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Comparative Feeding of Grey (*Halichoerus grypus*) and Common Seals (*Phoca vitulina*) in Coastal Waters of Iceland, with a Note on the Diet of Hooded (*Cystophora cristata*) and Harp Seals (*Phoca groenlandica*)

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Abstract

During 1992–93, an extensive collection program of seal stomachs was conducted as a part of the Multi-Species Research program of the Marine Research Institute in Iceland which commenced in 1991. The aim of the seal part of the program was to investigate their food and feeding habits and role as top-predators. In total 1 059 stomachs from grey seals (*Halichoerus grypus*) (737 had food remains), 799 stomachs from common seals (*Phoca vitulina*) (493 had food remains), 62 stomachs from hooded seals (*Cystophora cristata*) (47 had food remains) and 72 stomachs from harp seals (*Phoca groenlandica*) (39 had food-remains) were obtained.

The main food species of grey seals in Icelandic waters ordered in percentage by weight, were cod (*Gadus morhua*), sand eels (Ammoditdae), catfish (*Anarhichas lupus*), saithe (*Pollachius virens*) and lumpsucker (*Cyclopterus lumpus*). Seasonal and geographic variation observed during the period January to September, showed sand eel was the dominant food of grey seals off the south-coast of Iceland, but cod, catfish, saithe and lumpsucker in other areas. During breeding, October to December, sand eel still dominated in grey seals from the south coast of Iceland, while saithe, catfish and lumpsuckers did not occur in the diet in the same amount in the west-northwest-northeast-east coastal area, where bull-rout (*Myoxocephalus scorpius*) was the main prey.

The main food species of common seals in Icelandic waters, ordered in percentage by weight, were cod, redfish (*Sebastes* sp.), sand eels, saithe, herring (*Clupea harengus*), catfish and capelin (*Mallotus villosus*). The most pronounced geographic difference in feeding was between common seals from the south coast and seals from the other coastal areas. Sand eel was the main prey item in the south, but cod in the other areas. There seemed to be no seasonal variation in feeding on cod, however, capelin and herring were more important in the diet in autumn/winter. Sand eel, on the other hand, was more important in the food in most coastal areas during spring/summer, than in autumn/winter.

The main food items of hooded seals were, redfish and cod, while harp seals took sand eels, herring, bull-rout and cod. The cod eaten by grey seals were mainly of the 2–5 year-olds, the common seals fed mostly on 0–3 year-olds, hooded seals on 3–5 year-olds, and harp seals on 0–2 year-olds.

Key words: common seal, grey seal, harp seal, hooded seal, Iceland, seal diet

Introduction

Food and feeding habits of common (*Phoca vilulina*), grey (*Halichoerus grypus*), hooded (*Cystophora cristata*) and harp seals (*Phoca groenlandica*), have been extensively studied in North Atlantic waters (Bowen *et al.*, 1993; Bowen and Harrison, 1994; Hammill *et al.*, 1995; Hammond *et al.*, 1994; Härkönen, 1987; Kapel, 1995; Lawson *et al.*, 1994; Lawson and Stenson, 1995; Murie and Lavigne, 1992; Nilssen, 1995; Nordøy *et al.*, 1995; Olesiuk, 1993; Olsen and Bjørge, 1995; Pierce *et al.*, 1991; Rae, 1973). Little information is, however, available from Icelandic waters (Bogason, 1997; Hauksson, 1984, 1997).

During 1992–93, an extensive collection program of seal stomachs was conducted by the Marine Research Institute, Reykjavík, Iceland. This was a part of the Multi-species Research Program initiated by the Marine Research Institute which commenced in 1991, with the aim of obtaining knowledge and understanding about the ecosystem of Icelandic waters and thereby make possible the rational exploitation of its resources (Jakobsson and Pálsson, 1997). The aim of the seal part of the Multi-Species Research Program was to investigate food and feeding habits of seals and their role as top-predators in Icelandic waters. In this paper comparative data on diet and feeding habits of the four most common seal species in Icelandic waters are presented.

Materials and Methods

Whole animals or samples of the lower jaw, stomachs and reproductive-organs were obtained from local fishers, dedicated collectors and seal-hunters. Material collected is overviewed in Table 1. The ages of animals were determined by counting the number of growth-layers in the cementum, or alternatively, the dentine of harp seals were studied from thin-sections (0.5–0.7 mm) of the canine tooth, cut transverse with a low speed saw near the base of the tooth. A binocular dissecting microscope with 6× to 50× magnification and transmitted light was used (Bowen *et al.*, 1983; Laws 1962; Lawson *et al.*, 1992; Mansfield and Fisher, 1960).

Samples from grey and common seals were taken following a sampling design to ensure that samples were representative in regard to coastal areas, seasons and age and sex of animals. This sampling strategy had a limited success because there were an inadequate number samples of grey and common seals from the east coast of Iceland and from the wintertime. Young common seals were also over-represented in the samples from most areas and seasons. Most of the hooded and harp seals sampled were obtained opportunistically, either from entanglements in gillnets or shot by local hunters during the period 1990–94. Samples of these latter species were therefore likely biased, but were considered to in some way, represent the parts of the populations visiting the Icelandic coast. A majority of the hooded seals obtained were adult males older than 6 years. Only 5 female hooded seals were collected, most of which were pups (Hauksson and Bogason, MS 1995a). The harp seals were all young animals, i.e. pups and yearlings, the rest were from 2–8 years of age (Hauksson and Bogason, MS 1995b).

Food remains in the stomachs were studied by cutting the stomach open, and washing the content through a series of sieves, the finest sieve being of 0.3 mm mesh-size. Otoliths and bones of fishes, carapace and shells from invertebrates as well as beaks from squids, were identified either to species or species group levels. Ages of cod and few other fish species were read from the growth layers

TABLE 1. Total number of seal stomachs sampled and number of stomachs containing food remains.

Species	Sampling period	Total of stomachs sampled	No. of stomachs with food remains
Grey seal	1990–93	1 059[1]	737
Common seal	1992–93	799	493
Hooded seal	1990–94	62[2]	47
Harp seal	1990–94	72[3]	39

[1] Including a total of 211 stomachs sampled prior to 1992 for investigating of stomach nematodes.
[2] Including all hooded seal stomachs obtained in the period 1990–94.
[3] Including all harp seal stomachs obtained in the period 1990–94.

in the otoliths, under a binocular-dissecting microscope with 6× to 50× magnification. Length and weight of fish in the food were estimated from regressions of otolith size, fish-length and fish–weight relationships, for fish species from Icelandic waters (Hauksson and Bogason, Mar. Res. Inst., Iceland,unpubl. data). The total biomass of prey in a stomach was estimated by summing the estimated wet weight of all prey items found therein. To estimate the biomass represented by eroded otoliths, it was assumed that eroded otoliths of each species were originally the same size as the average of the uneroded measured otoliths in that stomach. The number of prey items with eroded otoliths in each stomach was then multiplied by the average weight determined from uneroded otoliths of the same species (Bogason, 1997; Hauksson, 1997).

To analyse geographic differences in feeding, the Icelandic coast was divided into 5 areas (Fig. 1). Diet of common seals was investigated in each area separately since common seals are distributed around the whole coast of Iceland and samples were obtained from all coastal areas. Diet of grey seals was compared between two areas, the south coast and the other coastal areas combined. This was done because the distribution of grey seals is uneven with two large groupings of animals, one off the west coast, west-fjords and northwest coast, and the other off the south coast. Only few animals inhabit the northeast-east coastal waters (Hauksson, 1994). There was also a lack of samples from the northeast-east coast. The South coast is topographically very different from the other coastal areas in Iceland; sandy shores dominating there, but rocky shores dominating elsewhere.

The year was divided into two seasons according to feeding and breeding times of seals. The breeding time of grey seals was taken to be the period October–December and it was assumed that feeding activity of the animals during this period was minimal. At other times of the year, the grey seals were considered as actively feeding. Similarly, the breeding time of common seals was considered to be from June to September, with assumed lower food consumption. For common seals, moulting takes place during breeding time, while grey seals moult several months after the breeding period, so in that case the moulting period was included in the feeding period. It is known that hooded seals and harp seals mainly visit the coast to feed, and there are no records of them breeding, mating or moulting in Icelandic waters (Hauksson, 1986).

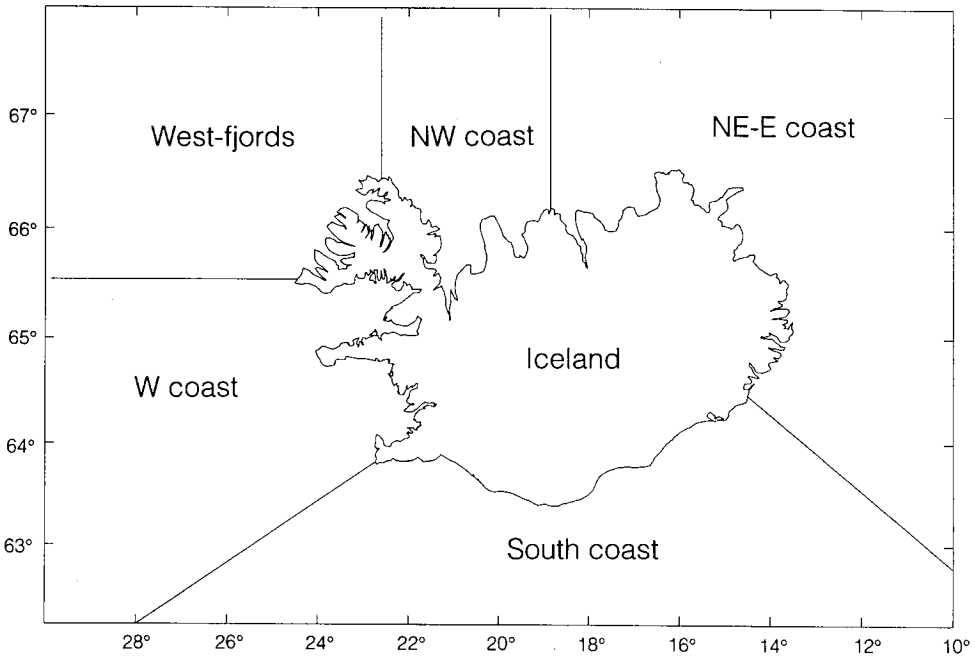

Fig. 1. Division of the coast of Iceland into areas used for analysing geographic differences of feeding.

Results and Discussion

Grey seals

The majority of the stomachs (55.6%) collected had some food-remains, except in the months September to November (Table 2).

Overall, the most common foods found in the stomach of grey seals in Icelandic coastal waters, given as percent by weight, were cod (*Gadus morhua*) (24%), sand eel (*Ammodytes* sp.) (23%), catfish (*Anarhichas lupus*) (15%), saithe (*Pollachius virens*) (11%) and lumpsucker (*Cyclopterus lumpus*) (7%) (Fig. 2).

During the period, January to September, grey seals fed mostly on cod, sand eel, catfish saithe and lumpsucker, in the west-northwest-northeast-east area. Sand eel was the dominant food of grey seals off the south-coast of Iceland. During breeding, October to December, sand eel still dominated in grey seals from the south coast of Iceland, while cod was also common in the food in other coastal areas. Lumpsuckers declined in importance, in the west-northwest-northeast-east coastal area, while bull-rout and cod were the main species eaten (Table 3).

There seemed to be a preference for 2 and 3 year old gadoids according to the samples of the grey seal stomachs (Table 4). According to sizes of otoliths found in the stomachs, the cod eaten were mostly 30–50 cm in length, saithe 10–60 cm in length, haddock 20–40 cm, sand eels 15–35 cm and catfish 20–60 cm. Most of the flatfishes eaten were in sizes 15–40 cm and of various ages depending on species involved; bull-rout were 15–25 cm of age 4–6 years. Herring, capelin and redfish were not dominant preys; herring eaten were 25–35 cm in length and of ages 1–4, capelin 10–15 cm and of ages 1–3 years, and redfish 20–30 cm in length (age unknown). Male grey seals older than 4 years, ate on average bigger and older prey than female grey seals and seals younger than 4 years of age of both sexes (Hauksson, 1997). Grey seals seemed to be able to catch and handle bigger fish than the common and harp seals can, which may explain its higher preference for lumpsuckers.

Grey seals in Icelandic waters feed on the same or similar prey species as in other parts of the North Atlantic. There were however some interesting differences. In the area of Inner and Outer Hebrides, British Isles (Hammond *et al*., 1994), grey seals ate gadoids, sand eels and various flatfish species, as in Iceland. However, they did not eat lumpsuckers, bull-rout and catfish to the same extent as they did when they occurred in coastal waters of Iceland. The diet of grey seals off the Icelandic coast was quite similar to the diet of grey seals off the coast of Sable Island, Eastern Canada (Bowen and Harrison, 1994), and southwest North Sea (Prime and Hammond, 1990) with the exception of lumpsucker which were not reported in the diet. On the other hand, lumpsucker was found in the food of grey seals in the northwestern Gulf of St.

TABLE 2. Percentage of stomachs from grey, common, hooded and harp seals with prey items in relation to the total number of stomachs collected during each month of the period 1990–94.

	Grey seals		Common seals		Hooded seals		Harp seals	
Months	% stomachs with food	Total number of stomachs	% stomachs with food	Total number of stomachs	% stomachs with food	Total number of stomachs	% stomachs with food	Total number of stomachs
January	71.4	7	73.7	19	0.0	2	0.0	2
February	70.0	10	55.6	45	100.0	1	66.7	6
March	81.3	16	44.6	92	0.0	1	57.1	7
April	90.0	50	68.4	174	50.0	4	45.5	11
May	76.3	228	63.8	163	46.2	13	55.3	38
June	92.6	27	63.4	134	50.0	4	100.0	2
July	69.7	119	60.0	70	100.0	8	25.0	4
August	74.7	75	70.6	34	100.0	21	–	0
September	30.9	55	50.0	28	100.0	2	–	0
October	32.2	354	52.0	25	100.0	4	–	0
November	42.4	118	70.0	10	0.0	1	–	0
December	–	–	100.0	5	100.0	1	100.0	2
Total	55.6	1 059	61.7	799	75.8	62	54.2	72

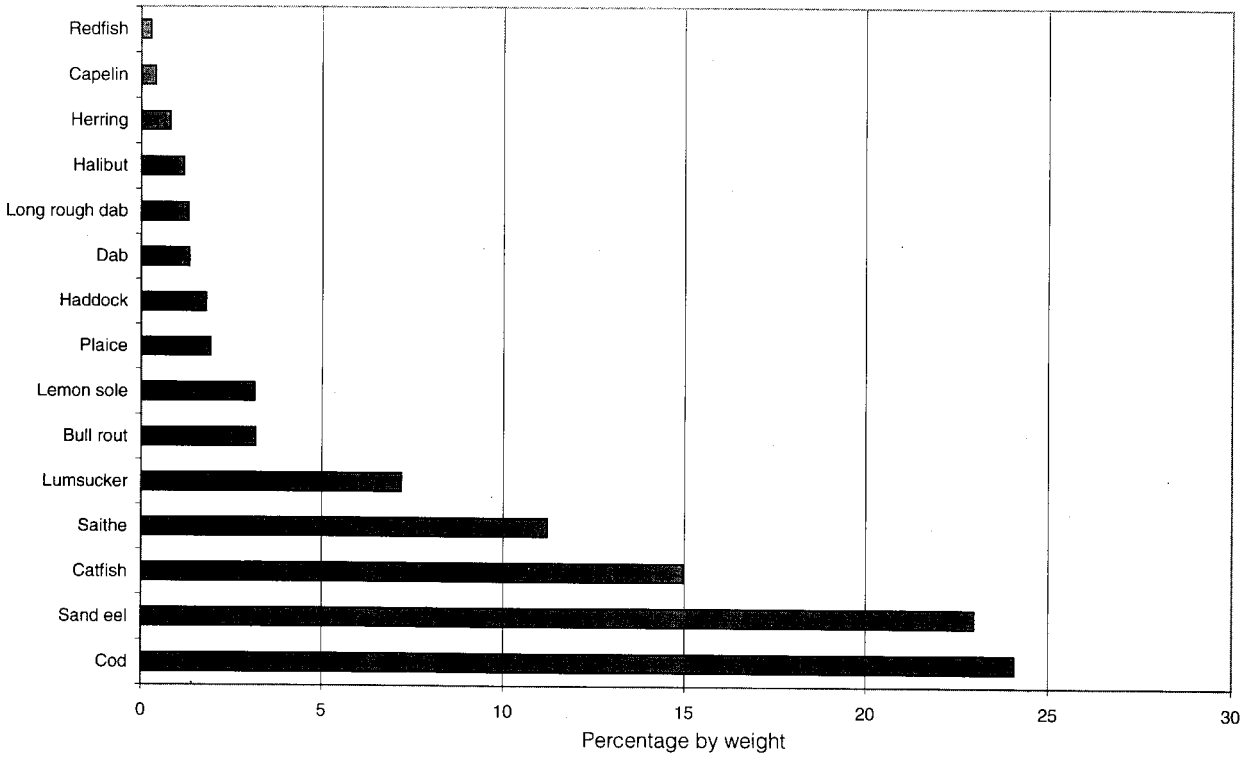

Fig. 2. Percentage by weight of prey-species in the stomachs of grey seals sampled in Icelandic waters in 1992–93; n = 589.

TABLE 3. Variation of the six most common prey items (percentage by weight) in grey seals from Icelandic waters based on geographic area, and feeding and breeding season, in the period 1992–93.

	West–Northwest–Northeast–East coast		South coast	
Food-species	Feeding N = 349	Breeding N = 62	Feeding N = 20	Breeding N = 4
Cod	25.6	31.7	0.1	0.0
Sand eel	18.2	21.4	78.4	91.6
Catfish	17.1	1.5	0.0	0.0
Saithe	12.8	0.8	0.0	0.0
Lumpsucker	8.1	1.3	0.5	0.0
Bull-rout	1.5	31.7	0.1	0.0

Lawrence, although there grey seals fed to a greater extent on capelin than in Icelandic waters (Murie and Lavigne, 1992). In waters off Scotland the diet of grey seals was similar to that of Icelandic waters. In contrast the salmonids, which were frequently taken there, were quite rare in the food of Icelandic grey seals (Rae, 1973).

In Icelandic waters, grey seals move inshore to breed in the autumn. During this time they change their diet from lumpsucker and catfish, to bull-rout, as lumpsucker and catfish are not abundant inshore at this time of the year in the western part of Icelandic waters. A similar form of seasonality was observed in the eastern coastal waters of Canada,

involving different food-species of grey seals, and another type of habitat (Bowen *et al.*, 1993).

Common seals

About 62% of the sampled stomachs were with food remains (Table 2).

A wide variety of prey species were found in the stomachs of common seals (Fig. 3); the most prominent being cod (48%), redfish (*Sebastes* sp.) (8%), sand eel (8%), saithe (8%), herring (7%) and catfish (7%).

The most pronounced geographic difference in feeding, measured by differences in percentage by weight, was between common seals from the south coast of Iceland and the other coastal areas. Sand eel was the main prey item in the former, compared to cod in the other areas. Another less significant difference was that common seals from the north-

TABLE 4. Percentage distribution of age-classes of gadoids in the food of grey seals sampled in Icelandic waters.

	Age-classes							Sample
Fish-species	0	I	II	III	IV	V	VI	size
Cod	11.5	8.8	27.1	30.8	15.0	5.3	1.5	468
Saithe	14.6	18.8	37.5	25.0	4.2	0.0	0.0	48
Haddock	0.0	5.0	55.0	25.0	5.0	10.0	0.0	20
Whiting	0.0	0.0	60.0	20.0	20.0	0.0	0.0	5
Polar cod	0.0	0.0	50.0	50.0	0.0	0.0	0.0	2

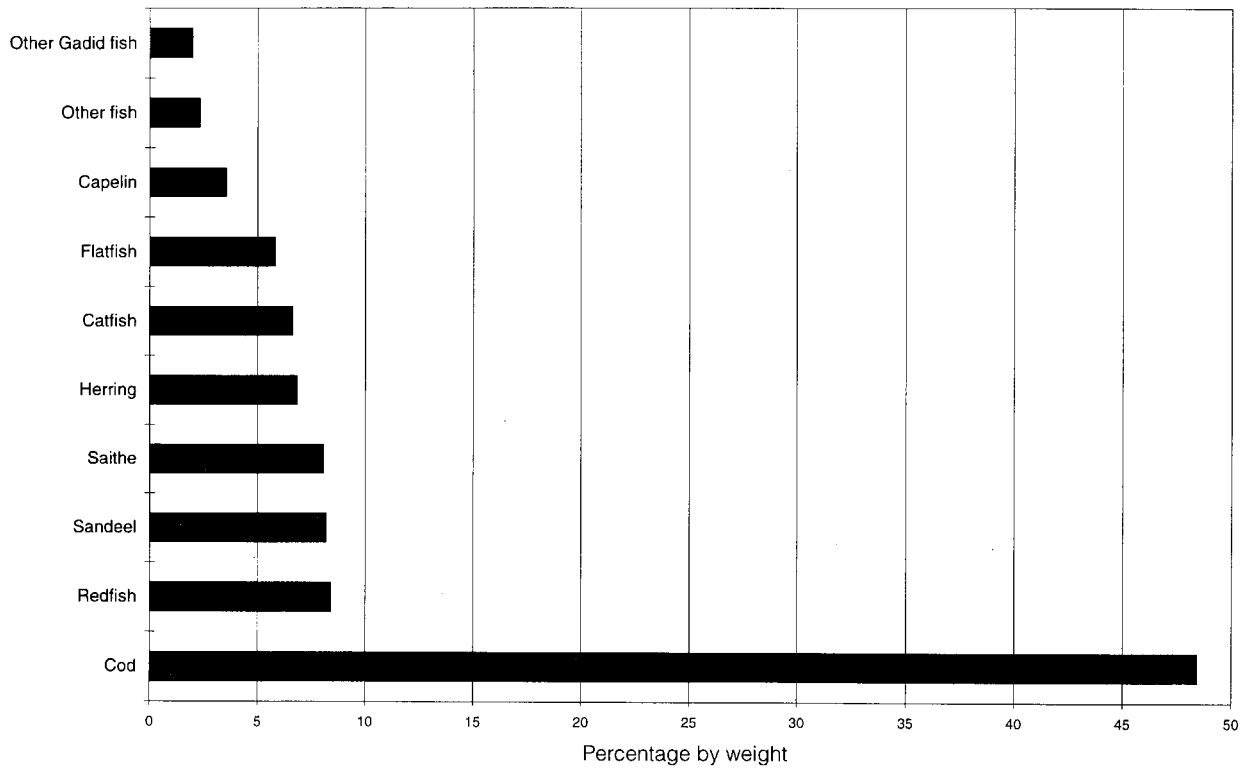

Fig. 3. Percentage by weight of prey-species in the stomachs of common seals sampled in Icelandic waters; n = 493.

TABLE 5. Variation of the eight most common prey-species (percentage by weight) in common seals from Icelandic waters, based on season, and feeding and geographic area in the period 1992–93.

	West coast		West-fjords		Northwest coast		Northeast–East coast		South coast	
Food-species	Autumn/ winter n = 38	Spring/ summer n = 90	Autumn/ winter r n = 59	Spring/ summer n = 69	Autumn/ winter r n = 63	Spring/ summer n = 94	Autumn/ winter r n = 47	Spring/ summer n = 7	Autumn/ winter n = 16	Spring/ summer n = 10
Cod	40.9	43.2	52.2	62.2	47.6	48.6	50.6	44.5	18.7	1.2
Herring	14.9	1.7	19.2	5.5	8.9	0.3	0.7	0.0	0.0	0.0
Capelin	12.8	0.3	0.6	0.8	6.2	3.4	2.2	0.0	42.9	0.0
Saithe	16.1	26.3	1.8	0.2	0.0	0.0	3.2	3.7	0.0	0.0
Redfish	0.8	1.5	4.1	5.9	12.1	20.0	25.4	12.0	0.0	0.0
Catfish	0.6	3.8	17.6	4.6	2.2	8.2	3.2	36.8	0.0	0.0
Sand eel	0.5	13.9	1.2	7.1	6.7	13.2	0.5	0.1	34.2	90.0

TABLE 6. Percentage distribution of age-classes, of gadoids in the food of common seals in Icelandic waters.

	Age-classes						Sample
Fish-species	0	I	II	III	IV	V	size
Cod	22.8	21.2	38.1	14.7	2.6	0.6	1 432
Saithe	19.0	52.9	24.0	4.1	0.0	0.0	121
Haddock	47.0	26.5	22.9	3.6	0.0	0.0	83
Polar cod	0.0	0.0	2.6	14.1	69.2	14.1	78
Whiting	0.0	38.5	30.8	15.4	7.7	7.7	13

west, northeast and east coasts took proportionally more redfish than elsewhere. Saithe was also more important in the food of common seals from the west coast of Iceland than in common seals taken in the other areas.

Some seasonal differences in feeding were observed. Capelin was much more important in the food of common seals from autumn and winter, than spring and summer. This was most pronounced in seals from the south and the west coasts of Iceland. In the west, west-fjords and north-east coastal areas, herring was more important as prey in autumn and winter, than spring and summer. Catfish, which was the second most important prey item, in common seals from the north-east and east coasts during spring and summer was not important at all in autumn and winter. Sand eel was also more important in the spring and summer diet, except off the northeast-east coast (Table 5).

Common seals fed mostly on 2 year old cod. Whiting and saithe were taken a year younger, and haddock mainly as 0-group. On the other hand, polar cod (*Boregadus saida*) was eaten mainly at the age of 4 (Table 6). Sizes of prey items of common seals were mainly 10–40 cm in length. Flatfishes were mostly 10–30 cm, and small fish species were of the sizes 10–20 cm. Fish larger than 40 cm in length were mostly eaten by the older and bigger common seals (Bogason, 1997).

Common seals fed much heavier on capelin in Icelandic waters than grey seals did. This of course was not the case in more southern parts of the Atlantic, where capelin do not exist. The food of common seals in Scottish waters was quite similar to their food in Icelandic water, except for salmonids which were more frequent in the diet of common seals there (Rae, 1973). In the more southern parts of the North Sea, where shallow sandy bottoms dominate, common seals fed mainly on flatfish species which were not found in its diet in the northern waters. In the south, flatfishes seem to be more important as food for common seals than around Iceland (Härkönen, 1987; Slivers, 1989).

Common seals do not move, between inshore and offshore areas in coastal waters of Iceland. Therefore, the small seasonal difference observed

are likely due to seasonal movements of prey species, such as capelin, rather than movement of the seals themselves. In Norwegian waters common seals showed both seasonal and regional variation in diet, which could be explained with variation in availability of species (Olsen and Bjørge, 1995).

Hooded seals

Hooded seals visit the coast of Iceland to feed; only 24% of the stomachs were without food remains. The main feeding season seemed to be in the summer and autumn, July–October, when all stomachs were with food (Table 2).

The most common food items, expressed as percent by weight, were redfish (75%) and cod (20%) (Fig. 4). Hooded seals in Icelandic waters fed on fish of commercial size. The ages of the gadoids eaten ranged from 1 year to 6 years of age, the majority of the fish was older than 3 years (Table 7). In the case of cod, hooded seals fed mainly on 3–5 year olds; fish with the mean-length 36.4 cm (range 14–73 cm). The average length of redfish eaten was 32.4 cm, with a range of 23–43 cm.

Hooded seal is the largest and probably the best diver of the four seal species. This may explain why it took more redfish than the other seals, and fed on older cod, which occur in deeper waters.

It is not within the scope of this paper to analyse the food of hooded seals in Icelandic waters, in comparison with diet of hooded seals in other parts of the North Atlantic. Any comparison of the diet of hooded seal in Icelandic waters, between coastal areas was impossible due to the small sample size and dominance of males. Also the majority of the hooded seals were from northeastern part of the Icelandic coast where they seem to aggregate in the summer (Hauksson and Bogason, MS1995a). It seemed, however, hooded seals feed much more on redfish and cod in Icelandic waters, than in the other areas of the North Atlantic, with the possible exception of the waters of Southeast Greenland where redfish was also dominating in the food, but cod was not (Kapel, 1995). Elsewhere, their food was more dominated by Greenland halibut (*Reinhardtius hippoglossoides*), or redfish and cod were co-dominating with capelin, polar cod, catfish and

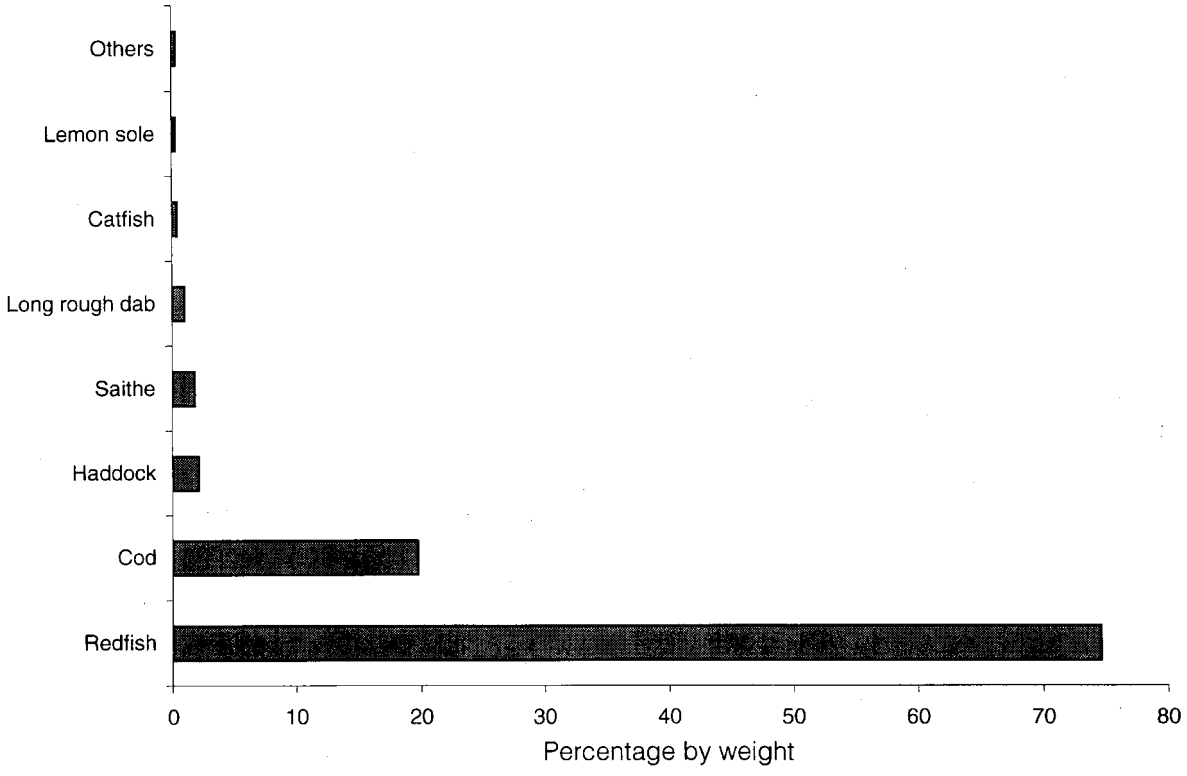

Fig. 4. Percentage by weight of prey-species in the stomachs of hooded seals sampled in Icelandic waters; n = 47.

squids (Kapel, 1995; Hammill and Stenson, MS 1997).

Harp seals

Feeding activity of harp seals occurred throughout the year in Icelandic waters. The number of stomachs with food was proportionally low (54%), but similar for each month (Table 2).

The most common prey item by percent-weight were, sand eel (53%), herring (12%), bull rout (11%) and cod (9%) (Fig. 5).

Harp seals in Icelandic waters fed mainly on small fish-species and young individuals of bigger sized fish (Table 8). In the case of cod, harp seals fed mainly on 1 year-olds. The mean size of cod found in the harp seal stomachs was 15.9 cm, range of cod eaten was 3–48 cm. The mean size of herring taken was 30.7 cm (range 23–36 cm).

Similarly, as in the case of the hooded seal, any comparison of the diet of harp seals in Icelandic waters with its diet elsewhere in the Atlantic was difficult due to small sample size in this study. Pups

TABLE 7. Distribution of age-classes, of gadoids in the food of hooded seals in Icelandic waters.

Fish-species	Age-classes 0	I	II	III	IV	V	VI	Sample size
Cod	0	8.8	2.9	16.2	38.2	27.9	5.9	68
Haddock	0	0	0	46.2	23.1	30.8	0	13
Saithe	0	50.0	0	0	0	25.0	25.0	4

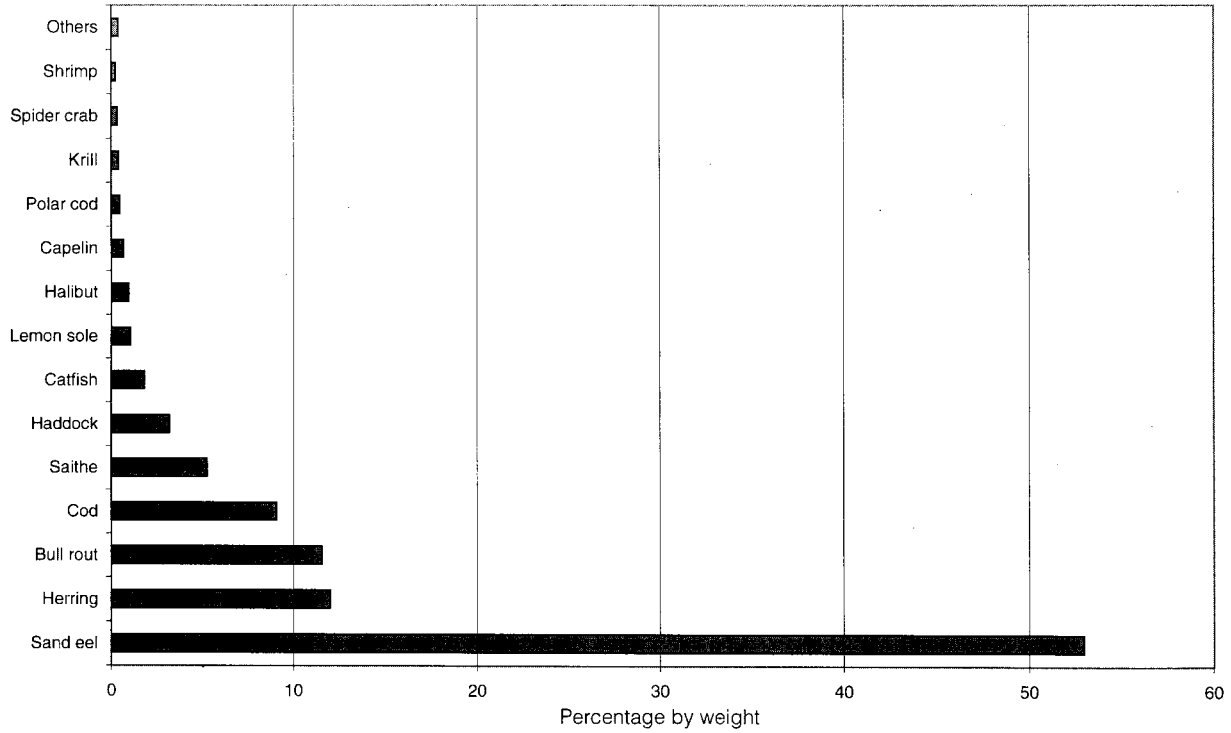

Fig. 5. Percentage by weight of prey-species in the stomachs of harp seals sampled in Icelandic waters; n = 39.

TABLE 8. Distribution of age-classes of gadoids in the food of harp seals sampled in Icelandic waters.

	Age-classes				
Fish-species	0	I	II	III	Sample size
Cod	13.2	60.5	13.2	13.2	38
Polar cod	10.0	0	30.0	60.0	10
Haddock	12.5	12.5	62.5	12.5	8
Saithe	0	75.0	12.5	12.5	8

and 1- year-olds also dominated in the collected animals. However, in Icelandic waters harp seal appeared to feed more on sand eels, than in waters of Newfoundland, Norway and Barents Sea. There their food is dominated by pelagic crustaceans, polar cod and capelin (Kapel, 1995; Lawson and Stenson, 1995; Nilssen, 1995; Nordøy *et al*., 1995). The diet of harp seals in Icelandic waters was most similar to the food of harp seals in the offshore areas of Southwest-Greenland in the summertime and offshore waters of Newfoundland (Lawson *et al*., 1994). Not surprisingly, harp seals visits to the coast also coincides with the spawning migration of the capelin stock to the coast of Iceland, since capelin is an important food of harp seals in Icelandic waters.

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