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Feeding of Grey Seals in Southern Gulf of St. Lawrence

Alimentation du phoque gris dans le sud du golfe du Saint-Laurent

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ABSTRACT

Diet composition of grey seals in the southern Gulf of St. Lawrence was examined using identification of otoliths recovered from 470 digestive tracts. Forty-six different prey taxa were identified. Grey seals fed mainly on sandlance, herring, hake, winter flounder. Cod was an important prey in both the western Gulf and the eastern Gulf, but was only a minor prey item in the Northumberland Strait area. Males consumed a slightly greater number of species, showed greater diet diversity and equal consumption across prey items than did females and young of the year (<6 months old). Cod was an important prey item for males in some areas, but was much less important to females. The mean length of cod consumed was 23.8 cm (SD=11, N=94).

RÉSUMÉ

Le régime alimentaire des phoques gris dans le sud du golfe du Saint-Laurent a été étudié grâce à l'identification des otolithes récoltés dans 470 tractus digestifs. Quarante-six taxons de proies différentes ont été identifiées. Les phoques gris se nourrissent principalement de lançon, de hareng, de merluche et de plie rouge. La morue est une proie importante tant dans la partie ouest du golfe que dans la partie est, mais elle constitue une proie de moindre importance dans la région du détroit de Northumberland. Les mâles consomment légèrement plus d'espèces, montrent une plus grande diversité alimentaire et une consommation plus égale entre les proies que les femelles et les jeunesde l'année (<6 mois). La morue est un élément important des proies pour les mâles dans certains régions, mais est beaucoup moins importante pour les femelles. La longueur moyenne des morues consommées était de 23,8 cm (SD = 11, N = 94).

INTRODUCTION

Marine mammals are often considered as important consumers because of their large size and abundance, which may lead to their having an important influence on the structure and function of marine ecosystems (Bowen 1997; Savenkoff et al. 2004). In marine systems, losses to predation may exceed losses to fisheries, yet it is often assumed that fisheries alone are responsible for variation in fish survival (Morissette et al. 2006). Evaluating the magnitude of this consumption and its contribution to M of cod, requires information on population size, energetic requirements, diet composition, size classes and energy density of the prey, as well as the distribution of marine mammal feeding effort (Harwood and Croxall, 1988; Harwood, 1992).

Over the last few decades, our understanding of diet has improved immensely. However, our understanding of diet in an operational sense remains uncertain. Several approaches have been developed including analyses of digestive tract contents (Tollit et al. 1997,2003), fatty acid and stable isotope analyses (Iverson et al 2004; Hammill et al. 2005). Additional approaches have attempted to associate seal diet, with prey availability, to improve our understanding of the functional relationships involved in prey selection (Smout and Lundstrøm 2007; Lundstrøm et al. 1998). However, all of these approaches have different biases associated with them, complicating attempts to understand true diet composition.

Here diet composition of grey seals collected from the southern Gulf coastal areas of New Brunswick, Prince Edward Island and Nova Scotia is examined.

MATERIALS AND METHODS

Stomach and intestinal contents were obtained by DFO employees or from contract hunters as part of ongoing research to monitor pinniped diets. Animals were sampled in the Gulf of St. Lawrence (Gulf)(Fig. 1). In this study, only material collected in the southern Gulf are examined. Stomachs and digestive tracts were removed in the field, and frozen at –20°C, until analysis. Contents were washed and sorted using three sieves with 2.4, 0.85 and 0.45 mm mesh. Otoliths passing through the smallest sieve were collected in plastic tubs. Invertebrates were measured to the nearest mm, and identified to the lowest possible taxa; cephalopods were identified using beak identification guide (Clarke 1986). Fish were identified using otoliths and from whole fish found in the stomach. Otoliths and other hard parts were sorted manually and conserved dry for later identification. Fish were identified to species when possible, using reference collections (Fisheries and Oceans Canada, Mont-Joli, Québec and St. John's NL) and an identification guide (Härkönen 1986). The number of fish in each stomach was determined by pairing the left and right otoliths if possible and using the maximum number of left or right. If otoliths could not be paired, the total number of otoliths collected was divided by two and rounded upwards.

Otoliths were sorted, visually, into three different classes depending on their degradation state: class D1, including perfectly conserved otoliths (generally found in intact skulls or whole fish in seal stomach); class D2, otoliths with very few degradation marks, but margins showing some signs of erosion; class D3, very eroded otoliths, with dorsal and ventral margins and internal and external areas showing advanced digestion marks. Only D1 otoliths were used to determine total fish length. If a large number of otoliths of a single species were present in a stomach, a random subsample (30) otoliths was measured. Otolith-fish metric relationships were developed from samples collected during Department of Fisheries and Oceans research missions or using values from the literature (e.g., Lawson et al. 1995; D. Chabot, Dept. of

Fisheries and Oceans, Mont-Joli, QC, unpublished data; DM and GBS unpublished data). Otoliths not measured were identified to species and it was assumed that their mass and energy density were equivalent to the mean size and caloric density of the measured otoliths for that species in the sample. Otoliths that could not be identified to species were assumed to have size and caloric density equivalent to the mean of all measured otoliths. In the case of invertebrates, total mass and energy contribution were determined by multiplying the number of identified individuals of a species by the mean mass and energy density calculated for this species. In some cases, only eyes or telson were present. The contribution of this material to the diet was determined by multiplying the number of individuals determined from the number of eyes and telson times a mean mass and a mean energy density using all identified invertebrates. Diets were reconstructed for each seal, using the seal as the sampling unit. To correct for loss of prey items due to digestion, numerical correction factors (NCF) were applied (Grellier and Hammond 2006; appendix 1). Diet composition is expressed as follows:

$$\% \text{ wet mass} = \frac{\text{Total estimated mass of a species found in a sample (stomach)}}{\text{Estimated mass of all items found}} \times 100.$$

Diet diversity was examined using species richness and calculating a Shannon index (H'). Species richness is the number of different species in the sample collection. The Shannon index is a measure of species diversity, taking into account the number of individuals examined and was calculated using:

$$H' = -\Sigma\{ p_i * \log(p_i)\},$$

where pi is the proportion of species x in the sample (Legendre and Legendre 1998). An equitability index (E_H) was defined as $E_H = H'/\ln(S)$, where S is the number of species (Legendre and Legendre 1998).

Diet composition may vary considerably between seals. Owing to the small sample sizes and individual variation, standard errors around the means were expected to be quite large. To reduce this variability, simulated data sets of total energy and total mass consumed were created using a bootstrapping technique (Resampling Stats, Arlington VA, USA 1999). Each stomach was treated as a unit for resampling purposes. This process was repeated 1000 times to generate estimates of total mass and total energy, from which proportions contributed by each prey group were calculated.

RESULTS

A total of 470 digestive tracts were collected, of which food remains were detected in 235 stomachs. Animals were collected between 1994 and 2008, between June and November. Forty-six prey species were identified, including 9 invertebrate species (Table 1).

In the stomachs, five species, hake, sandlance, flounder, herring and wrymouth accounted for 85% of the diet by weight (Table 1). From the intestines, where prey items did not have NCF applied to them, sandlance, hake, flounders, herring , unidentified and cod were the most important species contributing to 82% of the diet. From the intestines, where NCF were applied to prey items, sandlance, flounders, herring, hake, unidentified and cod were the most important species contributing to 84% of the diet.

Among males (N=96), hake, herring, sandlance , flounder and cod accounted for 84% of the diet by weight for the stomachs. Among females (N=118), flounders, hake, sandlance , herring, sculpins and wrymouth accounted for 86% of the diet. For males, cod accounted for 6.4 % (SD=2.7) of the diet, whereas for females, cod only accounted for 1.3% (SD=0.7) of the diet. Using the intestines, among males (N=171), sandlance, herring, flounder, cod, sculpin, mackerel, plaice, wrymouth and butterfish accounted for 80% of the diet. Diet information using intestines from females (N=242), indicated that sandlance, flounder, herring and cunner accounted for 82% of the diet. Cod accounted for only 1% (SD=0.4) of the diet. Among juveniles (N=24), blenny's, invertebrates and sandlance accounted for 82% of the diet. Cod accounted for less than 1% of the diet (Table 2).

Using the NCF corrected intestine samples only, the species richness was 41, 39 and 30 for adult males, adult females and juveniles respectively. The Shannon index was 1.52, 1.24 and 0.17 for adult males, adult females and juveniles respectively. The Equitability index was .41, .34, and 0.05 for adult males, adult females and juveniles respectively.

Collections were made in three main regions, the western Gulf, centered around the Miramichi River area, the Northumberland Strait area with sampling near Charlottetown on Prince Edward Island and at Amet Island on the south side of the strait in Nova Scotia, and the third area was the west side of Cape Breton Island with sampling from the Port Hood/Cape North area, with most samples coming from near Inverness. Additional samples (N=7) were obtained from the Magdalen Islands. Collections were divided into spring (May to July) and Fall (September to December).

From the Miramichi area intestine samples, sandlance was the predominant prey item for both sexes, contributing to 64% of the male diet from the spring (78% in fall)(Table 3a). Sandlance was a much more important prey item for females making up 93% of the female diet in spring (89% in fall). Herring were important prey for male grey seals but were not an important prey item among females. Cod was also an important prey item for males (6-22%) particularly during the fall, but was not an important prey for females (<3%). Looking at stomach contents, no samples from males were available from the spring/summer period. Sandlance was again the dominant prey item followed by herring among males, followed by flounders and the fall cod among females (22%)(Table 3b).

From the Northumberland Strait intestine samples, sandlance were important prey for females, but not for males, while herring were also important prey for both species particularly in the fall for males. Blennies and invertebrates were also more important prey items for grey seals from the Strait. Cod made up less than 1% of the diet of grey seals from this area(Table 4a). In the stomach content analyses, sandlance were a trivial prey item, whereas herring was a major prey item particularly for fall males. Winter flounder were also a major prey species. As in the intestines, cod was also a trivial prey item (Table 4b).

A small sample of stomachs was obtained from the Magdalen Islands during the 1990s (Table 5). Samples were obtained from both the summer and the winter. Herring, lumpfish, cod and plaice were the dominant prey items. Cod made up about 26% (SD=8) of the diet, but only a few animals were examined (N=7).

From Cape Breton Island, only fall samples were available. Sandlance, herring, winter flounder, white hake and cod were the most important prey species. The application of correction factors reduced the contribution of gadids to the diet and increased the contribution of sandlance and herring. Looking at the stomach contents, sandlance, white hake, herring and flounders were the most important prey items. The contribution of cod to the diet was about 10% for males and about 4% for females (Table 6b).

There appeared to be a trend in reconstructed cod mass found in male grey seal intestines from Cape Breton over time, but there was considerable variability between years suggesting the trend was not significant. Looking at sampling effort, it can also be seen that there was greater sampling effort in October and November in early years, and increased effort in November and December in latter years. Cod leave the Gulf during the fall, so that in general sampling later in fall would be expected to have less cod. Although, most sampling occurred between Port Hood and Cheticamp, sampling further to the north cannot be excluded.

The mean length of cod consumed by grey seals was 23.8 (SD=11.0, N=94). However, if weighted by fish mass, the mean length increases to 37.2 (SD=10.6)(Fig. 3). The mean length of white hake and winter flounder were 22.6 (SD=8.8,N=275) and 18.9 (SD=12.7,N=721) respectively. The weighted mean length was 29.5 (SD=8.1) cm and 24.8 (SD=6.8) cm for white hake and winter flounder respectively (Fig. 4).

DISCUSSION

Major limitations to the use of hard parts to reconstruct ingested prey to quantify diet composition include the failure to find hard parts in the sample and under-estimating hard part size due to erosion while in the stomach (Jobling and Breiby 1986; Tollit et al. 1997,2003). The degree to which these problems occur is affected by foraging behaviour, species composition of the diet, activity levels of the animal and meal size (Murie and Lavigne 1985; Jobling and Breiby 1986; Jobling 1987; Lawson et al. 1995; Tollit et al. 1997; Marcus et al. 1998). The impact of variability in otolith erosion rates, including complete otolith digestion on diet reconstructions, has been examined in captive studies (Jobling and Breiby 1986; Jobling 1987) and some ways to correct the measurement have been proposed (Tollit et al. 1997, 2003; Bowen 2000; Grellier and Hammond 2006). We did not measure eroded otoliths because suggested correction factors to adjust otolith lengths to account for partial digestion are quite variable (reviewed by Bowen 2000) and if applied, add uncertainty to estimates of diet composition (Hammond and Rothery 1996), but this may also fail to capture fully the complete size range of fish consumed because the numbers of non-eroded otoliths re more limited. In this study, we applied NCF to hard parts recovered to the intestines, but not the stomachs. NCFs are not available for material recovered from stomachs, but In previous work on harp seals, where prey with smaller otloliths are consumed this approach has been shown to result in unbiased diet estimates (Hammill et al. 2005). However, there is some evidence that large, robust otoliths eg cod otoliths are retained longer in the stomach, increasing the apparent contribution of these species to the diet (Stenson et al. 2010). The application of NCF increases the contribution of species with frail otoliths such as sandlance, capelin and herring, and reduces the contribution of species with robust otoliths such as cod, and hake. The use of NCF assumes some constant relationship between otoliths ingested and otoliths recovered, but as indicated above this is unlikely. Alternative models have suggested that small prey, may be over-represented and large prey, which often have more robust otoliths, but are consumed in fewer numbers, may be under-represented in scat samples (in this case intestine) (Arim and Naya 2003), but this difficulty should be overcome if sufficient numbers of samples are obtained. Ideally, a combination of methods involving digestive tract reconstruction and chemical methods such as application of Bayesian methods to stable isotope mixing models to determine diet composition (Parnell et al. 2010) are needed to reduce bias or to understand more fully where biases lie.

Grey seals are primarily piscivorous, with invertebrates accounting for only a very small fraction of their diet (Benoît and Bowen 1990 a,b; Murie and Lavigne 1992; Bowen et al. 1993; this study). Although a wide range of species were consumed, 9 or fewer species accounted for over 80% of the grey seal diet. Major prey items included sand lance, winter flounder, herring, cod, and white hake, which have also been reported as important prey elsewhere (Benoît and Bowen 1990a,b; Bowen et al. 1993; Bowen and Harrison 1994). We also identified mackerel, sculpin, plaice, wrymouth and butterfish as important prey particularly among males. Males had a more diverse diet and consumed different prey more evenly than did females and juveniles. We did not observe that females consumed more pelagic prey than did males as has been observed elsewhere (Beck et al. 2007), but species such as sandlance were much more important to the female diet, while cod were much more important to the male diet.

Length of prey consumed by grey seals was examined only among a few prey items. Using frequency of occurrence, grey seals consumed prey with a mean length of 19 to 23 cm. Taking into account the weighted contribution of fish to the diet, the mean length of prey consumed increased to 25-37 cm.

In the early 1990s, moratoria on fishing for Atlantic cod were declared after several eastern Canadian cod fisheries had collapsed. Almost a decade later, evidence of marked changes in ecosystem structure are still evident, with almost all of these stocks showing no or very limited signs of recovery (DFO, 2003). In the southern Gulf of St. Lawrence, the lack of recovery in the 4T cod stock is associated with very high levels of natural mortality among large cod and it has been suggested that grey seal predation may be an important factor, contributing to this high mortality (Chouinard et al. 2005). High mortality and changes in distribution have also been observed among skate, white hake and winter flounder populations in the Gulf (Swain and Benoit 2006; Swain et al. 2009; Harvey et al 2010). Hake and flounder are also important prey items, and skate have been identified in grey seal diets in previous studies (Mansfield and Beck 1977) suggesting that grey seals may also be having an impact on these species as well.

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Table 1. Diet composition (5% weight) of grey seals collected from the southern Gulf of St. Lawrence based on stomach and intestine samples. Intestine samples are presented as before and after applying numerical correction factors. Prey species with values of 0 represent only trace amounts.

Common name		**Stomach Mean**	**SD**	**Intestine Mean**	**No NCF SD**	**Intestine Mean**	**With NCF SD**
Sandlance	*Ammodytes sp*	23.4	3.4	24.0	3.6	39.0	4.7
Hookear sculpin	*Artediellus atlanticus*	0.0	0.0	0.0	0.0	0.0	0.0
At. Herring	*Clupea harengus*	10.7	2.9	6.9	1.3	11.4	2.1
Sculpin	*Cottidae sp*	0.2	0.1	0.1	0.0	0.2	0.1
Wrymouth	*Cryptacanthodes maculatus*	8.0	3.8	2.0	1.0	1.1	0.5
Lumpfish	*Cyclopterus lumpus*	0.0	0.0	0.0	0.0	0.0	0.0
Fourbeard rockling	*Enchelyopus cimbrius*	0.1	0.1	0.2	0.1	0.1	0.0
Fourline snakeblenny	*Eumesogrammus praecisius*	0.0	0.0	0.0	0.0	0.0	0.0
At. Cod	*Gadus morhua*	2.5	0.6	5.9	1.3	3.7	0.9
Gadid	*Gadus sp*	1.3	0.4	1.5	0.5	0.9	0.3
Arctic staghorn sculpin	*Gymnocanthus tricuspis*	0.0	0.0	0.0	0.0	0.0	0.0
Sea raven	*Hemitriptere americanus*	0.0	0.0	0.0	0.0	0.0	0.0
American plaice	*Hippoglossoïdes platessoïdes*	0.4	0.1	1.8	0.8	1.3	0.6
Yellowtail flounder	*Limanda ferruginea*	3.2	0.9	1.2	0.3	0.9	0.3
Snakeblenny	*Lumpenus lumpreteaformis*	0.0	0.0	0.5	0.1	0.4	0.1
Daubed shanny	*Lumpenus maculatus*	0.0	0.0	0.0	0.0	0.0	0.0
Blenny	*Lumpenus sp*	0.0	0.0	0.0	0.0	0.0	0.0
Checker eelpout	*Lycode vahlii*	0.0	0.0	0.0	0.0	0.0	0.0
Eelpout	*Lycodes sp*	0.0	0.0	0.1	0.0	0.0	0.0
Ocean pout	*Macrozoarces americanus*	0.0	0.0	0.3	0.1	0.2	0.1
Capelin	*Mallotus villosus*	0.0	0.0	0.0	0.0	0.0	0.0
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	0.0	0.0	1.8	0.5	2.9	0.8
Shorthorn sculpin	*Myoxocephalus scorpius*	0.0	0.0	0.0	0.0	0.0	0.0
Sculpin	*Myoxocephalus sp*	0.0	0.0	0.1	0.1	0.2	0.1
White barracudina	*Notolepis rissoi*	0.0	0.0	0.0	0.0	0.0	0.0
Smelt	*Osmerus mordax*	0.0	0.0	0.2	0.1	0.1	0.0
Butterfish	*Peprilus triacanthus*	3.4	0.7	1.7	0.6	0.9	0.3
Flounders	*Pleuronectidae sp*	6.5	1.5	8.5	1.4	5.7	1.0
Winter flounder	*Pseudopleuronectes americanus*	12.6	2.4	16.4	2.7	11.8	2.1
Mackerel	*Scomber scombrus*	0.9	0.4	2.6	0.9	2.0	0.7
Windowpane	*Scophthalmus aquosus*	0.3	0.1	1.0	0.3	0.7	0.2
Redfish	*Sebastes sp*	0.0	0.0	0.2	0.1	0.1	0.1
Arctic shanny	*Stichaeus punctatus*	0.0	0.0	0.0	0.0	0.0	0.0

Table 1. (End)

Common name		Stomach Mean	SD	Intestine Mean	No NCF SD	Intestine Mean	With NCF SD
Prickleback/Blenny	*Stichaeidae sp*	0.0	0.0	0.0	0.0	0.0	0.0
Cunner	*Tautogaulabrus adspersus*	0.1	0.0	1.9	1.0	2.9	1.7
	unspecified	1.8	0.5	6.3	1.1	3.8	0.6
Wh. Hake	*Urophycis tenuis*	24.2	2.9	13.9	2.1	8.6	1.5
Eelpout	*Zoarcidae sp*	0.3	0.2	0.1	0.0	0.2	0.1
Amphipod	*Amphipoda*	0.0	0.0	0.0	0.0	0.0	0.0
Bivalvia	*Bivalvia*	0.0	0.0	0.1	0.0	0.0	0.0
Shrimps	*Caridea*	0.0	0.0	0.5	0.2	0.3	0.1
Crab	*crab*	0.0	0.0	0.0	0.0	0.0	0.0
Squid	*Cephalopoda*	0.0	0.0	0.0	0.0	0.0	0.0
Cumacean	*Cumacae*	0.0	0.0	0.0	0.0	0.0	0.0
Euphausid	*Euphausiacae*	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda (periwinkle, whelk)	*Gastropoda*	0.0	0.0	0.5	0.4	0.3	0.2
Isopod	*Isopode*	0.0	0.0	0.0	0.0	0.0	0.0
Ave mass per stomach (g)		1312.6	695.0	1905.0	2625.9	2930.4	4759.8

Table 2. Diet composition (%wet weight) of grey seals collected in the southern Gulf of St. Lawrence based on analyses of stomach and intestine samples. NCF were applied to the intestine samples.

Common name	Male Mean	Stomach SD	Female Mean	Stomach SD	Male Mean	Intestine SD	Female Mean	Intestine SD	Juvenile Mean	Intestine SD
Sandlance	16.5	8.0	13.1	4.2	30.6	7.5	48.1	5.9	6.1	6.2
Hookear sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Herring	22.0	5.8	10.9	4.4	17.9	4.3	7.2	2.0	0.0	0.0
Sculpin	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.0	0.0
Wrymouth	0.8	0.3	4.0	3.1	1.7	1.3	0.7	0.3	0.0	0.0
Lumpfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fourbeard rockling	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1
Fourline snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Cod	6.4	2.7	1.3	0.7	6.8	1.9	1.0	0.4	0.6	0.7
Gadid	0.4	0.3	0.5	0.3	1.0	0.7	0.9	0.3	0.0	0.0
Arctic staghorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sea raven	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American plaice	0.3	0.2	0.2	0.1	2.1	1.3	0.8	0.4	0.0	0.0
Yellowtail flounder	0.4	0.3	1.6	0.8	1.0	0.5	0.9	0.3	0.1	0.1
Snakeblenny	1.0	0.5	0.6	0.3	0.5	0.2	0.3	0.1	0.9	0.6
Daubed shanny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Checker eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eelpout	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Ocean pout	0.3	0.1	0.6	0.4	0.3	0.2	0.2	0.1	0.3	0.3
Capelin	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5	0.5
Longhorn sculpin	5.6	2.9	5.6	5.2	3.6	1.6	2.3	0.8	1.3	0.9
Shorthorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sculpin	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.1	1.0	1.0
White barracudina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Smelt	0.1	0.0	0.5	0.4	0.1	0.0	0.0	0.0	1.7	1.4

Table 2. (end)

Common name	Male Mean	Stomach SD	Female Mean	Stomach SD	Male Mean	Intestine SD	Female Mean	Intestine SD	Juvenile Mean	Intestine SD
Butterfish	1.4	0.8	1.3	0.6	1.4	0.8	0.1	0.1	2.9	2.6
Flounders	5.9	3.1	3.9	1.5	6.0	1.8	5.9	1.3	6.4	3.3
Winter flounder	10.8	2.6	31.6	7.3	7.0	3.0	15.6	3.3	32.1	16.9
Mackerel	0.0	0.0	0.9	0.7	3.5	1.7	0.6	0.4	15.4	11.2
Windowpane	2.2	1.1	1.8	0.8	0.7	0.4	0.8	0.2	2.5	1.5
Redfish	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1
Arctic shanny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prickleback/Blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cunner	0.6	0.3	1.1	0.5	0.3	0.1	5.3	2.9	2.9	1.5
Unspecified	2.9	1.2	2.8	1.0	4.6	1.0	2.9	0.8	21.8	11.0
Wh. Hake	22.1	5.9	17.0	3.9	9.9	2.6	4.8	1.2	2.3	2.4
Eelpout	0.1	0.0	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0
Amphipod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bivalvia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrimps	0.0	0.0	0.0	0.0	0.1	0.0	0.4	0.2	0.8	0.4
Crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Squid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumacean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda	0.0	0.0	0.0	0.0	0.5	0.5	0.1	0.2	0.0	0.0
Isopod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ave mass per stomach (g)	2120.0	2414.8	1918.3	3242.2	3951.1	5637.5	3227.2	4696.6	1473.0	2150.8

Table 3a. Diet composition of grey seals collected from the Miramichi area based on NCF corrected intestine contents.

Miramichi	Fall females Intestine		Males Fall intestine		Females spring intestine		Males spring intestine	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
N=	46		23		27		5	
Sandlance	88.9	3.2	77.7	11.4	92.9	3.6	64.5	27.7
Hookear sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Herring	1.3	0.8	10.5	6.1	0.5	0.5	0.0	0.0
Sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wrymouth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lumpfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fourbeard rockling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fourline snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Cod	0.9	0.6	6.0	6.2	2.5	2.1	22.3	18.1
Gadid	1.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Arctic staghorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sea raven	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American plaice	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Yellowtail flounder	1.5	0.9	0.1	0.1	1.6	0.8	10.3	8.4
Snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daubed shanny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Checker eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ocean pout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capelin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Longhorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shorthorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sculpin	0.0	0.0	0.8	0.9	0.0	0.0	0.0	0.0
White barracudina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smelt	0.1	0.1	0.0	0.0	0.3	0.3	0.0	0.0
Butterfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Flounders	1.7	0.7	1.2	0.7	0.4	0.2	0.0	0.0
Winter flounder	2.7	0.9	1.7	1.1	1.2	0.8	1.5	1.3
Mackerel	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Windowpane	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0
Redfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arctic shanny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prickleback/Blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cunner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3a. (End).

Miramichi	Fall females Intestine		Males Fall intestine		Females spring intestine		Males spring intestine	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Unspecified	0.2	0.1	1.1	1.3	0.1	0.1	0.4	0.4
Wh. Hake	0.0	0.0	1.0	0.6	0.2	0.3	0.9	0.8
Eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphipod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bivalvia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrimps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Squid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumacean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isopod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ave mass per stomach (g)	4398.4	4429.3	4468.3	8342.3	5095.4	5986.2	4092.2	2637.0

Table 3b. Diet composition of grey seals collected from the Miramichi area based on stomach contents.

	Miramichi fall female		Miramichi fall male		Miramichi spring female	
	Mean	SD	Mean	SD	Mean	SD
N=	27		10		12	
Sandlance	77.4	7.0	52.1	21.6	38.7	19.0
Hookear sculpin	0.0	0.0	0.0	0.0	0.0	0.0
At. Herring	1.4	1.3	32.2	25.9	0.0	0.0
Sculpin	0.0	0.0	0.0	0.0	0.0	0.0
Wrymouth	0.0	0.0	0.0	0.0	0.0	0.0
Lumpfish	0.0	0.0	0.0	0.0	0.0	0.0
Fourbeard rockling	0.0	0.0	0.0	0.0	0.0	0.0
Fourline snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0
At. Cod	0.0	0.0	0.0	0.0	22.5	20.8
Gadid	1.9	2.0	3.9	3.8	0.0	0.0
Arctic staghorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0
Sea raven	0.0	0.0	0.0	0.0	0.0	0.0
American plaice	0.5	0.5	0.0	0.0	0.0	0.0
Yellowtail flounder	3.2	2.7	0.0	0.0	0.0	0.0
Snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0
Daubed shanny	0.0	0.0	0.0	0.0	0.0	0.0
Blenny	0.0	0.0	0.0	0.0	0.0	0.0
Checker eelpout	0.0	0.0	0.0	0.0	0.0	0.0
Eelpout	0.0	0.0	0.0	0.0	0.0	0.0
Ocean pout	0.0	0.0	0.0	0.0	0.0	0.0
Capelin	0.0	0.0	0.0	0.0	0.0	0.0
Longhorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0
Shorthorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0
Sculpin	0.0	0.0	0.0	0.0	0.0	0.0
White barracudina	0.0	0.0	0.0	0.0	0.0	0.0
Smelt	0.1	0.1	0.0	0.0	0.0	0.0
Butterfish	0.0	0.0	0.0	0.0	0.0	0.0
Flounders	2.1	1.5	1.9	2.2	0.0	0.0
Winter flounder	12.2	4.8	6.2	7.0	25.2	22.5
Mackerel	0.0	0.0	0.0	0.0	0.0	0.0
Windowpane	0.2	0.2	0.2	0.3	0.0	0.0
Redfish	0.0	0.0	0.0	0.0	0.0	0.0
Arctic shanny	0.0	0.0	0.0	0.0	0.0	0.0
Prickleback/Blenny	0.0	0.0	0.0	0.0	0.0	0.0
Cunner	0.0	0.0	0.0	0.0	0.0	0.0
Unspecified	0.0	0.0	0.3	0.4	5.4	5.2
Wh. Hake	0.9	0.6	3.3	2.9	8.2	9.1
Eelpout	0.0	0.0	0.0	0.0	0.0	0.0
Amphipod	0.0	0.0	0.0	0.0	0.0	0.0
Bivalvia	0.0	0.0	0.0	0.0	0.0	0.0
Shrimps	0.0	0.0	0.0	0.0	0.0	0.0
Crab	0.0	0.0	0.0	0.0	0.0	0.0
Squid	0.0	0.0	0.0	0.0	0.0	0.0
Cumacean	0.0	0.0	0.0	0.0	0.0	0.0
Euphausid	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda	0.0	0.0	0.0	0.0	0.0	0.0
Isopod	0.0	0.0	0.0	0.0	0.0	0.0
Ave mass per stomach (g)	1022.4	1884.7	515.8	695.9	204.5	193.6

Table 4a. Diet composition of grey seals collected from the Northumberland Strait area based on NCF corrected intestine contents.

Intestine	Northumberland Males spring		Northumberland Females Spring		Northumberland Males Fall		Northumberland Female Fall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
N=	42		45		35		68	
Sandlance	0.2	0.1	16.3	11.5	0.2	0.1	14.0	12.1
Hookear sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Herring	4.5	3.0	11.2	3.5	69.3	14.1	16.8	7.3
Sculpin	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Wrymouth	14.5	10.8	1.9	1.6	0.5	0.4	0.4	0.4
Lumpfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fourbeard rockling	0.2	0.1	0.7	0.4	0.0	0.0	0.0	0.0
Fourline snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Cod	0.1	0.1	0.0	0.0	0.7	0.6	0.0	0.0
Gadid	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.0
Arctic staghorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sea raven	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0
American plaice	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Yellowtail flounder	0.5	0.4	0.5	0.5	0.7	0.7	0.1	0.1
Snakeblenny	3.8	1.7	2.2	1.1	0.6	0.7	0.1	0.1
Daubed shanny	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Checker eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ocean pout	2.4	2.0	1.0	0.7	0.3	0.2	0.3	0.1
Capelin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Longhorn sculpin	14.9	8.3	1.6	1.2	6.5	6.6	7.8	3.2
Shorthorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sculpin	0.0	0.0	0.0	0.0	1.0	1.2	0.3	0.3
White barracudina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smelt	0.3	0.1	0.7	0.5	0.3	0.1	0.1	0.0
Butterfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Flounders	12.5	5.4	10.9	5.1	3.1	1.8	7.8	3.7
Winter flounder	21.1	6.0	27.9	8.2	4.0	2.2	21.7	6.9
Mackerel	0.0	0.0	1.2	1.2	0.0	0.0	0.0	0.0
Windowpane	3.5	1.6	0.5	0.2	3.0	1.8	2.1	0.8
Redfish	0.1	0.1	0.8	0.6	0.2	0.1	0.1	0.0
Arctic shanny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prickleback/Blenny	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Cunner	1.4	0.7	3.9	2.9	0.4	0.3	18.3	10.1

Table 4a. (End).

Intestine	Northumberland Males spring		Northumberland Females Spring		Northumberland Males Fall		Northumberland Female Fall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Unspecified	10.5	4.2	3.1	1.2	5.9	3.4	5.4	1.9
Wh. Hake	3.4	1.4	12.1	6.1	2.2	1.2	2.7	1.0
Eelpout	0.2	0.2	0.9	0.6	0.7	0.5	0.0	0.0
Amphipod	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Bivalvia	0.5	0.4	0.2	0.2	0.0	0.0	0.0	0.0
Shrimps	0.3	0.1	0.3	0.1	0.2	0.1	1.6	0.7
Crab	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Squid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumacean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda	4.7	4.8	1.5	1.6	0.0	0.0	0.0	0.0
Isopod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ave mass per stomach (g)	1607.282	2343.294	1237.9	2176.7	1789.6	3627.43	2973.8	5383.1

Table 4b. Diet composition of grey seals collected from the Northumberland Strait area based on stomach contents.

	Northumberland Male Spring		Northumberland Female Spring		Northumberland Male Fall		Northumberland Female Fall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
N=	27		27		14		24	
Sandlance	0.0	0.0	0.2	0.2	0.4	0.3	0.0	0.0
Hookear sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Herring	15.9	8.5	15.2	8.9	62.9	21.5	12.3	8.6
Sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wrymouth	4.4	1.5	5.0	4.1	0.0	0.0	0.5	0.3
Lumpfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fourbeard rockling	0.2	0.1	0.3	0.3	0.0	0.0	0.1	0.1
Fourline snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
At. Cod	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1
Gadid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arctic staghorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sea raven	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American plaice	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Yellowtail flounder	2.1	1.6	0.5	0.3	0.0	0.0	0.0	0.0
Snakeblenny	5.6	2.5	3.1	1.6	0.0	0.0	0.0	0.0
Daubed shanny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Checker eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eelpout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ocean pout	0.9	0.5	0.5	0.4	0.7	0.5	1.4	0.9
Capelin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Longhorn sculpin	18.3	9.5	0.8	0.5	16.1	12.8	15.0	12.6
Shorthorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4
White barracudina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smelt	0.2	0.2	1.7	1.5	0.1	0.1	0.1	0.1
Butterfish	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0
Flounders	0.8	0.7	5.0	3.9	1.2	1.3	0.7	0.4
Winter flounder	37.0	7.5	42.4	13.3	14.4	8.1	50.1	13.4
Mackerel	0.0	0.0	2.6	2.6	0.0	0.0	0.0	0.0
Windowpane	4.2	1.2	0.5	0.4	1.8	1.0	4.9	2.1
Redfish	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Arctic shanny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prickleback/Blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cunner	2.1	0.7	2.1	1.0	0.4	0.3	2.2	1.8
Unspecified	3.3	2.1	5.5	3.2	1.3	1.4	3.6	2.3
Wh. Hake	4.5	2.5	12.8	5.5	0.6	0.6	8.4	4.2

Table 4b. (End)

	Northumberland Male Spring		Northumberland Female Spring		Northumberland Male Fall		Northumberland Female Fall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eelpout	0.3	0.2	0.8	0.4	0.0	0.0	0.1	0.1
Amphipod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bivalvia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrimps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Squid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumacean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda (periwinkle, whelk)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isopod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ave mass per stomach (g)	1701.3	1480.5	1938.6	2221.0	892.7	1985.0	2109.7	2908.4

Table 5. Diet composition of grey seals collected from the Magdalen Islands based on stomach contents.

	Magdalen Islands	
	Mean	**SD**
N=	7	
Sandlance	0.1	0.0
Hookear sculpin	0.0	0.0
At. Herring	16.5	11.2
20.2Sculpin	0.0	0.0
Wrymouth	0.0	0.0
Lumpfish	20.4	0.0
Fourbeard rockling	0.0	0.0
Fourline snakeblenny	0.0	0.0
At. Cod	25.8	0.0
Gadid	0.0	0.0
Arctic staghorn sculpin	0.2	0.2
Sea raven	0.0	0.0
American plaice	12.5	7.0
Yellowtail flounder	3.3	3.3
Snakeblenny	0.0	0.0
Daubed shanny	0.0	0.0
Blenny	0.0	0.0
Checker eelpout	5.1	2.1
Eelpout	0.0	0.0
Ocean pout	0.0	0.0
Capelin	0.1	0.0
Longhorn sculpin	0.0	0.0
Shorthorn sculpin	6.9	5.1
Sculpin	0.0	0.0
White barracudina	0.0	0.0
Smelt	0.0	0.0
Butterfish	0.0	0.0
Flounders	1.6	0.0
Winter flounder	0.0	0.0
Mackerel	0.0	0.0
Windowpane	0.0	0.0
Redfish	0.0	0.0
Arctic shanny	0.0	0.0
Prickleback/Blenny	0.0	0.0
Cunner	0.0	0.0
Unspecified	7.5	3.7
Wh. Hake	0.0	0.0
Eelpout	0.0	0.0
Amphipod	0.0	0.0
Bivalvia	0.0	0.0
Shrimps	0.0	0.0
Crab	0.0	0.0
Squid	0.0	0.0
Cumacean	0.0	0.0
Euphausid	0.0	0.0
Gastropoda (periwinkle, whelk)	0.0	0.0
Isopod	0.0	0.0
Ave mass per stomach (g)	1529.6	1259.8

Table 6a. *Diet composition of grey seals collected from the west coast of Cape Breton Island based on intestine contents.*

Common name	Cape Breton Female fall		Cape Breton Male fall		Cape Breton Males,Fall no NCF correction	
	Mean	SD	Mean	SD	Mean	SD
N=	58		77			
Sandlance	29.2	19.4	25.3	9.1	14.0	6.2
Hookear sculpin	0.0	0.0	0.0	0.0	0.0	0.0
At. Herring	5.8	2.8	13.5	4.1	7.1	2.3
Sculpin	0.6	0.5	0.3	0.2	0.2	0.1
Wrymouth	1.6	1.2	0.2	0.1	0.2	0.2
Lumpfish	0.0	0.0	0.0	0.0	0.0	0.0
Fourbeard rockling	0.0	0.0	0.1	0.1	0.2	0.1
Fourline snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0
At. Cod	2.0	1.3	9.3	2.6	12.8	3.2
Gadid	2.2	1.1	1.8	1.2	2.5	1.6
Arctic staghorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0
Sea raven	0.0	0.0	0.0	0.0	0.0	0.0
American plaice	1.1	0.6	3.9	2.4	4.5	2.5
Yellowtail flounder	1.1	1.1	0.9	0.6	1.1	0.6
Snakeblenny	0.0	0.0	0.0	0.0	0.0	0.0
Daubed shanny	0.0	0.0	0.0	0.0	0.0	0.0
Blenny	0.0	0.0	0.0	0.0	0.0	0.0
Checker eelpout	0.0	0.0	0.0	0.0	0.0	0.0
Eelpout	0.0	0.0	0.2	0.1	0.2	0.1
Ocean pout	0.0	0.0	0.0	0.0	0.0	0.0
Capelin	0.0	0.0	0.0	0.0	0.0	0.0
Longhorn sculpin	1.2	1.1	2.1	1.3	1.1	0.7
Shorthorn sculpin	0.0	0.0	0.0	0.0	0.0	0.0
Sculpin	0.2	0.2	0.0	0.0	0.0	0.0
White barracudina	0.0	0.0	0.0	0.0	0.0	0.0
Smelt	0.0	0.0	0.0	0.0	0.0	0.0
Butterfish	0.4	0.2	2.6	1.4	4.1	2.2
Flounders	8.7	3.6	7.4	3.0	9.4	3.6
Winter flounder	27.7	11.7	7.4	5.0	8.3	5.9
Mackerel	0.9	1.1	4.5	2.4	4.8	2.8
Windowpane	0.9	0.5	0.0	0.7	0.0	0.8
Redfish	0.6	0.5	0.0	0.0	0.0	0.0
Arctic shanny	0.0	0.0	0.0	0.0	0.0	0.0
Prickleback/Blenny	0.0	0.0	0.0	0.0	0.0	0.0
Cunner	0.8	1.0	0.2	0.1	0.1	0.1
Unspecified	4.3	2.7	3.6	1.6	7.1	2.0
Wh. Hake	10.4	4.3	16.3	4.4	22.0	5.1
Eelpout	0.0	0.0	0.2	0.2	0.1	0.1
Amphipod	0.0	0.0	0.0	0.0	0.0	0.0
Bivalvia	0.0	0.0	0.0	0.0	0.0	0.0
Shrimps	0.1	0.1	0.0	0.0	0.0	0.0
Crab	0.0	0.0	0.0	0.0	0.0	0.0
Squid	0.0	0.0	0.0	0.0	0.0	0.0
Cumacean	0.0	0.0	0.0	0.0	0.0	0.0
Euphausid	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda (periwinkle, whelk..)	0.0	0.0	0.0	0.0	0.0	0.0
Isopod	0.0	0.0	0.0	0.0	0.0	0.0
Ave mass/ stomach (g)	4634.8	8810.3	4390.2	6761.1	3656.8	6302.2

Table 6b. Diet composition of grey seals collected from the west coast of Cape Breton Island based on stomach contents.

Common name	Cape Breton Male, Fall		Cape Breton Female, Fall	
N=	12		29	
Sandlance	21.4	10.8	10.4	6.2
Hookear sculpin	0.0	0.0	0.0	0.0
At. Herring	16.7	6.9	9.9	6.3
Sculpin	0.2	0.1	0.3	0.3
Wrymouth	0.0	0.0	8.9	8.6
Lumpfish	0.0	0.0	0.0	0.0
Fourbeard rockling	0.1	0.1	0.1	0.1
Fourline snakeblenny	0.0	0.0	0.0	0.0
At. Cod	9.6	3.9	3.7	1.8
Gadid	0.4	0.3	0.5	0.3
Arctic staghorn sculpin	0.0	0.0	0.0	0.0
Sea raven	0.0	0.0	0.0	0.0
American plaice	0.4	0.3	0.3	0.2
Yellowtail flounder	0.1	0.1	3.6	2.1
Snakeblenny	0.0	0.0	0.0	0.0
Daubed shanny	0.0	0.0	0.0	0.0
Blenny	0.0	0.0	0.0	0.0
Checker eelpout	0.0	0.0	0.0	0.0
Eelpout	0.0	0.0	0.0	0.0
Ocean pout	0.0	0.0	0.0	0.0
Capelin	0.0	0.0	0.0	0.0
Longhorn sculpin	0.5	0.5	0.0	0.0
Shorthorn sculpin	0.0	0.0	0.0	0.0
Sculpin	0.0	0.0	0.0	0.0
White barracudina	0.0	0.0	0.0	0.0
Smelt	0.0	0.0	0.0	0.0
Butterfish	2.1	1.2	1.3	0.7
Flounders	7.9	4.5	8.4	3.4
Winter flounder	3.7	1.8	12.3	5.6
Mackerel	0.0	0.0	0.0	0.0
Windowpane	1.9	1.7	0.2	0.2
Redfish	0.1	0.1	0.0	0.0
Arctic shanny	0.0	0.0	0.0	0.0
Prickleback/Blenny	0.0	0.0	0.0	0.0
Cunner	0.4	0.4	0.0	0.0
Unspecified	3.3	1.7	1.6	1.1
Wh. Hake	31.2	8.0	38.0	7.7
Eelpout	0.0	0.0	0.4	0.3
Amphipod	0.0	0.0	0.0	0.0
Bivalvia	0.0	0.0	0.0	0.0
Shrimps	0.0	0.0	0.0	0.0
Crab	0.0	0.0	0.0	0.0
Squid	0.0	0.0	0.0	0.0
Cumacean	0.0	0.0	0.0	0.0
Euphausid	0.0	0.0	0.0	0.0
Gastropoda (periwinkle, whelk)	0.0	0.0	0.0	0.0
Isopod	0.0	0.0	0.0	0.0
Ave mass per stomach (g)	3321.6	3115.2	1659.6	2006.2

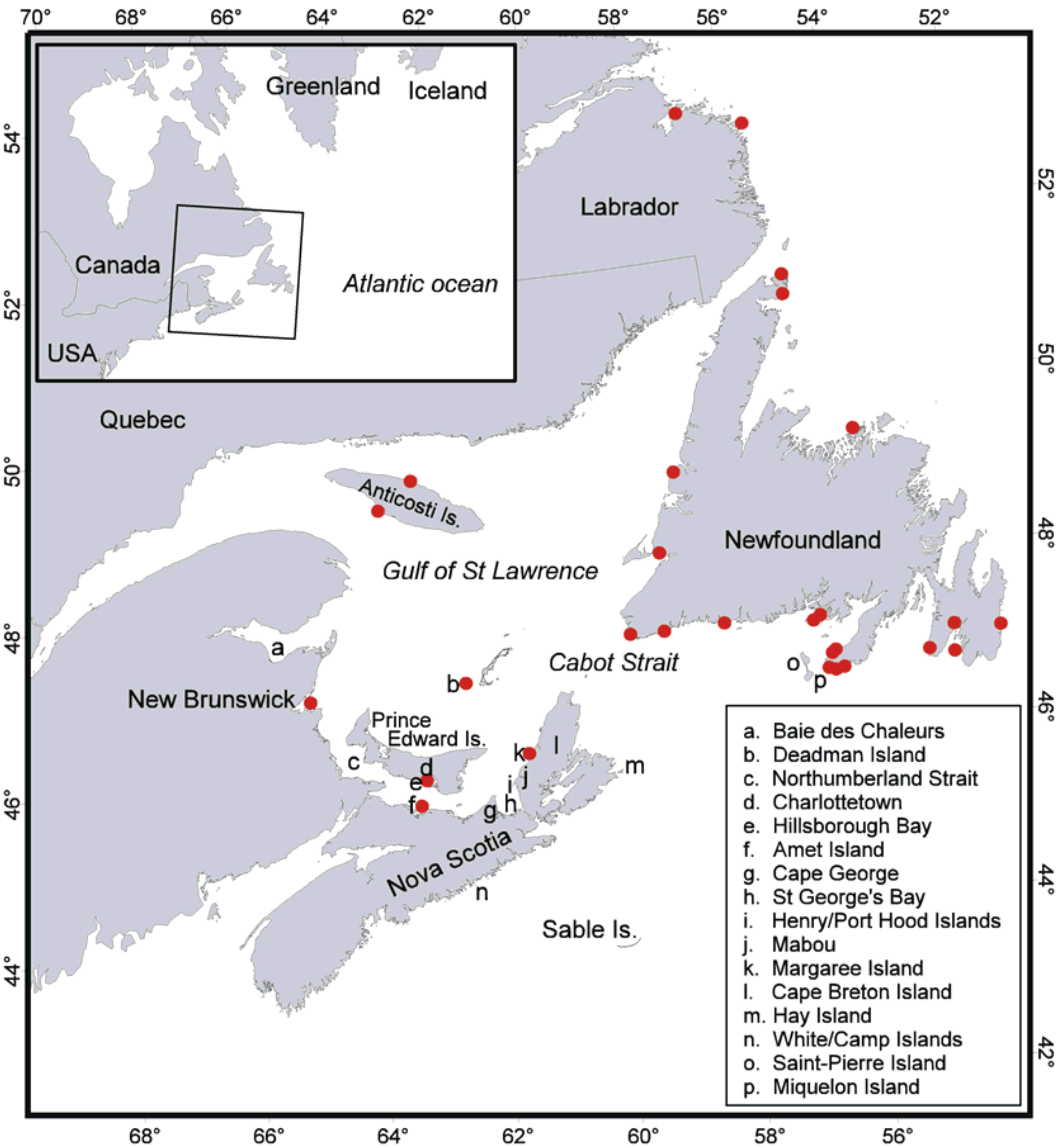
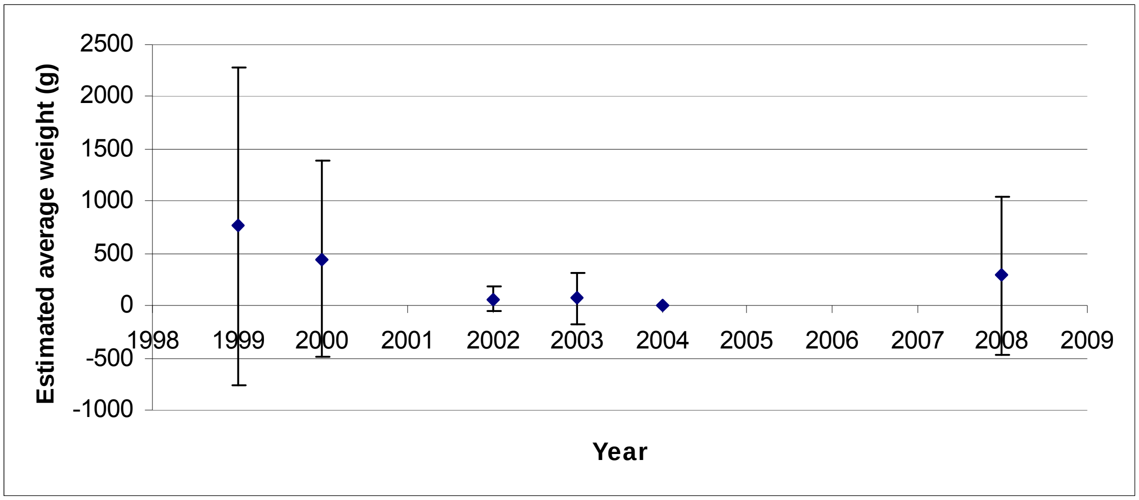


Figure 1. Map showing study area and place names. The dots represent locations where animals have been collected (from Hammill et al. 2007).



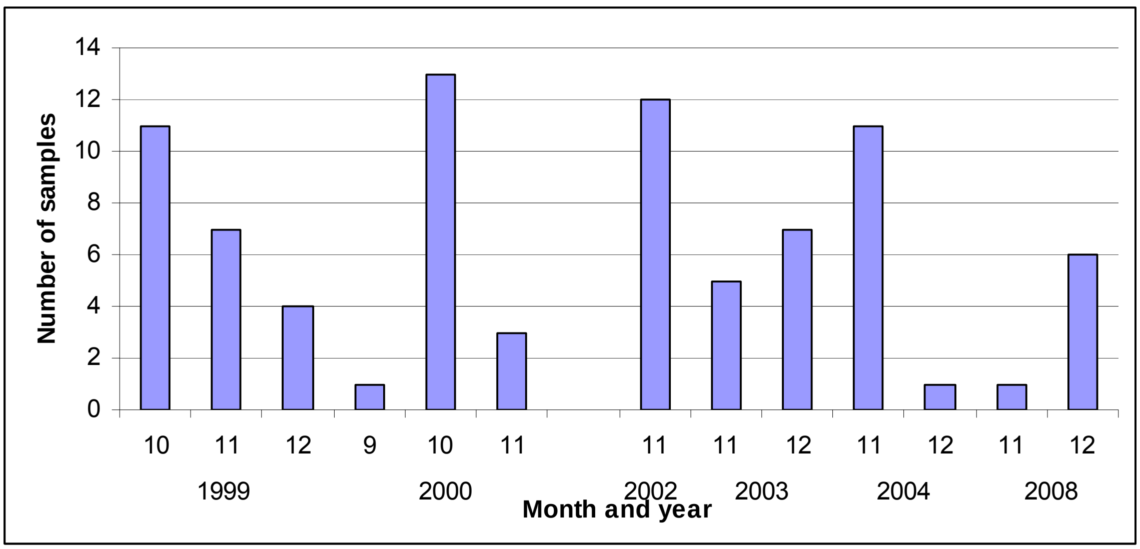
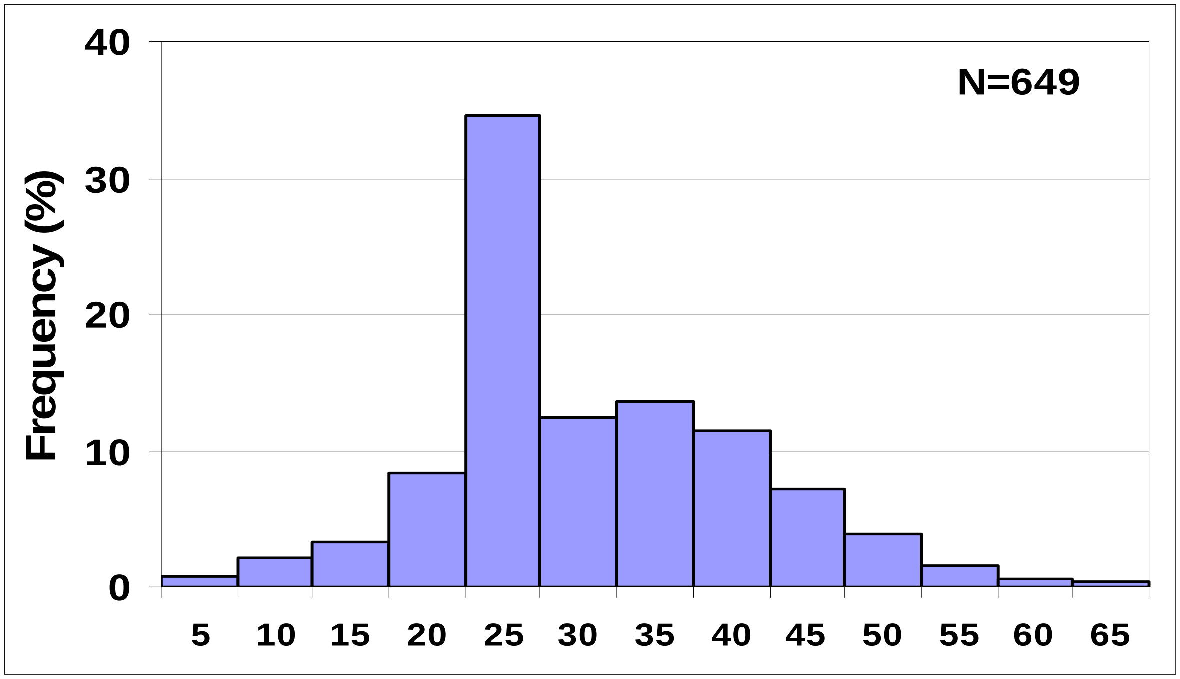


Figure 2. Change in average (±SD) contribution in grams of cod to male grey seal diets in Cape Breton Island with sampling year (Top). Number of samples collected per month (Bottom).



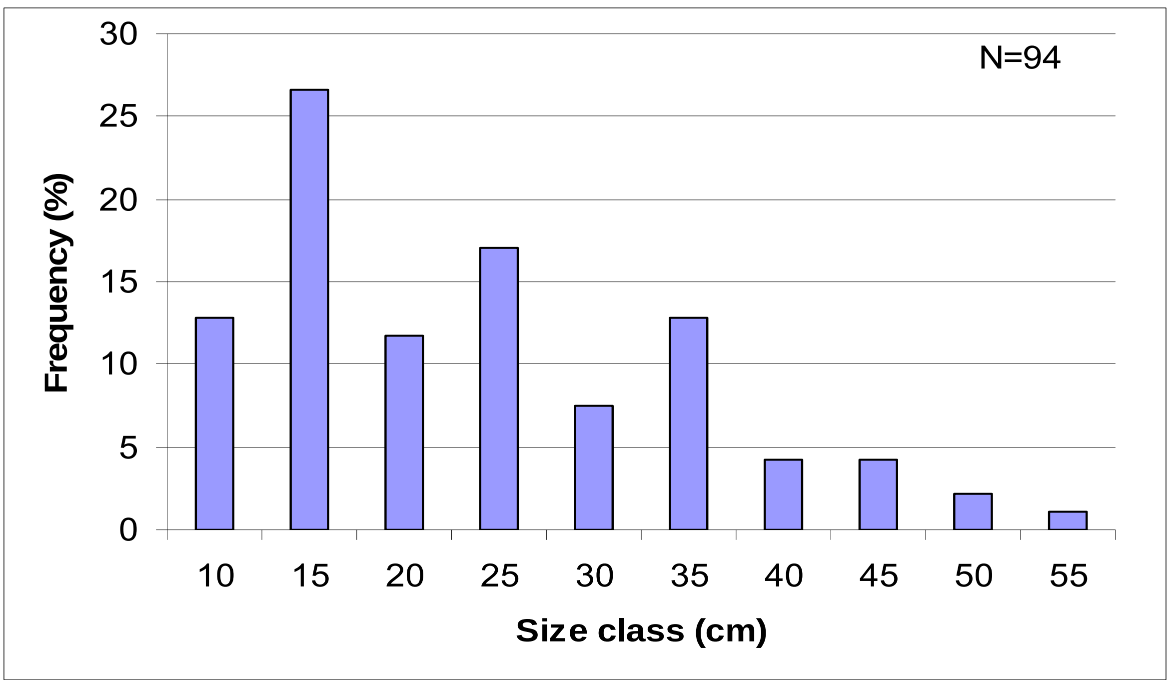
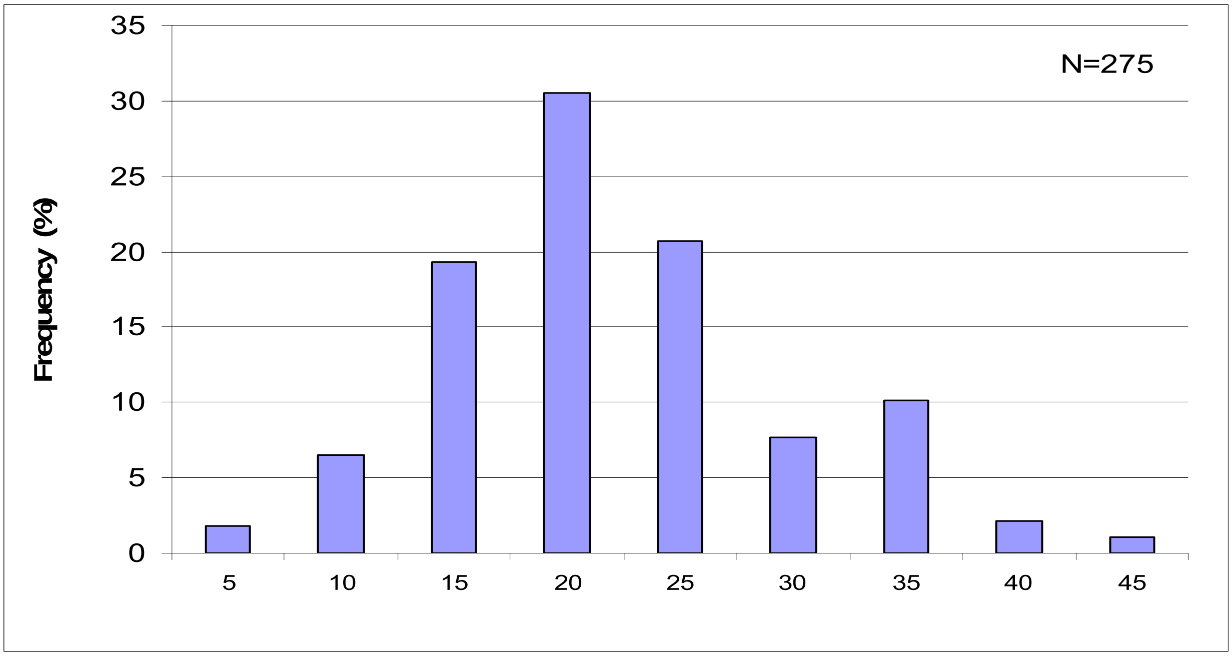


Figure 3. Length frequency of cod consumed by grey seals in the Gulf of St. Lawrence presented as frequency of occurrence (%). Southern Gulf of St. Lawrence (bottom) and northern Gulf of St. Lawrence (Anticosti Island)(top). Length class 5 cm, includes fish 5cm -9.9 cm long, class 10 includes fish 10 cm to 19.9 cm long.



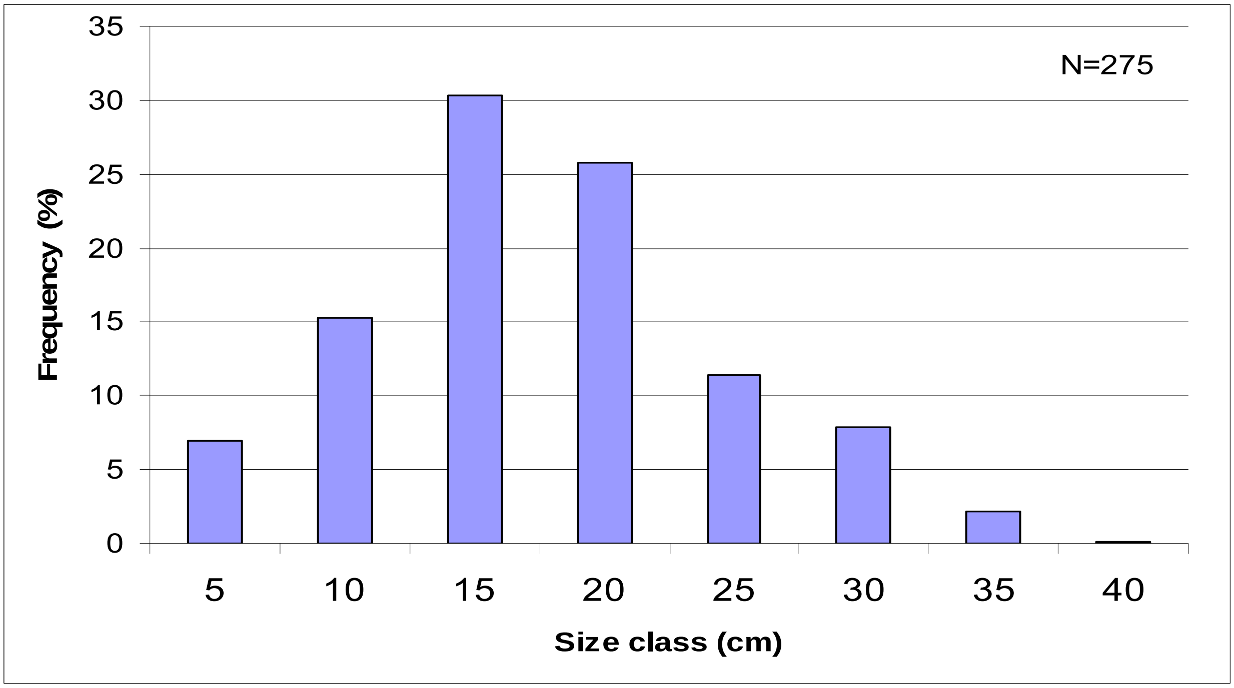


Figure 4. Length frequency of occurrence (%) of different length classes (cm) of white hake (top) and winter flounder (bottom) consumed by grey seals in the Gulf of St. Lawrence. Length class 5 cm, includes fish 5cm -9.9 cm long, class 10 includes fish 10 cm to 19.9 cm long.

Appendix 1. Numerical correction factors applied to intestine contents to correct for otolith loss (Grellier and Hammond 2006)

Common name	Scientific name	Size (cm)*	NFC	Rounded NCF	Species	Source
Atlantic herring	*Clupea harengus*	20.2–29.3	2.867	**2.9**	Hg	1
Atlantic mackerel	*Scomber scombrus*	26.6–33.0	1.391	**1.4**	Hg	1
Sandeel	*Ammodytes marinus*	13.2–22.4	2.861	**2.9**	Hg	1
Atlantic cod	*Gadus morhua*	15.8–51.7	1.060	**1.1**	Hg	1
Haddock	*Melanogrammus aeglefinus*	13.5–37.9	1.113	**1.1**	Hg	1
European hake	*Merluccius merluccius*	16.5–40.2	1.081	**1.1**	Hg	1
	Merlangius merlangus					
Whiting		10.0–35.0	1.027	**1.0**	Hg	1
All large gadoids		10.0–51.7	1.069	**1.1**		
	Limanda limanda					
Common dab	*Platichthys flesus*	14.8–29.3	1.226	**1.2**	Hg	1
Flounder	*Microstomus kitt*	23.1–32.5	1.418	**1.4**	Hg	1
Lemon sole	*Hippoglossoides*	14.9–32.1	1.539	**1.5**	Hg	1
Long rough dab	*platessoides*	14.0–23.9	1.163	**1.2**	Hg	1
	Pleuronectes platessa					
European plaice	*Glyptocephalus*	13.8–34.3	1.190	**1.2**	Hg	1
Witch flounder	*cynoglossus*	24.7–32.0	1.037	**1.0**	Hg	1
Flounder–plaice						
All flatfish		13.8–34.3	1.294	**1.3**	Hg	1
		13.8–34.3	1.241	**1.2**	Hg	
Squid				**1.1**		
	Loligo forbesii	13.5–337	1.064		Hg	1
Capelin	*Mallotus villous*	14.3-14.8	7.87	**7.9**	Ej	2
Surf Smelt	*Hypomesus pretiosus*	16.7	4.33	**4.3**	Pv	3
Wolffish	*Anarhichas lupus*			***2.9***		
Sculpin	Cottidae			***2.9***		
Lumpfish	*Cyclopterus lumpus*			***2.9***		
Eel pout	*Lycodes* sp			***1.2***		
Winter flounder	*Psuedopleuronectes americanius*			***1.3***		
Redfish	*Sebastes* sp			***1.1***		
White Hake	*Urophysis tenuis*			***1.1***		
Ocean pout	*Zoarces americanus*			***2.9***		
American Plaice	*Hippogloossides platessoides*			***1.3***		
Yellowtail flounder	*Limanda feruginea*			***1.3***		
Windowpane flounder	*Scophthalmus aquosus*			***1.3***		
Cunner	*Tautagolabrus adspersus*			***2.9***		
Fourline Snakebeeny	*Eumesogrammus praecisus*			***1.3***		
Butterfish	*Perprilus triacanthus*					
Silver hake	*Merluccius bilinearis*			***1.1***		
Pollock	*Pollachius virens*			***1.1***		