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The food of Atlantic salmon, *Salmo salar* L., north of the Faroe Islands

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ABSTRACT

The food of salmon was investigated from samples taken in a research fishery for salmon north of the Faroe Islands. The salmon caught on floating long-lines were sampled in November-March during the three consecutive fishing seasons 1992/93, 1993/94 and 1994/95, in total, 3,848 stomachs were collected. The proportion of empty stomachs was on average 31%, being significantly higher in December (47%) than in March (22%). Crustaceans of the genus *Themisto*, euphausiids and shrimps were most frequently found in the stomachs, then followed by pelagic and mesopelagic fish consisting of lantern fishes, pearlsides and barracudinas. In total number the crustaceans accounted for more than 80% of the food. In weight more than 60% of the food was fish consisting of the same mesopelagic fish as previous but now the relatively few herring, blue whiting and mackerel present contributed significantly to the weight. Generally the average prey size in the stomachs did not depend on fish size, except for *Themisto libellula*, where a significant positive relationship was observed. Early in the fishing season (November-December) the crustaceans dominated the stomachs whereas fish were most abundant during February-March. The available prey sampled from 15 plankton tows at 0-50 m depth, generally included the same species as were found in the stomachs, although salmon did not feed on *Sagitta* spp. and *Calanus finmarchius* that were observed in the plankton samples.

Keywords: Food composition, ocean, opportunistic forage, prey selection, *Salmo salar*, stomach content.

INTRODUCTION

Although more information about Atlantic salmon in the marine phase has been generated/gained in recent years (Mills 1993), still little is known about the food and feeding habits of salmon in the Northeast Atlantic (cf. Hislop & Shelton 1993 for review). The few studies so far in the Faroese area and the Norwegian Sea mainly give a qualitative picture of the importance of the prey species for salmon (Struthers, 1970; 1971; Thurow, 1973; Hislop & Youngson, 1984; Hansen & Pethon, 1985). Salmon spend most of its time in the ocean pelagically near the surface where they prey on various pelagic or mesopelagic animals such as different species of crustaceans, mostly amphipods and euphausiids, different fish species like myctophids, pearlsides, capelin, sand eels, herring, and barracudinas, and on the arctic squid.

Several authors have suggested that Atlantic salmon are opportunistic feeders (Hansen & Pethon 1985; Reddin 1988; Hislop & Shelton 1993). However, there is no information available to compare the distribution of food organisms available to salmon and what they really eat.

In this paper we examined qualitatively and quantitatively the food of Atlantic salmon during November-March through three consecutive fishing seasons, 1992/92, 1993/94 and 1994/1995 north of the Faroe Islands. Furthermore, we examined whether salmon is an opportunistic feeder by comparing data from plankton sampling and stomach content of salmon, and to assess if large salmon prefer larger prey than small salmon.

MATERIAL AND METHODS

Sampling

Atlantic salmon were caught north of the Faroe Islands using floating long-lines set by commercial fishermen, baited with good quality sprats (around 12 cm total length). The lines were usually set early in the morning, hauling started approximately at noon and were completed between 5 and 10 hours later, dependent on the weather conditions and other possible complications that occurred (e.g. breaking of the line). The average number of hooks in each set was about 2,000, and usually the first 50 salmon caught were sampled for stomach analysis. Fishing took place between November and March during three consecutive fishing seasons 1992/93, 1993/94 and 1994/95, stomach samples were taken over the whole season, and in total 3,848 stomachs were collected (Table 1). The salmon fishery starts in November in the western and north-western area of the Faroese EEZ (south-west of the stippled line in Figure 1) and as the season progresses the fishery moves gradually in an north-eastern direction towards the fishery limit in March (north-east of the stippled line in Figure 1).

Immediately after capture the salmon were measured (fork length and total weight), sexed, and the stomachs were removed and frozen. The fish were determined to be wild or farmed by examining whether the fish showed external characters like e.g. fin erosion which is common on reared salmon (Lund *et al.*, 1989). The length distribution of wild and farmed fish is shown in Figure 2. Furthermore, scale samples were collected from the area recommended by Shearer (1992).

In the laboratory, the stomachs were examined, and the prey were determined to species, if possible. However, parts of the food items were digested to varying degrees making identification to species impossible, in those cases either the genus or the taxa was specified. The number of the different prey were noted, and their lengths and weights were recorded.

Sprats that were obviously baits were observed in a number of stomachs, and in some stomachs we observed more than one sprat. A number of stomachs (5% of the total number) also contained different inorganic material, such as nylon gut, sheets of plastic, dry paint etc. Bait and inorganic material were excluded from further analysis.

On 15 localities (Figure 1, encircled points) sampling of plankton was carried out at the fishing stations using a "Modified Isaackid midwater trawl" (MIK), which is a 2 m diameter plankton net towed for 30 minutes with 2-3 knots in three depths (10 min at each depth): 5 m, 25 m, and 50 m. The retained material was conserved and stored on 4% formaldehyde solution, and determined to species in the laboratory. The MIK plankton samples were taken in March and November 1994 (5 samples) and in February-March 1995 (10 samples).

Stomach analysis
About 25 stomachs were thawed in one batch and subsequently analysed. The stomach content was spread on the desk and large specimens, i.e. fish, shrimps and bait (fresh sprat) were first picked out of the material, thus representing the total amount of those species in the sorted material. Then the rest of the material was grouped by the degree of digestion, leaving the most digested material impossible to identify to genus or family as one batch which was weighted and given a "species"-code as, e.g. crustacea, pisces or unidentified organic remains. The remaining stomach content was sorted into species and measured and weighted individually if possible, or sorted into length groups which were weighted and counted.

It was attempted to collect and conserve fresh and good quality reference specimens from the stomachs for future consultation and to aid in solving possible ambiguities in species identification at a later stage. As an aid in species identification of fish difficult to identify due to advanced digestion, the otoliths were removed and identified, by consulting a reference sample of otoliths from fresh material of all observed species. This was found to be a particularly convenient exercise and is recommended in such kind of analysis. The barracudinas (Paralepidae: *Notolepis rissoi kroyeri* and *Paralepis coregonoides borealis*) were grouped into species when it was possible to count all vertebrae, the *N. r. kroyeri* has fewer vertebrae (67-73) than *P. c. borealis* (77-84) (Whitehead *et al.*, 1984). Bones of herring (*Clupea harengus*) including the full vertebrae were easily identified by number of vertebrae and the characteristic otoliths. Blue whiting (*Micromesistius poutassou*) and mackerel (*Scomber scombrus*) were also relatively easy identified by the aid of the otoliths.

As the digestion of prey progresses the flesh and soft parts of the animals are absorbed faster than the hard parts, leaving endo- or exosceletons left in the stomachs to measure and weight. From this it is obvious that the obtained weight distribution of the prey is biased downwards, the weight at length being underestimated from the stomachs samples. Therefore a number of prey was only measured in length as the weight would be meaningless. To partly overcome this source of error in the subsequent analysis the "fresh" stomach material that were possible to identify to species, was measured and weighted, and a length-weight regression was then used for estimation of weight of prey items which were difficult or impossible to weight (Berg, 1979). However, the total number of specimen estimated this way was less than 2% of the total number in the stomach material analysed.

To analyse the dietary importance of different prey items for salmon, four indices were used, if possible to obtain from the material (see Hyslop (1980) for a review on methods): percentage frequency of occurrence (%F), percentage in number (%N), percentage in weight (%W), and %IRI (Index of Relative Importance), IRI = %F*(%N+%W) (Pinkas *et al.*, 1971) and %IRI = IRI_i *100/ IRI_t where the subscript i refers to prey item i and subscript t stands for sum of IRI_i over all i (Emmet *et al.*, 1986).

RESULTS

Empty stomachs

The proportion of empty stomachs was on average 31%, being significantly higher in November-December (47%) than in February-March (22%) (X^2=131, p=0.000) (Figure 3), and this was also the case for each individual season. The results of the comparison of the proportion of empty stomachs between wild and farmed salmon among fishing seasons showed a significant difference in the 1994/95 season (X^2= 6.63, p=0.01), being higher in the wild fish than expected provided that this was a random sample. The average food content in weight (g) per salmon is lower in the November-December period than in February-March in each fishing season (Figure 4).

Prey composition

Table 2 details the different prey species recorded in the salmon stomachs by frequency of occurrence (%) and Table 3 gives the details of the same food organisms by weight percentages for each month during the 1992/93, 1993/94 and 1994/95 fishing seasons.

Crustaceans of the genus *Themisto*, euphausiids and shrimps were most frequently found in the stomachs (Table 2), then followed by pelagic and mesopelagic fish consisting of lantern fishes, pearlsides and barracudinas. In total number the crustaceans accounted for more than 80% of the food. In weight (Table 3) more than 60% of the food was fish consisting of the same mesopelagic fish as previous but now the relatively few herring, blue whiting and mackerel present contributed significantly to the weight.

To study the different measures of dietary importance of different food items/groups from the present stomach analysis, two representations are given. In Figure 5 the percentage distribution of stomach content is given in number (%N) and weight (%W) of the major species groups: *Crustacea*, *Pisces* and "Other" for all seasons combined. Figure 6 presents the frequency of occurrence (%F), the numerical percentages (%N) and weight percentages (%W) superimposed on each other for each prey species.

The most important crustaceans were: amphipods (*Themisto libellula, T. compressa, T. abyssorum* and *Eusirus holmi*), shrimps (*Hymenodora glacialis*) and krill (*Meganyctiphanes norvegica* and *Thysanoessa inermis*).

The most important fishes were: pearlside (*Maurolicus muelleri*), lantern fishes (*Benthosema glaciale* and *Notoscopelus kroeyeri*), barracudinas (*Notolepis rissoi kroyeri*, *Paralepis coregonoides borealis*), herring (*Clupea harengus*), blue whiting (*Micromesistius poutassou*), capelin (*Mallotus villotus*) and mackerel (*Scomber combrus*). It should noted that only 19 herring and 17 blue whiting were found in the salmon stomachs, however, the weight of these fish (prey) in these 36 salmon accounted for 12% of the total weight of all prey in the 2,664 stomachs containing food.

The species and size composition of *Themisto libellula* and *T. compressa*, two of the three species of the genus *Themisto* spp. observed as prey, showed an inverse relationship of occurrence in the salmon stomachs (both in frequency (Table 2) and in weight (Table 3)). When *T. compressa* is present in large numbers and weight, then the number of *T. libellula* is low and vice versa.

Prey size
We were able to examine the relationships between average prey size and fish size for *Themisto libellula*, *Meganyctiphanes norvegica*, *Hymenodora glacialis* and *Maurolicus muelleri*. Generally the average prey size in the stomachs did not depend on fish size, except for *T. libellula*, where a significant positive relationship was observed (r^2=0.039, df=426, p<0.0001) (Figure 7). The prey length data of *T. libellula* were transformed to natural logarithms to assure that they were normally distributed, however, a large significant positive autocorrelation was observed in this material, based on residual plots from Systat (Wilkinson, 1992). A significant autocorrelation indicate that the error term is not independent and according to Sokal & Rolf (1995) implying that the validity of the usual F-test of significance can be seriously impaired.

Seasonal variation in the food
Certain grouping of species, genus or major taxa were done to evaluate possible trends in time, as a varying proportion of the sorted material was identifiable to species for some groups in the different periods. The monthly distribution (1992-95) between crustaceans and fish of frequency of occurrence, number and weight percentages and %IRI is shown in Figure 8a-d. The proportion of crustacea is high in the beginning of the fishing season (November-December) and diminishes in the February-March, the trend being less pronounced in the 1994/95 fishing season. The fishes, on the other hand, do show an opposite trend with increasing importance in the diet in the late winter period (February-March) (Figure 8a-d). The crustaceans and fish account for more than 98% of total stomach content.

Prey availability and prey selection
The available prey was sampled with a MIK plankton net in the area where salmon stomachs were collected. The organisms available in the surface layer (0-50 m depth) generally included the same species as were found in the stomachs, although *Sagitta* spp. and *Calanus finmarchius* were found in the plankton samples, but were absent from the salmon stomachs. Of the species found in both the plankton sample and in the salmon stomachs, three species were studied in more detail: the amphipod *Themisto libellula* (Figure 9), krill (*Meganyctiphanes norvegica*) (Figure 10) and pearlside (*Maurolicus müelleri*) (Figure 11). The percentage length distribution of the species from the stomachs and from the plankton samples were superimposed on each other for

comparison. Generally the size distribution of the prey eaten by salmon was larger than the size groups of the available animals caught in the plankton samples. This is especially true for the *M. müelleri* (Figure 11), where the 1 and 2+ groups (Gjøsæter, 1981) were well separated, and also an apparent difference in the length distributions for *M. norvegica* is noted, the length distribution from the MIK plankton samples being shifted 2-3 mm downwards (Figure 10).

DISCUSSION

The fishing locations during the three fishing season are approximately in the same areas each season. However, in the 1993/94 season a few sets were taken east and south of the Faroe Islands. The material collected from these localities may reflect different environmental conditions than the material sampled in the rest of the area north of the Faroes. The warmer and more saline Atlantic water south of the islands is different to the colder East Icelandic current mixed with Atlantic water north of the Faroes (Hansen, 1985), and therefore the fauna might be different. However, the samples from the southern area represents only 2% of total material.

The length distributions of wild and farmed salmon sampled are similar in all three seasons , and the two main length cohorts around 45-50cm and 65-70cm, representing 1 and 2 sea-winter (SW) salmon respectively, are well separated in the material. The 3 SW salmon (greater than 85cm) are most abundant in the February-March sample in 1993. The sea age of the salmon varied between 0+ and 4 years, being significantly lower in November-December than in February-March (Anon, 1996).

The present material gives no indication that salmon regurgitate after capture. This statement cannot be verified, however, neither the scientific staff onboard the research vessel nor the salmon fishermen noted any remains of stomach content on deck or on the side when hauling the line. This question has to be taken into account when considering the quality of salmon stomach data in general. Christensen (1961) reported that long line caught salmon contained less food than salmon caught by gillnet in the Baltic, however, Thurow (1966) analysed similar data from the same area, and reported no significant difference in stomach content between net- and hook-caught salmon. Christensen (1961) also offered two possible explanations to the observed difference in his material between the two groups: firstly that salmon not being filled up with food might be more inclined to take the bait than the relatively full salmon which, in return, are comparatively easier to catch by netting, and secondly that the two fishing gears were not used on the same time of the day, the nets caught the salmon at night while the hooks caught mainly in the daytime in the Baltic.

On the assumption that the proportion of empty stomachs is indicative of the intensity of feeding (Rae, 1967), salmon feed more intensively in the February-March (22% of the stomachs were empty) than in November-December, where about half of the stomachs were found empty. Of the stomachs containing food, the average food content (g) per salmon was significantly lower in the November-December period compared to February-March in each season, emphasising the lower feeding rate of salmon observed during late autumn. This observation is in accordance with work in the Baltic, where a tendency of decreasing food quantities in the salmon stomachs was observed during autumn until January-February when it again increased (Christensen, 1961; Thurow, 1966). Salmon sampled in the Labrador Sea had less food in their stomachs in the autumn than in the spring (3.1 g and 5.7 g food per kg of salmon respectively) and were feeding less actively (28% and 8% empty stomachs respectively) (Lear & Sandeman, 1980). The low feeding rate in late autumn could be an indication of low food availability, implying that salmon may have a hard time in the sea in this period. Survival of salmon in the sea has been shown partly to depend in some way on the environment in the sea, through a link in the sea-surface temperature (Friedland, *et al.*, 1993; Friedland & Reddin, 1993). This might at least partly be the result of temperature dependence or preference of the available prey for salmon, as indicated by the low feeding rate in November-January. This leads to the question whether the food is a limiting factor for salmon in the sea, but at present this remains unanswered.

In recent years large numbers of salmon escaped from fish farms have been commonly observed in oceanic waters in the Faroese area (Hansen *et al.*; 1993; 1996). These fish farm escapees could easily be detected as most of them display defects such as e.g. eroded fins. One question that can be asked is whether these fish farm escapees take the same prey with the same efficiency as wild fish do. Apparently there was a difference in the proportion of empty stomachs between wild salmon and fish farm escapees in the 1994/95 season, being higher in wild fish than expected. The biological significance of this observation is not clear. Hislop & Webb (1992) found that farmed salmon caught in Scottish coastal waters fed on natural prey.

The available prey sampled from plankton tows, generally included the same species as found in the stomachs in any amount, i.e. the *Themisto* spp., euphausiids, the shrimp *Hymenodora glacialis*, lantern fishes and pearlsides. However, salmon did not appear to eat *Sagitta* spp. and *Calanus finmarchius* that were observed in the plankton samples. It might be speculated that *Sagitta* spp. is too transparent and *Calanus finmarchius* too small to be eaten by a salmon larger than 45 cm.

A comparison of the length distributions from the plankton material and the salmon stomachs of *T. libellula* show a nearly complete overlap, and indicate that the plankton net and salmon capture the same size groups. However, some preference for larger amphipods of *T. libellula* by salmon or conversely the large *T. libellula* do avoid the "small" plankton net of 2 m diameter can be suggested. The apparently smaller length distribution of the *M. norvegica* collected with the plankton sampler than in the salmon stomachs can partly be explained by the following observation at the laboratory: when the more or less digested *M. norvegica* from the salmon stomachs are measured, they tend to be slender and soft which results in overestimation of the lengths when they are stretched out on the measuring board. At least two year classes (1 and 2+ group) of pearlside (*Maurolicus müelleri*) were obviously abundant in the stomachs. However, only the 1 group was present in the MIK samples. There might be several explanations for this: either does the larger 2+ group of *M. müelleri* avoid the plankton sampler, or the older and larger individuals are present below 50 m depth which was the lower limit of plankton sampling. The *M. müelleri* has been reported in some areas to be separated into two vertical layers in the sea during winter, with the older individuals occupying the lower layer (Goodson *et al.*, 1995). There is no problem for salmon to dive deeper than 50 m to feed, and Jákupsstovu (1988) observed that salmon tagged with depth-sensitive acoustic tags north of the Faroes were diving deeper than 150 m. However, Luo &

Brandt (1994) simulated the "fish's perspective of the size distribution of prey" and found that the actual prey size distribution perceived by a fish may be very different from that measured from plankton samples, and that generally the fish would perceive relatively more of the larger prey when compared to a size distribution from a plankton sample, mainly due to differential encounter rates of prey. Hart & Ison (1991) also stated that the probability of a prey size being taken, was a function of prey size, fish stomach fullness and encounter rate.

Crustaceans dominate by number in the salmon stomachs whereas the fish dominate in weight. This pattern is due to the generally small size of the crustaceans compared with the size of fish prey. It must also be noted that the estimated numbers of crustaceans are generally underestimated, as in many cases only the weight is recorded due to advanced digestion. The number of specimens in such a digested bulk can be several hundreds, and especially the prey group "Crustacea remains" is thus grossly underestimated. Another important point is the relatively large influence of herring, blue whiting and mackerel on the total weight in the material. Only 19 herring and 17 blue whiting have been found in the nearly 4,000 stomachs analysed, and this means that at most 36 salmon have had exceptionally advantage of capturing this large prey, but it would be misleading to give herring and blue whiting a large general importance in the diet of salmon as their observed weight percentage (13%) would imply.

Based on the present material we cannot reject the hypothesis that the forage behaviour of salmon in the sea is opportunistic. This can be seen from the large range of prey species found in our material, and the apparent lack of size selective feeding. This supports data presented by several authors (Hansen & Pethon 1985; Reddin 1988; Pearcy, 1992; Hislop & Shelton 1993; Sturlaugsson, 1994). Generally the average prey size in the stomachs did not depend on fish size, except for *Themisto libellula*, where a significant positive relationship was observed. However, this relationship is doubtful, due to an observation of a large significant positive autocorrelation in the material. The general lack of any significant relationship between salmon length and prey length (or width) reported in literature (Anon, 1983; Hislop & Shelton 1993; Sturlaugsson, 1994), is in general agreement with our data. However, Holst et al. (1996) observed a significant relationship between mean length of *Parathemisto* spp. (*Themisto* spp. according to Schneppenheim, (1986)) and size of postsmolts captured in the Norwegian sea, suggesting that some size selective feeding may occur.

A trend within fish seasons was observed in the food composition between crustaceans and fish: Early in the fishing season (November-December) the crustaceans made up the bulk in the stomachs whereas fish were most abundant in February-March. The reasons might be sought in the horizontal and vertical distribution of the prey during the year, as the November-December fishery generally is located further south and closer to the Faroe islands.

The species and size composition of *Themisto libellula* and *T. compressa*, two of the three species of the genus *Themisto* spp. observed as prey, showed an inverse relationship of occurrence in the salmon stomachs both in frequency and in weight. This might be due to different temperature regimes where the salmon have been feeding, as *T. libellula* is considered being an arctic species, whereas *T. compressa* is described in both arctic and subarctic waters (e.g. Dunbar, 1964; Dalpadado *et al.*, 1994).

A definitive conclusion on which prey group that are most important for salmon in the sea north of the Faroes cannot be given at present, because calorific values of the prey must be added to the previously discussed measures of dietary importance, as well as consideration of the turnover rate of food in the salmon stomachs must be included. However, that the crustaceans and particularly the hyperiid amphipods of the genus *Themisto*, euphausiids and mesopelagic shrimps are an important source of food for salmon in the autumn period is beyond any doubt and equally important becomes the different mesopelagic fish as lantern fishes, pearlsides and barracudinas during late winter. The occasional presence of larger fish in the stomachs, such as herring, blue whiting and mackerel is not considered as a main source of food for salmon in the sea during autumn and winter north of the Faroes.

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Table 1. Number of salmon stomachs sampled by month in the Faroese research fishery during the three consecutive fishing seasons 1992/93, 1993/94, and 1994/95, divided into wild salmon and salmon of farmed origin, based external chareteristics.

		No. sampled		
Year	**Month**	**Wild**	**Farmed**	**Total**
1992	Nov	18	7	25
1992	Dec	79	19	98
1993	Mar	931	219	1,150
Season 92/93		1,028	245	1,273
1993	Nov	185	65	250
1993	Dec	150	50	200
1994	Feb	199	65	264
1994	Mar	210	88	298
Season 93/94		744	268	1,012
1994	Nov	509	122	631
1994	Dec	99	18	117
1995	Feb	298	97	395
1995	Mar	321	99	420
Season 94/95		1,227	336	1,563
Total		2,999	849	3,848

Table 2. Frequency of occurrence (%) of food items (species) in salmon caught north of the Faroes during the three fishing seasons 1992/93 - 1994/95.

	1992		1993			1994				1995		
Prey groups	**Nov**	**Dec**	**Mar**	**Nov**	**Dec**	**Feb**	**Mar**	**Nov**	**Dec**	**Feb**	**Mar**	**Total**
Crustaceans:												
Hyperiid amphipods:												
Themisto spp.	28.6	52.2	19.0	40.8	15.0	12.9	11.5	41.3	32.0	26.1	37.2	25.7
Themisto libellula	28.6	19.6	18.3	3.0	19.5	16.0	46.1	46.2	20.0	52.5	55.6	32.0
Themisto compressa	21.4	15.2	18.9	43.8	73.5	44.2	40.1	41.3	44.0	20.7	30.4	31.2
Themisto abyssorum	-	-	-	-	-	1.8	11.2	3.6	6.0	10.2	6.9	3.8
Euphausiids:												
Euphausiidae	21.4	4.3	-	37.9	22.1	26.4	30.5	23.4	8.0	15.9	18.6	15.2
Meganyctiphanes norvegica	57.1	39.1	45.7	-	7.1	14.7	34.6	35.3	20.0	62.7	53.6	39.3
Thysanoessa inermis	-	-	-	-	-	1.2	5.6	2.6	6.0	8.8	3.2	2.4
Thysanoessa longicaudata	-	-	-	-	-	-	0.4	2.0	-	-	0.9	0.4
Shrimps:												
Hymenodora glacialis	-	-	20.6	1.2	-	15.3	43.5	10.2	2.0	46.1	39.5	23.8
Sergestes arcticus	-	-	0.6	2.4	-	-	-	-	2.0	-	-	0.4
Pasiphea tarda	-	-	-	-	-	0.6	-	-	-	-	-	0.0
Other crustaceans:	-	-	-	-	-	-	-	-	-	-	-	-
Paraeuchaeta norvegica	-	-	-	-	0.9	-	-	1.3	-	-	-	0.2
Gammaridea	-	-	-	-	-	-	1.9	-	-	-	-	0.2
Aristias tumidus	-	-	-	-	-	-	-	0.3	-	-	-	0.0
Eusirus holmi	-	-	1.0	0.6	-	1.8	9.3	-	-	1.0	4.3	2.1
Crustacea remains:	-	-	31.8	5.3	1.8	12.9	17.1	4.0	16.0	22.0	18.1	19.1
Fishes:												
Silversides:												
Maurolicus muelleri	-	6.5	29.9	5.9	6.2	21.5	11.2	2.3	6.0	23.1	12.3	17.8
Baracudinas:	-	-	-	-	-	-	-	-	-	-	-	-
Paralepidae	-	-	3.2	1.2	-	6.7	3.0	0.7	-	1.0	3.2	2.5
Notolepis rissoi kroyeri	-	-	-	-	-	4.9	3.3	0.3	-	1.0	0.6	0.9
Paralepis coregonoides borealis	-	-	0.3	-	-	0.6	-	1.3	-	0.3	0.3	0.4
Lanternfishes:												
Myctophidae	21.4	2.2	10.2	1.2	0.9	13.5	16.0	1.0	-	4.7	9.5	8.0
Lampanyctus crocodilus	-	-	-	-	-	-	0.4	-	-	-	-	0.0
Notoscopelus kroeyeri	-	-	-	-	2.7	1.2	0.4	1.0	-	0.3	-	0.4
Myctophum punctatum	-	-	0.7	-	-	0.6	1.1	0.3	-	0.3	0.9	0.6
Benthosema glaciale	-	4.3	6.2	0.6	-	12.3	32.0	2.3	4.0	15.6	14.6	10.1
Other fish:												
Ammodyteidae	-	-	0.1	-	-	-	0.7	-	-	-	-	0.1
Mallotus villosus	-	-	0.1	0.6	-	-	-	0.3	-	-	1.4	0.3
Fry (mostly *Mallotus villotus)*	-	-	2.1	-	-	3.7	11.2	2.0	-	3.4	7.4	3.6
Clupea harengus	-	-	-	0.6	0.9	3.1	0.7	0.3	-	2.7	-	0.7
Micromesistius poutassou	-	2.2	-	1.2	5.3	-	-	0.3	-	-	-	0.4
Onogadus argentatus	-	-	-	0.6	-	-	-	-	-	-	-	0.0
Lycenchelys sp.	-	-	-	-	-	0.6	-	-	-	-	-	0.0
Scomber scombrus	-	-	-	-	2.7	0.6	-	-	-	-	-	0.2
Belone belone	-	-	-	-	-	0.6	0.4	-	-	-	-	0.1
Gasterosteus aculeatus	-	-	0.2	-	-	-	-	-	-	-	-	0.1
Fish remains:	-	17.4	61.0	12.4	15.0	40.5	43.1	7.3	28.0	24.7	28.9	36.9
Squid:												
Gonatidae	-	-	1.3	-	-	1.8	1.9	0.3	-	1.0	1.4	1.1
Gonatus fabricii	-	-	0.1	-	-	-	-	-	-	-	-	0.0
Remains organic:	-	-	-	-	0.9	1.2	10.0	5.6	18.0	6.1	12.9	4.5
Birds and bird remains:	-	-	0.6	0.6	-	-	0.7	0.7	6.0	1.0	1.4	0.8
Algae:	-	-	-	-	0.9	1.2	0.4	-	2.0	0.3	-	0.2
Insects (remains):	-	-	-	-	-	-	-	0.3	-	-	-	0.0
No. of stomachs analysed	25	98	1150	250	200	264	298	631	117	395	420	3848
Percentage empty stomachs	44	53	22	32	44	38	10	52	57	25	17	31

Table 3. Weight distribution (%) of food items in salmon caught north of the Faroes during the three fishing seasons 1992/93 - 1994/95.

	1992		1993			1994				1995		
Prey species groups	**Nov**	**Dec**	**Mar**	**Nov**	**Dec**	**Feb**	**Mar**	**Nov**	**Dec**	**Feb**	**Mar**	**Total**
Crustaceans:												
Hyperiid amphipods:												
Themisto libellula	34.1	15.4	3.3	0.1	1.2	1.9	3.9	25.7	6.2	22.9	29.3	9.0
Themisto compressa	17.5	2.7	1.2	59.9	35.6	5.0	1.9	9.7	42.6	0.3	1.0	8.3
Themisto abyssorum	-	-	-	-	-	0.0	0.1	0.1	0.3	0.1	0.1	0.0
Euphausiids:												
Euphausiidae	9.1	0.1	-	3.5	1.3	1.3	2.4	4.1	1.2	0.9	1.5	1.3
Meganyctiphanes norvegica	7.6	7.1	2.4	-	0.2	0.6	3.5	7.4	2.5	7.5	5.1	3.1
Thysanoessa inermis	-	-	-	-	-	0.0	0.2	0.2	0.8	0.2	0.1	0.1
Thysanoessa longicaudata	-	-	-	-	-	-	0.0	0.0	-	-	0.0	0.0
Shrimps:												
Hymenodora glacialis	-	-	3.7	0.3	-	1.3	5.5	3.3	2.2	6.6	7.1	3.8
Sergestes arcticus	-	-	0.2	0.1	-	-	-	-	0.8	-	-	0.1
Pasiphea tarda	-	-	-	-	-	0.0	-	-	-	-	-	0.0
Other crustaceans:												
Paraeuchaeta norvegica	-	-	-	-	0.0	-	-	0.0	-	-	-	0.0
Gammaridea	-	-	-	-	-	-	0.0	-	-	-	-	0.0
Aristias tumidus	-	-	-	-	-	-	-	0.0	-	-	-	0.0
Eusirus holmi	-	-	0.1	0.0	-	0.0	0.6	-	-	0.1	0.3	0.2
Crustacea remains:	-	-	5.6	0.4	0.1	0.8	2.4	4.4	3.8	6.3	8.0	4.0
Fishes:												
Silversides:												
Maurolicus muelleri	-	3.6	19.9	1.0	1.9	2.1	3.1	1.0	3.1	4.2	3.0	8.0
Baracudinas:												
Paralepidae	-	-	13.1	4.1	-	6.5	7.2	1.8	-	2.1	6.2	7.3
Notolepis rissoi kroyeri	-	-	-	-	-	7.1	10.0	1.8	-	3.1	1.7	3.0
Paralepis coregonoides borealis	-	-	1.3	-	-	0.4	-	10.1	-	1.0	1.1	1.1
Lanternfishes:												
Myctophidae	31.7	1.2	5.6	0.5	0.4	13.7	7.5	0.8	-	1.3	3.6	5.6
Lampanyctus crocodilus	-	-	-	-	-	-	0.6	-	-	-	-	0.1
Notoscopelus kroeyeri	-	-	-	-	2.8	0.7	0.3	6.7	-	0.7	-	0.6
Myctophum punctatum	-	-	0.8	-	-	0.3	0.8	0.5	-	0.1	0.4	0.5
Benthosema glaciale	-	4.6	2.9	0.1	-	19.2	16.6	2.9	5.5	5.3	8.8	7.9
Other fish:												
Ammodyteidae	-	-	0.0	-	-	-	0.1	-	-	-	-	0.0
Mallotus villosus	-	-	0.7	0.2	-	-	-	1.2	-	-	4.3	0.8
Fry (mostly *Mallotus villotus)*	-	-	1.2	-	-	0.3	3.4	0.8	-	0.9	3.2	1.3
Clupea harengus	-	-	-	8.2	2.6	19.1	10.7	7.5	-	27.7	-	8.8
Micromesistius poutassou	-	56.6	-	16.1	32.1	-	-	3.3	-	-	-	3.2
Onogadus argentatus	-	-	-	0.4	-	-	-	-	-	-	-	0.0
Lycenchelys sp.	-	-	-	-	-	0.3	-	-	-	-	-	0.0
Scomber scombrus	-	-	-	-	18.9	1.9	-	-	-	-	-	1.3
Belone belone	-	-	-	-	-	1.1	1.5	-	-	-	-	0.4
Gasterosteus aculeatus	-	-	0.1	-	-	-	-	-	-	-	-	0.0
Fish remains:	-	8.7	32.9	5.0	2.2	15.1	11.6	2.7	20.8	6.3	5.4	16.2
Squid:												
Gonatidae	-	-	4.4	-	-	0.7	1.7	0.1	-	0.4	2.3	2.0
Gonatus fabricii	-	-	0.3	-	-	-	-	-	-	-	-	0.1
Remains organic:	-	-	-	-	0.7	0.6	3.9	3.6	10.2	1.9	6.9	1.8
Birds and bird remains:	-	-	0.3	-	-	-	0.5	-	-	0.1	0.5	0.2
No. of stomachs analysed	25	98	1150	250	200	264	298	631	117	395	420	3848
Percentage empty stomachs	44	53	22	32	44	38	10	52	57	25	17	31

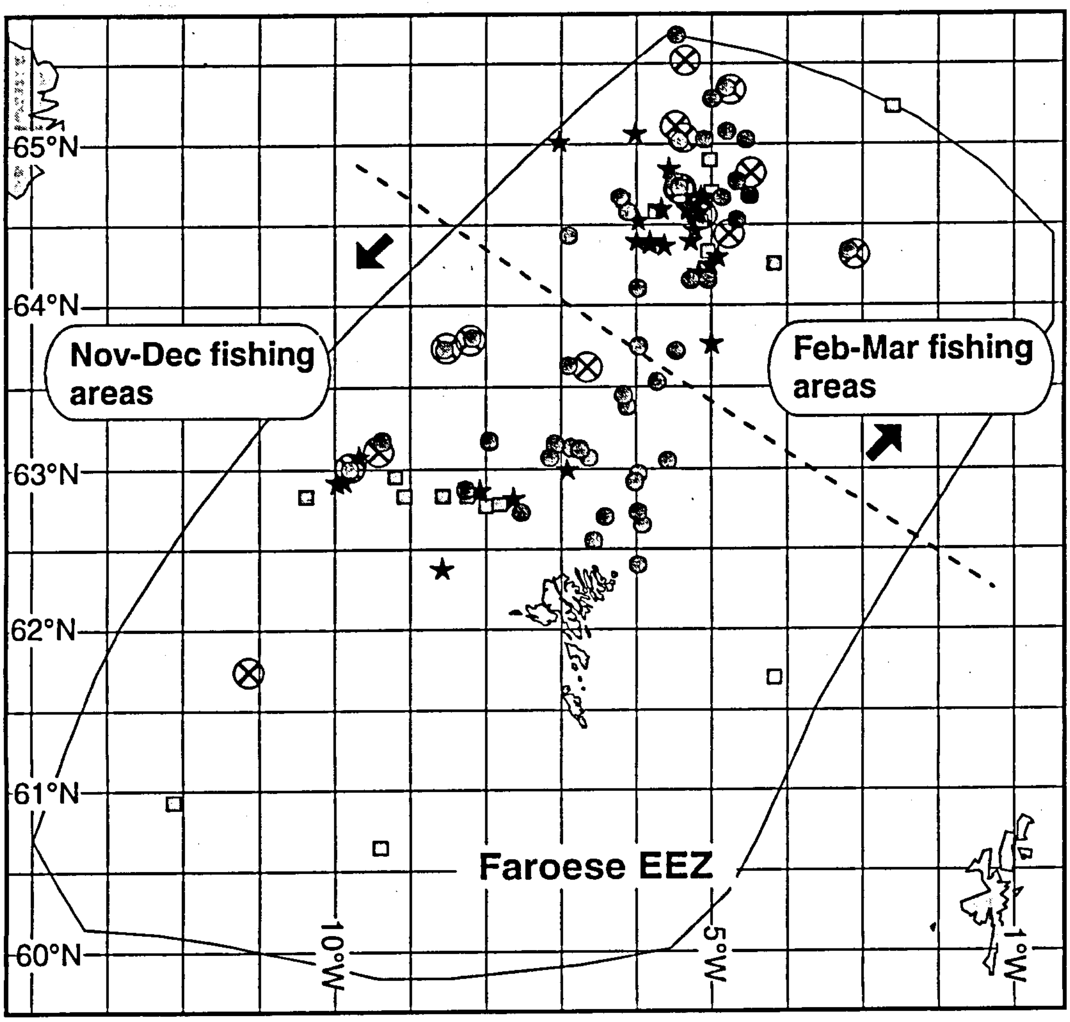

Figure 1. Map showing set locations where 3,848 salmon stomachs were sampled during three consecutive fishing seasons 1992/1993 (★), 1993/1994 (■), and 1994/1995 (●). Plankton samples (MIK plankton net, 2 m Ø) taken in 1994-95 are superimposed as crossed circles. The fishing areas in Nov-Dec and Feb-Mar are usually confined to the area south-west and north-east of the stippled line, respectively.

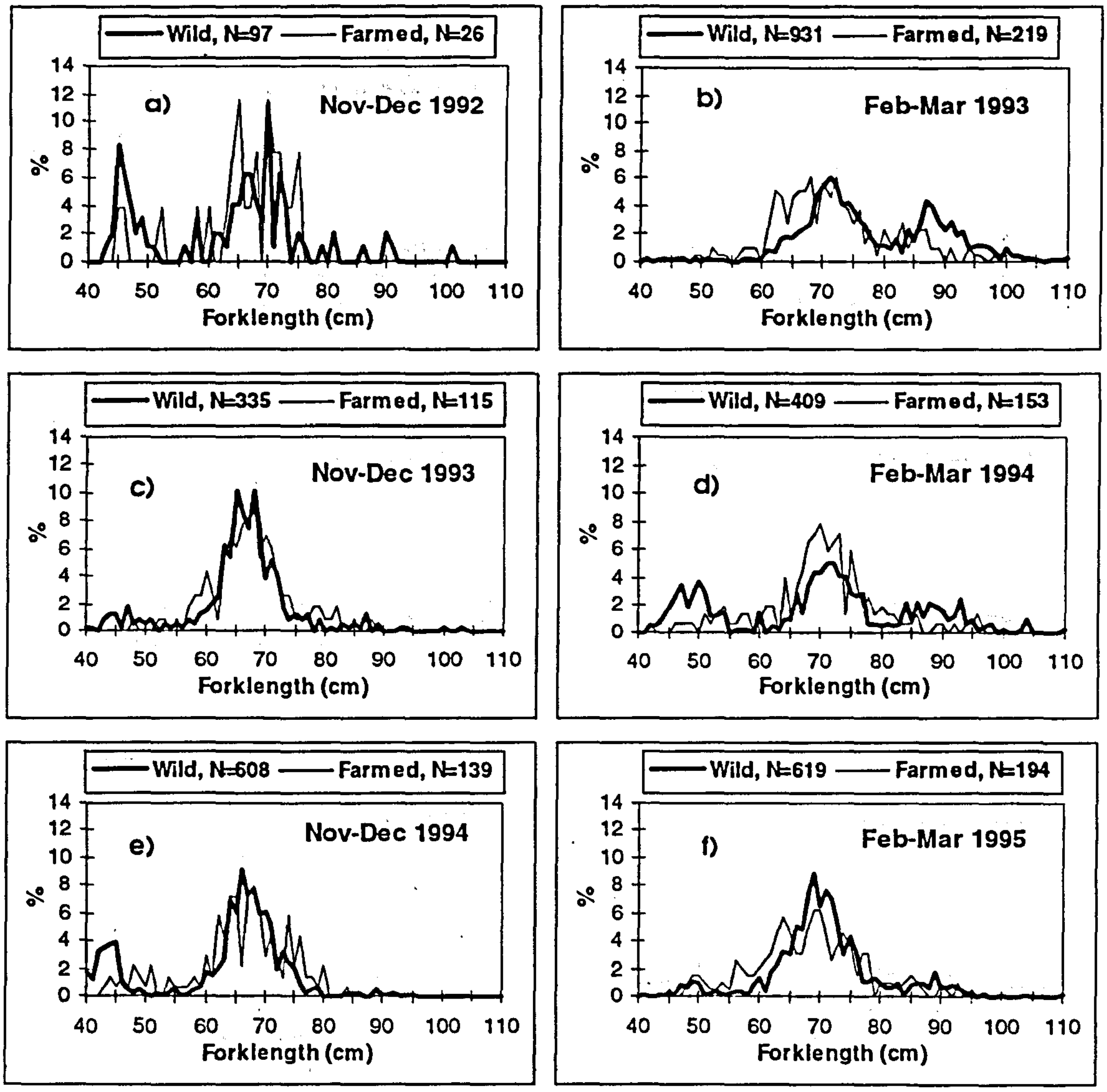

Figure 2. Length distribution (%) of wild and farmed salmon sampled for stomach analysis in Nov-Dec and Feb-Mar in three fishing seasons 1992/93, 1993/94 amd 1994/95 from the area north of the Faroes.

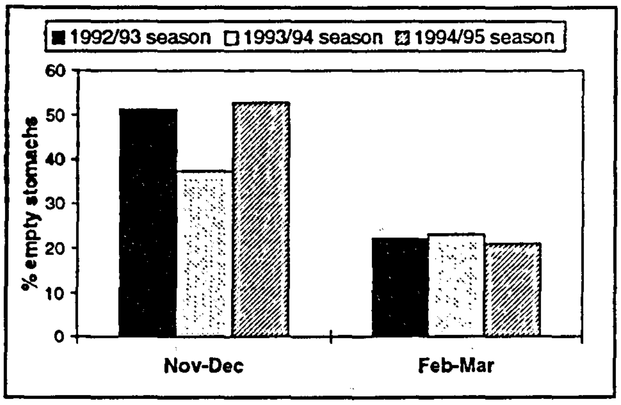

Figure 3. Percentage of empty salmon stomachs in Nov-Dec and Feb-Mar in three consecutive fishing seasons 1992/93, 1993/94 and 1994/95 from the area north of the Faroes.

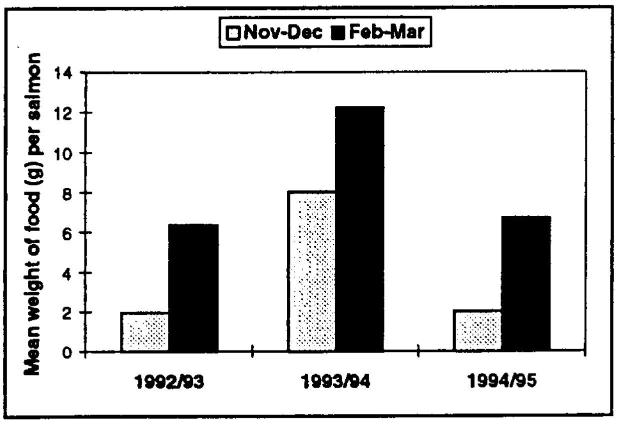

Figure 4. Mean weight of food content (g) per salmon in Nov-Dec and in Feb-Mar during three consecutive fishing seasons 1992/93, 1993/94 and 1994/95.

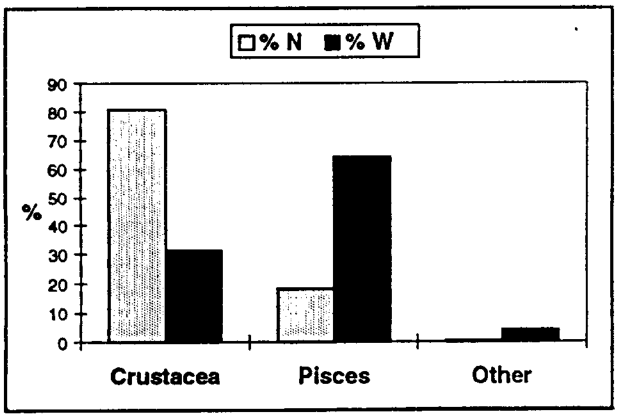

Figure 5. Percentage distribution of stomach content in number (%N) and weight (%W) of the major prey-groups for all three fishing seasons combined (1992/93 - 1994/95).

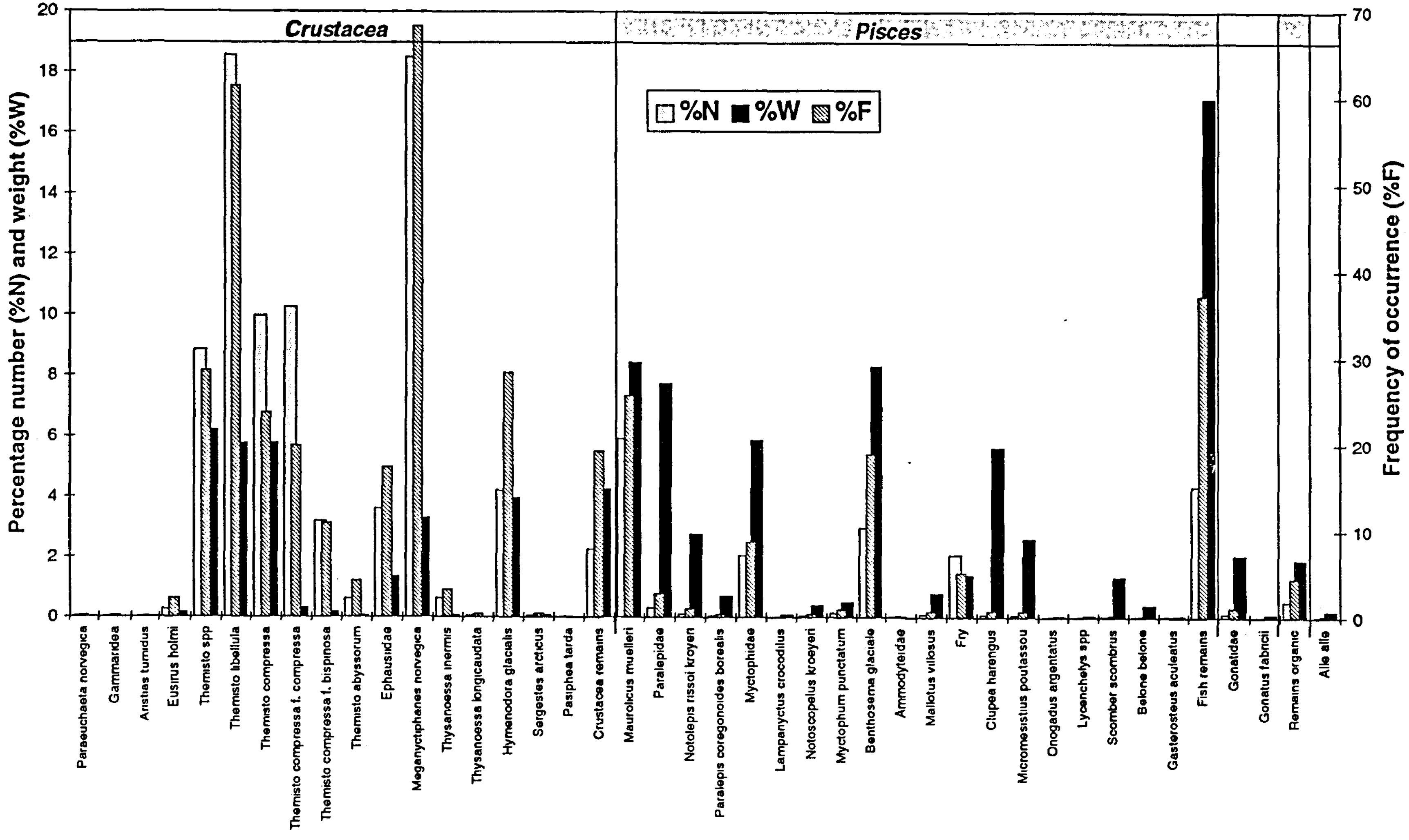

Figure 6. Different measures of stomach content of salmon: %F - frequency of occurrence, %N - numercial percentages, and %W - weight percentages, for each prey species for all three seasons combined (1992/93 - 1994/95).

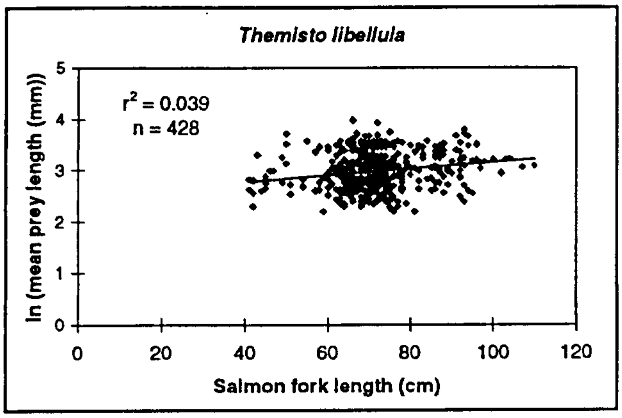

Figure 7. Regression of salmon fork length (cm) vs. the natural logarithm of mean prey-length (mm) of *Themisto libellula* for all available data (n= 428, r^2= 0.039, p<0.0005).

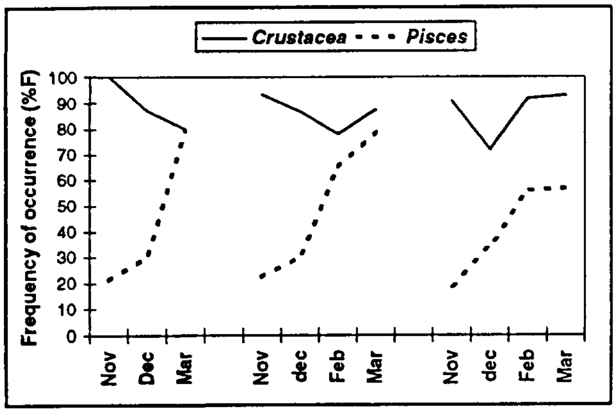

Figure 8a. Percentage frequency of occurrence (%F) of prey of crustaceans vs. fish by month in salmon stomachs in three consecutive fishing seasons 1992/93, 1993/94 and 1994/95 from the area north of the Faroes.

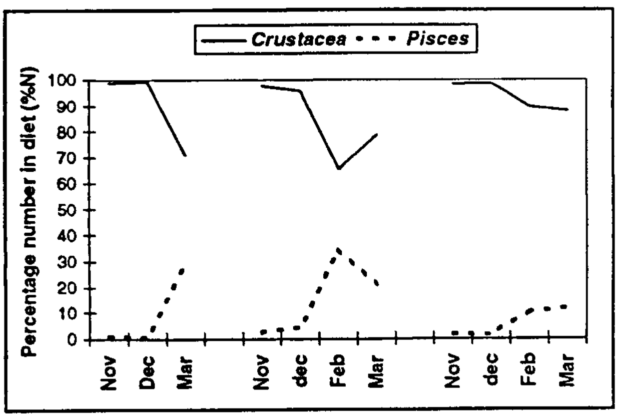

Figure 8b. Percentage distribution of number (%N) of prey of crustaceans vs. fish by month in salmon stomachs in three consecutive fishing seasons 1992/93, 1993/94 and 1994/95 from the area north of the Faroes.

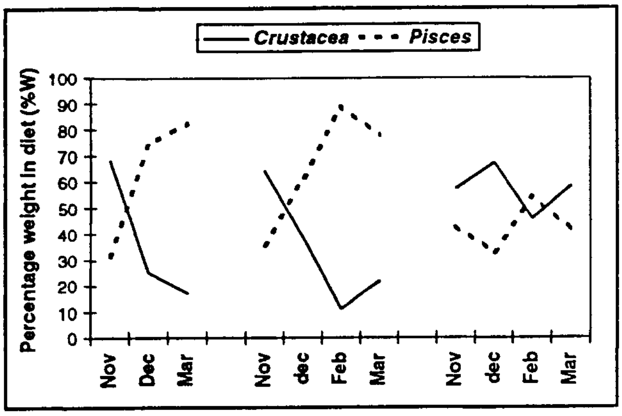

Figure 8c. Percentage weight distribution (%W) of prey of crustaceans vs. fish by month in salmon stomachs in three consecutive fishing seasons 1992/93, 1993/94 and 1994/95 from the area north of the Faroes.

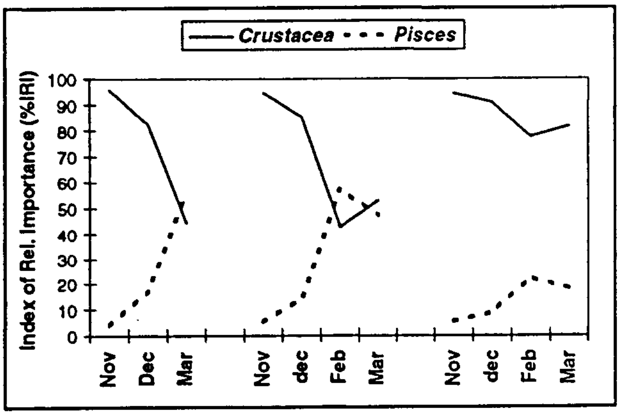

Figure 8d. Percentage Index of Relative Importance (%IRI) of prey of crustaceans vs. fish by month in salmon stomachs in three consecutive fishing seasons 1992/93, 1993/94 and 1994/95 from the area north of the Faroes.

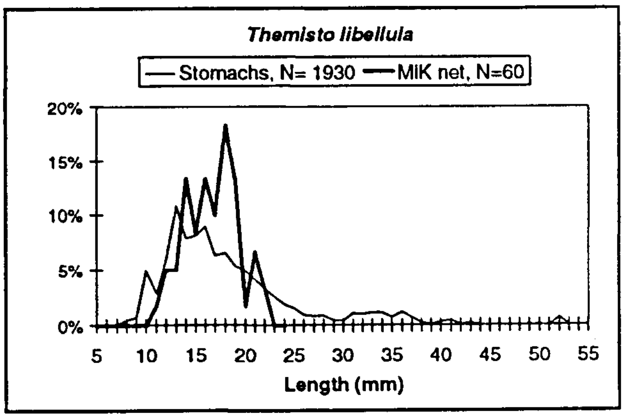

Figure 9. Length distribution of *Themisto libellula* from stomach samples of salmon and from MIK plankton net samples (0-50 m depth) in the same area.

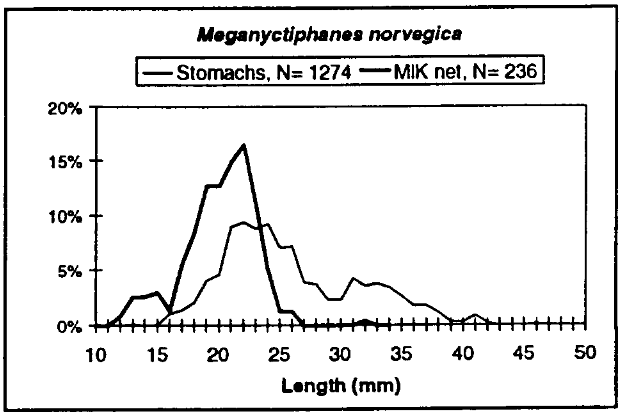

Figure 10. Length distribution of *Meganyctiphanes norvegica* from stomach samples of salmon and from MIK plankton net samples (0-50 m depth) in the same area.

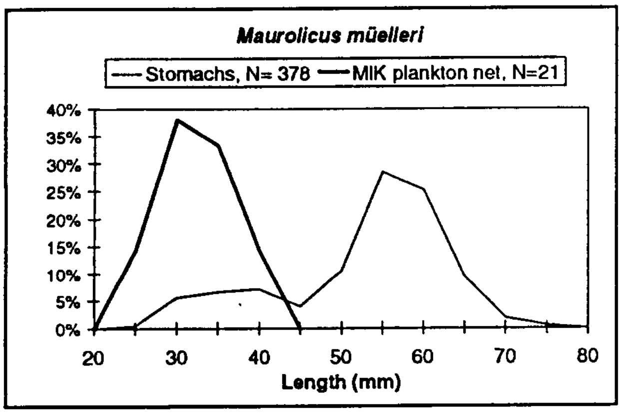

Figure 11. Length distribution of *Maurolicus müelleri* from stomach samples of salmon and from MIK plankton net samples (0-50 m depth) in the same area.