi 7, 112 Reykjavik, Iceland*

Abstract

During fishing for salmon (*Salmo salar* L.) postsmolts in West Iceland in 1993, all by-catch was examined as potential competitors for food or potential predators on the postsmolts. The most numerous species in the by-catch were: saithe (*Pollachius virens* (L.)), short spined sea scorpion (*Myoxocephalus scorpius* (L.)), cod (*Gadus morhua* L.) and greater sandeel (*Hyperoplus lanceolatus* (Le Sauvage)). In August 1993 salmon postsmolts and saithe of similar size shared five of eight of their most important food groups. Cod also shared more than half of the most important food groups with the postsmolts, but sea scorpion and greater sandeel were not competing with the postsmolts for food. The salmon postsmolts migrated almost 40 km from the releasing site during the first 24 hours after release, which reduces the competition for food with the marine species. Salmon postsmolts were found in the stomach of (or seen taken by) 12 species of birds, 4 species of fishes and 2 species of seals. Estimated total predation on the salmon postsmolts during the first 24 hours after release was 0.2 - 1.1 %.

Introduction

Information on the ecology of Atlantic salmon (*Salmo salar* L.) postsmolts is still rather limited. It has repeatedly been suggested, however, that the first days or weeks of the sea migration are a critical period for the postsmolts with elevated mortality (Larson 1984, Hvidsten and Lund 1988, Hvidsten et al. 1993). Hvidsten and Lund (1988) have suggested that cod may be a large scale predator on salmon postsmolts during the first days of their sea migration, and Montevecchi et al. (1988), have shown that postsmolts are taken by avian predators.

Studies on food competition between salmon postsmolts and marine fishes are few (Hvidsten et al.1993) but as the uppermost 10 m of the near shore waters are often shared by seithe (Godø et al. 1989) and salmon postsmolts these two species are potential competitors for the available food.

The purpose of the present study was to find marine fish species that compete with the salmon postsmolts for food, and predators that prey on the postsmolts. Furthermore to estimate the effect of these competitors and predators upon the postsmolts during their first hours or days in the sea.

Material and methods

The data were collected during April to September 1993 and June to July 1994 in Kolgrafafjord and the Southern half of Breidafjord (Fig. 1). Some supplementary material from an earlier study in Kolgrafafjord during June 1990 will also be used. Most of the methods and material have been described elsewhere (see papers I and II in this series), and will not be repeated here. A description of the material and methods exclusive to this part of the study follows.

During the study of the migration of salmon postsmolts (see paper II in this series), all sea-fish caught in the various fishing-gear were examined. The length and weight of the fish was measured, either the day they were caught or they were deepfrozen the same day and measured later. The stomach was removed for later inspection. The stomach contents of fish from selected dates were separated into species or species groups, and each group counted and weighed separately. The stomach content of all by-catch fish from the driftnet fishing during 7. - 11. August, and bycatch from the beach net settings from the same days was examined in this way.

One net unit in each driftnet set had a series of coarse meshes (see paper II in this series) suited to catch fish which were potential predators on the salmon postsmolts. The stomach of all large fish caught were searched for salmon smolts. In addition, the stomach content of all seals, birds and large fish from the southern part of Breidafjord, made available by others, were examined and the number of postsmolts, if any, was recorded.

The behaviour of the birds present during and after three postsmolt releases was studied (Nielsen 1995) and seals were counted in Kolgrafafjord after 11 postsmolt releases.

Results

Saithe (*Pollachius virens* (L.)), was the most numerous of the marine fish caught. Other sea-fish frequently caught were greater sandeel (*Hyperoplus lanceolatus* (Le Sauvage)), cod (*Gadus morhua* L.) and short spined sea scorpion (*Myoxocephalus scorpius* (L.)). The length distribution of these species is shown in Figure 2. For comparison, the average length of the salmon postsmolts in 1993 was 20 cm, but only 15 cm in June 1990 (see paper II in this series).

During the period of most intense fishing in August 1993, saithe of comparable size to the salmon postsmolts were competing with the salmon postsmolts (Fig. 3 a). Five of the eight most important food groups were shared. Similarly, 28 June 1990 seithe fed on six of the eight most important food groups of the postsmolts (Fig. 3 b). There was also some overlap in the food of salmon postsmolts and cod of similar size in August 1993 (five shared food groups out of eight), but the number of fish was small (n = 12 + 8 respectively).

A list of proven predators is shown in Table I. In most cases salmon postsmolts have been found in the stomacs but in few cases (birds), the species has only been seen to take the postsmolts. Cod was added subsequently to the list by a local fisherman who caught several cod with salmon postsmolts in their stomachs.

Table I. A list of proven predators on the salmon postsmolts (The list of birds is largely from Nielsen 1995).

Birds	**Fishes**
Fulmar - *Fulmarus glacialis*	Salmon - *Salmo salar*
Gannet - *Sula bassana*	Cod - *Gadus morhua*
Cormorant - *Phalacrocorax carbo*	Seithe - *Pollachius virens*
Black guillemot - *Cepphus grylle*	Sea scorpion - *Myoxochephalus scorpius*
Puffin - *Fratercula arctica*	
Great black-backed gull - *Larus marinus*	
Lesser black-backed gull - *Larus fuscus*	
Black headed gull - *Larus ridibundus*	**Seals**
Kittiwake - *Rissa tridactyla*	Harbour seal - *Phoca vitulina*
Glaucous gull - *Larus hyperboreus*	Grey seal - *Halichoerus grypus*
Arctic tern - *Sterna paradisaea*	
Arctic skua - *Stercorarius parasiticus*	

To calculate the maximum total predation on the salmon postsmolts, the following data and estimates were used:

1) The bird studies showed that the birds were eating maximally 8, 21, and 135 salmon postsmolts the first two hours after each release (Nielsen 1995). Almost all this predation happened less than one km from the releasing site. Average predation by birds was thus 55 postsmolts per release.

2) A total of 18 seals were seen during the 11 postsmolt releases studied, 1.6 seals per release on the average. Eleven seal stomachs were examined, with a total of 49 postsmolts or 4.5 postsmolts/seal on the average. Therefore, the average number of postsmolts eaten by seals / release was 1.6 * 4.5 = 7 postsmolts.

3) Salmon postsmolts were found in the stomacs of three species of fish, saithe, sea scorpion and maturing homing salmon (Table I). In addition to this, a local fisherman found salmon postsmolts in the stomachs of cod caught in this area. Of the three marine species, fish large enough to eat the salmon postsmolts were rare in this area. Out of the about 5,100 sea fish caught during the whole study only 201 sea fish were considered potential predators, i.e. sea scorpion ≥ 20 cm, cod and saithe ≥ 25 cm. In the stomachs of those 201 fish a total of 5 salmon postsmolts were found. Estimated average number of large marine fish (assuming the same catching efficiency of nets for sea fish as for the salmon postsmolts) was about 4,500. In addition to the true marine fishes, cannibalistic maturing adult salmon was also found and in the 190 salmon stomachs examined a total of 5 postsmolts were recorded. The occurrence of postsmolts in homing adult salmon and in the larger marine fishes is thus about the same (about 0.025 postsmolts / predator). During the harvesting season, about 1000 adult salmon are caught each day at the Silfurlax ranching station. Assuming that all these salmon were inside Kolgrafafjord during the first two hours after the release, they probably ate about 1,000 * 0.025 = 25 postsmolts. Additionally the marine fishes consumed per release about 4,500 * 0.025 = 113 postsmolts

A total of 200 salmon postsmolts are thus eaten during the first two hours after release (i.e. while they are still inside Kolgrafafjord). For a release of 223,000 postsmolts (average for 1993), this corresponds to only 0.09 % of the released postsmolts during the first 2 hours after release.

Predation on the salmon postsmolts is probably reduced in Breidafjord. This conclusion is based on the following: a) In our fishing experiments in Breidafjord 1993 and 1994, no sea fish, large enough to be a predator was caught. b) Even though seals were abundant in Breidafjord, they were sparsly distributed along the most probable migrating route of the salmon postsmolts. During the present study only a single seal was once seen in this area. c) The 32 birds accidentally caught in our nets had no salmon postsmolts in their guts. No birds were seen either, to take salmon postsmolts in Breidafjord, except few from our nets.

Discussion

Saithe of similar sizes as the salmon postsmolts are rather common in Kolgrafafjord. Sea scorpion, cod and greater sandeel are also fairly common in this area. Data from 1990 and 1993 show that saithe was competing with the salmon postsmolts for food in both June and August (Fig. 3). Of the potential competitors saithe is also the species most similar to the salmon postsmolts in behaviour, inhabiting the uppermost 10 m (Godø et al. 1989). The food preference of cod and salmon postsmolts seemed also to overlap, but neither sea scorpion nor greater sandeel competed with the salmon postsmolts for food. Because of the fast migration of the salmon postsmolts (see paper II in this series) the feeding of the postsmolts on the one hand, and saithe and cod on the other, are unlikely to affect either appreciably.

The calculated predation on the salmon postsmolts during the first two hours after release, while still inside Kolgrafafjord, was 0.09 %. That no predation was found in Breidafjord, indicates a lower predation rate there, than inside Kolgrafafjord.

That predation from seals is reduced in the outer area is supported by a survey of the food of seals in the southern part of Breidafjord 1992. During April to September, 67 grey seal stomachs and 58 harbour seal stomachs from this area were examined. No salmon postsmolts nor postsmolt otoliths were found in the seal stomachs (Valur Bogason personal communication).

Contrary to the present findings of low predation rate by fish in Breidafjord, however, is the following observation of a local fisherman. There was a large release of salmon postsmolts from another salmon ranching station 18 km West of the Silfurlax station during spring 1995. The following day a fisherman on an small fishing vessel took about 400 kg of large cod, from a small area less than one km from the releasing site. According to this fisherman all the cod had salmon postsmolts in their stomachs and up to 10 postsmolts per cod. The condition of these postsmolts can be questioned however, as the man himself was able to catch some postsmolts in this area with a simple handnet (Sigurdur Einarsson personal communication).

Let us assume that the mortality of salmon postsmolts is primarily caused by predation. If we, as a minimum, assumed an order of magnitude lower predation rate in Breidafjord than in Kolgrafafjord, the total predation during the first 24 hours after release, was just 0.09+11*0.009 ~ 0.2 % of the released postsmolts (a minimum daily mortality). As a maximum estimate let us suppose that the predation was equally high in Breidafjord bay as in Kolgrafafjord. This would mean that during the first 24 hours the mortality was 12 * 0.09 ~ 1.1 % (a maximum daily mortality). Using these estimates and assuming a constant daily mortality, the total mortality during the first year in the sea would equal 2-48 % in returns, which is as good or better than observed values.

The suggested hasardous first days or weeks at sea are thus not supported by this study and alternative causes of mortality are to be looked for. Friedland et al. (1993) also doubt the high mortality ment to occur at the beginning of the sea migration. In direct contrast to this Hvidsten and Lund (1988), estimated in river Orkla in Norway that 20% of the postsmolts were eaten in the estuary by cod alone.

The primary cause of the very high mortality of salmon postsmolts during their sea migration remains unknown. Salmon with ripe gonads have, however, been reported from the Norwegian sea, hundreds of km from the nearest coast (Olafsson 1987). This may indicate that some salmon are unable to find land in time, before the maturation process advances too far. Even though this salmon may be able to absorb the gonads again, and find land the subsequent year, an increase in total mortality will result. This is just one of several possible causes of mortality that need to be investigated to clarify these matters.

Acknowledgement

Thanks are due to director Jakob Jakobsson of the Marine Research Institute and director Arni Isaksson of the Institute of Freshwater Fisheries for their assistance in finding ways to finance the study. We thank Hildur Petursdottir for the identification of the zooplankton samples. Thanks are due to Valur Bogason for making unpublished data on the food of seals available to us and to Olafur K. Nielsen for permission to use the data on birds. Thanks are also due to an anonymus reviewer and Margret Audunsdottir for corrections on the manuscript and helpful suggestions. We also acknowledge the help of the staff at Silfurlax Ltd. ranching station. This study was sponsored by the Research Council of Iceland and the Icelandic Ministry of Fisheries.

References

Friedland, K. D., D. G. Reddin and J. F. Kocik. 1993. Marine survival of North American and European Atlantic salmon: effects of growth and environment. ICES J. mar Sci. 50: 481-492.

Godø, O. R., J. Gjøsaeter, K. Sunnanaa and O. Dragesund. 1989. Spatial distribution of 0-group gadoids off mid Norway. Rapp. P.-v. Reun. Cons. int. Explor.Mer. 191: 273-280.

Hvidsten, N. A. and R. Lund. 1988. Predation on hatchery- reared and wild smolts of Atlantic salmon, *Salmo salar* L., in the estuary of River Orkla, Norway. J. Fish Biol. 33: 121-126.

Hvidsten, N. A., J. Sturlaugsson, R. Strand and B. O. Johnsen. 1993. Naeringsvalg hos fjordutsatt havbeitesmolt av laks pa Island og i Norge (Food of ranched Atlantic salmon (*Salmo salar* L.) postsmolts in coastal waters in Iceland and Norway., with English abstract). NINA Oppdragsmelding 187: 1-16.

Larson, P. O. 1984. Growth of Baltic salmon *Salmo salar* in the sea. Mar. Ecol. Prog. Ser. 17: 215-226.

Montevecchi, W. A., D. K. Cairns and V. L. Birt. 1988. Migration of postsmolt Atlantic salmon, *Salmo salar*, off northeastern Newfoundland, as inferred from tag recoveries in a seabird colony. Can. J. Fish. Aquat. Sci. 45: 568-571.

Nielsen, O. K. (In press). Afran fugla a laxaseidum vid sleppingar i Kolgrafafirdi sumarid 1993 (Predation by birds on salmon postsmolts after release in Kolgrafafjord in the summer of 1993. In Icelandic, with English abstract). Bliki, Natturufraedistofnun Reykjavik.

Olafsson, G. 1987. Laxveidiferd med Faereyingum i Noregshafi 1982 (A trip on a Faroese salmon fishing boat in the Norwegian Sea in 1982. In Icelandic, with English summary). Natturufraedingurinn 57: 115-126.

Sturlaugsson, J. and K. Thorisson. 1995. Postsmolts of ranched Atlantic salmon (Salmo salar L.) in Iceland. II. The first days of the sea migration. ICES, C.M.1995/M:15. 17 p.

Thorisson, K. and J. Sturlaugsson. 1995. Postsmolts of ranched Atlantic salmon (Salmo salar L.) in Iceland. I. Environmental conditions. ICES, C. M.1995/M:10. 9 p.

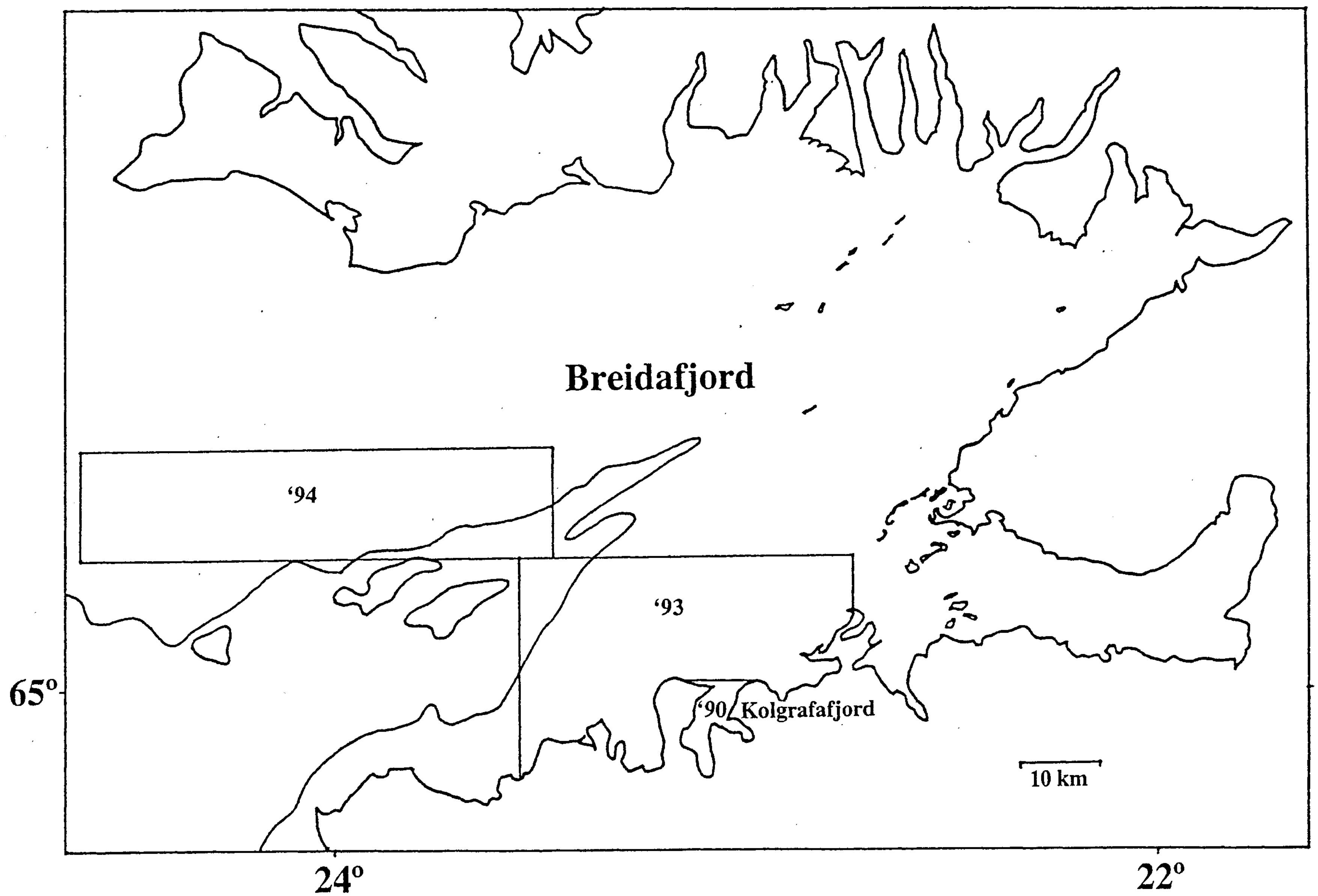


Figure 1. a) Map of Breidafjord West Iceland. The main sampling areas of different years are shown. Each year, some additional sampling was done in the area of the previous year.

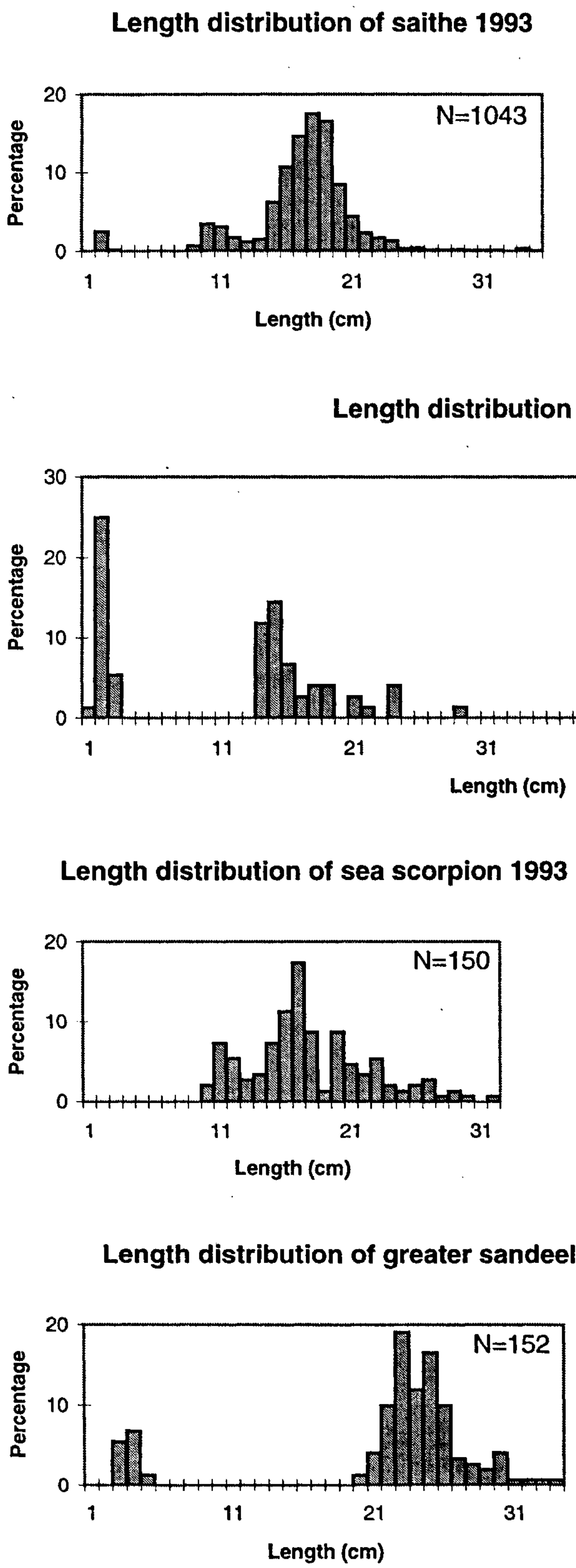
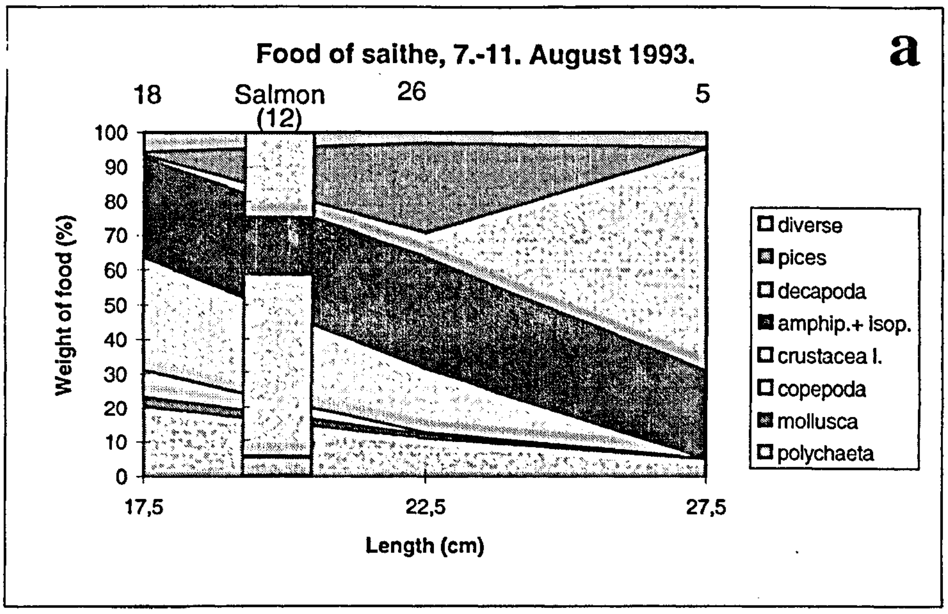


Figure 2. The length distribution of the most common marine fish, that were caught with the salmon postsmolts in 1993. The number of fish (N) is shown. For comparison see length distribution of postsmolts in paper II in this series.



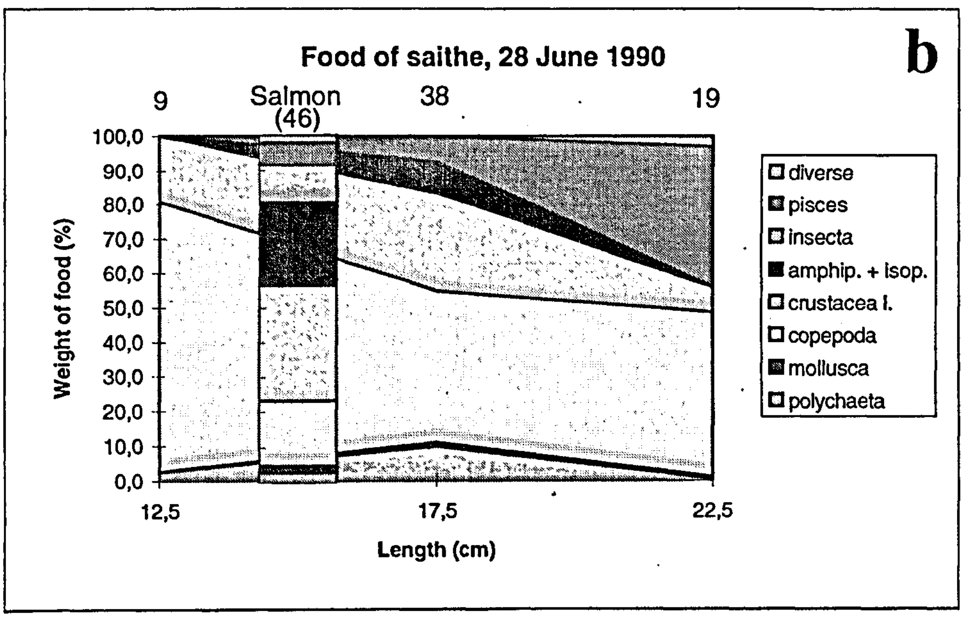


Figure 3. a) The food composition of 15-30 cm long saithe in August 1993. b) The food composition of 10-25 cm long saithe in June 1990. For comparison, the food of the salmon postsmolts caught in the same nets is also shown (the average length of postsmolts was 15 cm in June and 20 cm in August).