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Estimated Prey Consumption by Harp Seals (*Phoca groenlandica*), Grey Seals (*Halichoerus grypus*), Harbour Seals (*Phoca vitulina*) and Hooded Seals (*Cystophora cristata*) in the Northwest Atlantic

by

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Abstract

Consumption of prey by grey, hooded, harbour and harp seals in Atlantic Canada was estimated for the period 1990-1996, by bringing together information on individual energy requirements, population size, distribution and diet composition. Total consumption by these pinnipeds has increased from 2.6 million to 3.4 million tonnes over this period. Sixty-three percent of this consumption consists of capelin, sand lance and arctic cod. Much of this consumption occurs in 2J3KL (73%), followed by the northern Gulf of St Lawrence (4R,S) (19%), and 4VsW (5%). In 1996, it was estimated that seals consumed a total of 245,200 t, 131,000 t, 262,500 t and 129,700 t of cod, herring, Greenland halibut and redfish respectively. The majority of fish consumed are smaller than those taken during a commercial fishery. Harp seals were the most important predator, accounting for 82% of total consumption. Although they have not been considered previously, hooded seals were found to consume a significant amount of prey, accounted for approximately 9% of the total. Grey seals also consumed approximately 9% while harbour seal consumption accounted for less than one percent of total consumption. Regional differences were observed in the importance of each predator with harp and hooded seals being important in 2J3KL, harps and greys in the northern Gulf, and grey seals in the southern Gulf and Scotian Shelf.

Introduction

Since the mid 1980s, the abundance of several Northwest Atlantic groundfish, most notably Atlantic cod (*Gadus morhua*) stocks has declined significantly, resulting in the closure of several commercial fisheries. A number of hypothesis

have been proposed to account for this decline including overfishing, unfavorable environmental conditions, and possibly predation (Anon., 1995). Although closures took place as early as 1992 many stocks, e.g. northern cod off northeastern Newfoundland (2J3KL), have shown little sign of recovery (Anon., 1995).

In the absence of fishing mortality, other factors that may affect the recovery of Northwest Atlantic fish stocks include unfavorable environmental conditions, competition for common prey species or direct predation by seals or other piscivorous predators. In order to examine the impact of predation on a fish stock, information on total natural mortality and the proportion of that mortality that can be attributed to individual predator species is required. One component of this analysis is to estimate total consumption by different predator species. This requires information on population size, energy requirements, diet composition, size classes and energy density of the prey, and the distribution of feeding effort (Harwood and Croxall, 1988; Harwood, 1992).

Four species of seals are common throughout Atlantic Canada. Grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) are abundant along the coast from the northeastern United States to Hamilton Inlet and in the Gulf of St Lawrence, while harp seals (*Phoca groenlandica*) and hooded seals (*Cystophora cristata*) are seasonal residents (Sergeant, 1976). Attempts have been made to estimate fish consumption by harp and grey seals in the last few years. Harp seals were estimated to consumed 142,000 t of cod off the Labrador and east coast of Newfoundland and in the Gulf of St Lawrence in 1994 (Stenson et al. 1995b). In 1993, grey seals were estimated to have consumed 39,000 t off the Nova Scotia coast and in the Gulf of St Lawrence (Hammill and Mohn 1994). More recently, Hammill et al (*in press*) have estimated that hooded seals consume 68 t of cod in the Gulf of St Lawrence. However, no information is available on fish consumption by harbour seals or by hooded seals off the Newfoundland coast where the majority of the population occurs.

Our objective here is to incorporate new information where possible to update our previous estimates of fish consumption by different species of pinnipeds and to provide information on the relative importance of different pinnipeds as predators in different regions throughout Atlantic Canada.

Materials and Methods

We begin by providing a general description of our approach. Specific models describing the population dynamics, growth, distribution and diet of each species were combined to estimate prey consumption from 1990 - 1996. Unfortunately, there are differences among species in the quality of information available. Details of the specific parameters used for each species are described in Appendix 1.

Population Dynamics

Age-specific estimates of harp seal abundance were obtained using the model developed by Shelton et al (1996), projected forward to 1996. In this exercise we used the form of the model where first year mortality was assumed to equal 3 times that of older seals.

For grey, hooded, and harbour seals the dynamics of the population were reconstructed by modifying estimates of survivorship and age specific reproductive rates to define a transition matrix (Leslie 1945) which generated the observed changes in the population. To determine the stable age composition the models were initiated with a starting population of 500 pups. The model populations were allowed to grow until there were no changes in the proportional age composition in the population. For most species we have only data on pup production. The actual population was reconstructed by dividing the estimate of pup production by the fraction of pups in the population according to the stable age structure composition of the model. This provided an estimate of total population size. The number of animals in each age class was then determined by multiplying the total population by proportion of animals in each age class.

In all of the models we assumed that first year mortality was greater than that of older seals, that the mortality rate of seals one year of age and greater was constant across year classes and that the mortality rates of males and females were similar. It was also assumed that the sex ratio at birth was 1:1.

Energy requirements

Energy requirements were assumed to be constant throughout the year. Individual energy requirements were calculated using:

$GE_i = JF_i * (A_i * 293 * BM_i^{0.75}) / Me_i$

Where GE is daily gross energy intake at age I, and JF is the additional energy required by young seals. The juvenile factor (JF) was set at 1.8, 1.6, 1.4, 1.3, 1.1, 1.1, and 1.0 for animals aged 0, 1, 2, 3, 4, 5, and ≥6 yrs respectively (Olesiuk, 1993). The activity factor (A) was assumed to be 2 to approximate the average daily energy requirements as a multiple of the basal metabolic rate ($293 * Bm_i^{0.75}$; Kleiber 1975), where BM is body mass in kg. The metabolizable energy (ME_i) was set at 0.83 (Ronald *et al.* 1984), assuming that seals consume primarily fish. Growth in body mass (BM_i) at age i was described using the Gompertz growth curve presented in Hammill *et al.* (1995):

$$BM = W_\infty * (W_0/W_\infty)^{\exp[k_0 i / W_0 * \ln(W_0/W_\infty)]}$$

where body mass (BM) , asymptotic weight W_∞ and weight at birth (W_0) are in kg, i is the animal's age (years)and k_0 is the rate of growth at birth.

Seasonal distribution

The study area was divided into six areas based upon the North Atlantic Fisheries Organization (NAFO) Division. These areas included: eastern Newfoundland and southern Labrador (2J3KL), the northern Gulf of St Lawrence (4R,S), the southern Gulf of St Lawrence (4T), the Scotian Shelf (4VsW), Flemish Cap (3M; Hoods only) and 'Other' which was used primarily for grey and harbour seals and is concerned with consumption by these species in the Bay of Fundy (4X) and along the southern coast Newfoundland (3PS) (Fig 1). The seasonal distribution of each species in the various areas was estimated from a combination of field observations, tag returns, observations from aerial surveys, historical catch data, anecdotal reports, and satellite telemetry. The amount of energy obtained from each area was assumed to be proportional to the time spent in the area.

Diet composition

The proportion of each prey species in the diet was determined by reconstructing the wet weight of prey ingested based upon stomach and/or faeces samples. Where possible the diet composition was varied with season and location. No correction was made for unidentified fish and the diet was assumed to remain constant over the 1990-1997 period. The mean energy density of the prey for each area/season was estimated from the appropriate diet using a weighted average of published energy values for individual species.

Prey Size

The quantity of commercial and non-commercial sized Atlantic cod, herring, redfish and Greenland halibut consumed by seals was estimated using size frequency information in the diet of ; grey seals (Benoit and Bowen 1990); harbour seals (Bowen and Harrison 1996); harp seals (Lawson and Stenson 1995) and hooded seals (Ross 1993).

Results

Changes in population size have been monitored in three out of the four seal species. The sole exception is the harbour seal, which has never been adequately censused in Atlantic Canada. The Northwest Atlantic harp seal is the most abundant species (Fig. 2). The total population was estimated to have been 3.9 million in 1990, increasing to 4.9 million animals in 1996. Hooded seals are the second most abundant species increasing from 451,000 in 1990 to about 598,000 in 1996. Grey seals have increased from approximately 99,000 animals in 1990 to 184,000 animals in 1996. From the population model, harbour seals have increased from approximately 20,700 animals in 1990 to 29,100 in 1996 (Fig. 2) .

From 1990 - 96 total estimated prey consumption increased from 3.0 million tonnes to 3.8 million tonnes. However, 53% of this consumption consists of three species; capelin, sand lance and arctic cod (Table 1; Appendix 2). Most prey were consumed in 2J3KL (74%), followed by the northern Gulf of St Lawrence (19%), and 4VsW (5%) (Table 2). Less than 2% of this consumption occurred in the southern Gulf of St Lawrence, the Flemish Cap and in regions Other.

Table 1. Estimated total fish consumption (tonnes) by species and region in Atlantic Canada in 1996.

	4VsW		N gulf		S Gulf		Other		2J3KL		Flemish Cap		Total
	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	
Capelin	163	0.0	322369	28.5	655	0.1	533	0.0	805856	71.3	325	0.0	1129902
Atl. herring	11080	8.1	27243	20.0	4056	3.0	3281	2.4	90808	66.5	0	0.0	136468
Sandlance	65682	21.7	6502	2.1	23788	7.9	18958	6.3	187954	62.1	0	0.0	302884
Smelt	0	0.0	140	37.9	1	0.3	1	0.2	228	61.6	0	0.0	370
Mackerel	2944	28.0	3448	32.8	2288	21.8	1826	17.4	6	0.1	0	0.0	10512
Atl. cod	19430	7.7	67645	26.9	10135	4.0	8088	3.2	142649	56.7	3648	1.5	251596
Arctic cod	0	0.0	2270	0.4	0	0.0	0	0.0	604454	99.6	0	0.0	606724
Haddock	3	0.1	3730	94.2	127	3.2	101	2.6	0	0.0	0	0.0	3961
Pollock	2436	66.0	203	5.5	541	14.7	457	12.4	55	1.5	0	0.0	3691
S. hake	6609	52.3	3087	24.4	1628	12.9	1299	10.3	3	0.0	0	0.0	12625
Wh. hake	86	4.2	666	32.4	39	1.9	37	1.8	1228	59.7	0	0.0	2057
Blue hake	0	0.0	0	0.0	0	0.0	0	0.0	13507	89.9	1517	10.1	15024
Gadus sp.	203	1.2	3185	18.0	30	0.2	38	0.2	14211	80.4	0	0.0	17667
Greenland halibut	0	0.0	3834	1.5	26	0.0	20	0.0	247223	94.2	11415	4.3	262518
Y-tailed flounder	0	0.0	2074	76.0	364	13.3	290	10.6	0	0.0	0	0.0	2727
Am. Plaice	0	0.0	2243	7.4	393	1.3	314	1.0	27390	90.3	0	0.0	30339
Winter flounder	39	16.3	141	59.8	27	11.4	24	10.2	6	2.4	0	0.0	237
Witch flounder	0	0.0	87	0.2	15	0.0	12	0.0	49847	89.7	5599	10.1	55560
Windowpane	0	0.0	13640	100.0	0	0.0	0	0.0	0	0.0	0	0.0	13640
Pleuronectidae	9742	4.4	73687	33.0	3181	1.4	2536	1.1	131315	58.8	2998	1.3	223459
Redfish	849	0.7	98265	76.0	323	0.2	258	0.2	28480	22.0	1192	0.9	129366
Salmon	0	0.0	3015	94.6	95	3.0	76	2.4	0	0.0	0	0.0	3186
Sculpin	6	0.0	6061	24.1	113	0.5	91	0.4	18863	75.1	0	0.0	25134
Cunner	9	7.4	82	68.6	15	12.4	12	10.4	1	1.1	0	0.0	120
Lumpfish	0	0.0	4437	76.0	779	13.3	620	10.6	0	0.0	0	0.0	5836
Wolfish	0	0.0	3630	76.0	637	13.3	508	10.6	0	0.0	0	0.0	4775
Grenadier	0	0.0	0	0.0	0	0.0	0	0.0	18331	89.9	2059	10.1	20390
Alewife	50	4.8	763	72.8	125	11.9	103	9.8	7	0.7	0	0.0	1048
Ocean pout	24	0.5	3296	75.5	580	13.3	463	10.6	3	0.1	0	0.0	4366
Eelpout	0	0.0	0	0.0	0	0.0	0	0.0	1286	89.9	144	10.1	1431
Lycod	0	0.0	89	76.0	16	13.3	12	10.6	0	0.0	0	0.0	117
Scaled lancetfish	0	0.0	0	0.0	0	0.0	0	0.0	5145	89.9	578	10.1	5723
Ray	0	0.0	1295	76.0	227	13.3	181	10.6	0	0.0	0	0.0	1704
Other fish	3139	2.1	22610	15.0	1289	0.9	1045	0.7	120653	80.0	2095	1.4	150830
Euphausiid	0	0.0	67	0.2	0	0.0	0	0.0	26961	99.8	0	0.0	27028
Shrimp	139	0.1	13715	12.8	21	0.0	26	0.0	93055	87.0	0	0.0	106956
Squid	5642	3.1	7418	4.0	1651	0.9	1345	0.7	164274	88.9	4552	2.5	184882
Other Invert	19	0.0	38054	45.4	3	0.0	4	0.0	45664	54.5	0	0.0	83743
Total fish	122494	3.6	679738	19.8	51493	1.5	41183	1.2	2509509	73.0	31572	0.9	3435988
Total prey	128294	3.3	738992	19.3	53168	1.4	42558	1.1	2839462	74.0	36123	0.9	3838597

Harp seals were the most important predator accounting for 82% of the total fish consumption (Table 2). Hooded seals and grey seals also consumed significant quantities of fish accounting for 10% and 8% of the fish consumed respectively. Harbour seals consumed insignificant quantities of fish accounting for less than 1% of the total consumption.

Regional differences were observed in the importance of each predator (Table 2). In 2J3Kl, the harp seal is the most important consumer, followed by the hooded seal. In the northern Gulf, the harp seal consumes the most fish followed by the grey seal. In 4VsW and in the southern Gulf, the Grey seal is the most important predator of the 4 seal species in terms of overall fish consumption.

Table 2. Estimated regional and total prey consumption (tonnes) by 4 seal species in Atlantic Canada in 1996.

		4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish	Total regions	All %
Grey seal	Total fish	120284	60130	51164	40774	0	0	272351	7.9
	Total prey	125486	60130	52750	42038	0	0	280403	7.4
Hooded seal	Total fish	0	8111	0	0	311861	31572	351543	10.2
	Total prey	0	8740	0	0	354770	36123	399633	10.5
Harbour seal	Total fish	2210	1190	329	409	320	0	4458	0.1
	Total prey	2808	1512	418	520	406	0	5664	0.1
Harp seal	Total fish	0	610308	0	0	2197328	0	2807637	81.7
	Total prey	0	643666	0	0	2484286	0	3127951	82.0
All species	Total fish	122494	679738	51493	41183	2509509	31572	3435988	
	%	3.6	19.8	1.5	1.2	73.0	0.9		
	Total prey	128294	714047	53168	42558	2839462	36123	3813652	
	%	3.4	18.7	1.4	1.1	74.5	0.9		

Looking at the consumption of four commercial fish species, during the period 1990-96, estimated cod consumption increased from 185,072 t to 251,596 t; estimated herring consumption increased from 101,385 t to 136,468 t; estimated Greenland halibut consumption increased from 202,140t to 262,518 t, and estimated redfish consumption increased from 100,888 t to 129,366 t (Appendix 2).

The regional and relative importance of the four seal predators were examined in more detail for Atlantic cod, herring, Greenland halibut and redfish using the 1996 consumption estimates. Estimated total Atlantic cod consumption was greatest (58%) in 2J3KL at 142,655 t , followed by the northern Gulf at 67,645 t (27%), and 4VsW at 19,430 t (8%) (Fig. 3). Consumption of herring and Greenland halibut followed a similar pattern; consumption being the greatest in 2J3KL, followed by the northern Gulf and 4VsW (Fig. 3). In contrast, the greatest amount of redfish consumption occurred in the northern Gulf (98,265 t; 76%), followed by 2J3KL at 28,480 t (22%) (Fig.3). Differences were also observed among regions in the relative importance of different seal species as predators of cod, herring, Greenland halibut and redfish. In two regions, the southern Gulf and 4VsW, harbour seals and grey seals are the only phocid predators. In both areas, grey seals were more important, accounting for 88-99% of the consumption of the four fish species (Fig. 4). In the northern Gulf, harp seals, grey seals, harbour seals and hooded seals may be found at different times of the year. In this area, the harp seal consumed the most cod, herring, and redfish, accounting for 68-98% of the fish of these species consumed. However, in the case of Greenland halibut, hooded seals accounted for 97% of the total consumption, followed by grey seals (3%) (Fig 4). Harp seals, hooded seals and harbour seals are also found in 2J3KL where harp seals were the major predator, accounting for 77-96% of the total cod and herring consumed. Little difference was seen between harp seals and hooded seals in the consumption of Greenland halibut. Harp seals consumed an estimated 51% of the 247,223 t of Greenland halibut, while hooded seals consumed 47%. Hooded seals were more important as predators on redfish than harp seals; hooded seals consumed 61% of the total 28,480 t, while harp seals consumed 38% (Fig. 4).

The majority of fish consumed are too small to be taken by the commercial fishery (Table 3). If the commercial size of cod, herring, redfish, and halibut is 40cm, 30 cm, 25 cm and 50 cm respectively. For grey seals 85% of cod, 84% of herring, and 60% of redfish consumed are too small to be taken by the commercial fishery. For harbour seals 98% of cod, and 63% of herring consumed are too small to be taken by the commercial fishery. For harp seals 98.7% of cod, 95% of herring and 90% of redfish consumed are too small to be taken by the fishery. In hooded seals 72% of herring, 60% of redfish and 90% of halibut consumed are too small to be taken by the fishery.

Table 3. Estimated consumption of commercial and non-commercial sized fish by seals in 1996. Size frequency information are not available for cod consumption by hooded seals, redfish consumption by harbour seals and Greenland halibut consumption by harp seals.

	Cod		Herring		Redfish		Halibut	
	<40cm	>40cm	<30cm	>30cm	<25cm	>25cm	<50cm	>50cm
4VsW	16538	2892	9155	1925	502	335	0	0
Northern Gulf	63265	4275	24649	2595	87879	10379	3319	369
Southern Gulf	8618	1517	3384	672	192	128	0	0
2J3KL	108343	1427	85166	5642	17087	11391	104062	11562

Discussion

Our objective was to estimate prey consumption by seals in Atlantic Canada. In order to do this several assumptions were made during model development, which may or may not be realistic. We did not assess the sensitivity of these estimates to the various parameters in this paper since our methods are similar to earlier studies on fish consumption by seals (Hammill and Mohn 1994; Stenson et al. 1995b; Mohn and Bowen 1996) where this has been done. These earlier studies found that estimates of population size were the most important factor affecting fish consumption estimates (Hammill and Mohn 1994; Stenson et al 1995b). However, this parameter changes very slowly, shows little year to year variability and for most pinniped populations in eastern Canada we have good estimates of population size. Instead variability in our estimates of consumption of different fish species are more likely to be due to factors such as the seasonal distribution of seals, and variation in the diet composition . These two factors are important because quantitative information on the spatial distribution of seals throughout the year is limited, and large changes in species composition of the diet can occur between years, or between geographical areas (Mohn and Bowen 1996; Shelton et al 1996). Unfortunately, with the exception of harp seals off the coast of Newfoundland and Labrador, changes in diet composition over time and over several regions within a seal's range has not been well documented.

The species for which we had the greatest amount of information, and therefore the greatest confidence in our estimates of consumption, is the harp seal. We have good data on abundance (Stenson et al. 1995a; Shelton et al. 1996) and body size (Chabot et al. 1996). There is extensive data on geographical and seasonal variations in the diet of harp seals off Newfoundland (Lawson et al. 1995; Lawson and Stenson 1995b, submitted) although there is less information for the Gulf. Our understanding of the population dynamics and diet of grey seals is also quite good. Estimates of abundance for both the Sable and Gulf components of the population are available (Zwanenberg and Bowen 1990; Hammill and Mohn 1994; Mohn and Bowen 1996) and the diet has been described in a variety of areas (Benoit and Bowen 1990; Murie and Lavinge 1992; Bowen et al 1993; Bowen and Harrison 1994; Proust and Hammill submitted). However, our understanding of their diet in the southern Gulf and 'Other' areas is poor or absent. Less is known about hooded seals although some information on abundance (Bowen et al. 1987; Stenson et al. 1997) and diet in nearshore (Ross 1993) and offshore (Lawson and Stenson submitted) areas of Newfoundland are available. Unfortunately, there is no information on the diet of hooded seals in the Gulf of St. Lawrence and so we assumed that the species composition is the same as that seen in inshore Newfoundland. If this assumption is incorrect, it could significantly affect our estimate of consumption in the northern Gulf, especially for Greenland Halibut. The species for which we know the least is the harbour seal. Our estimates of current abundance and distribution are based on a study carried out in the 1970s (Boulva and McLaren 1979) and only a single diet study is available (Bowen and Harrison 1996). Although our estimates of harbour seal consumption are based upon very limited data, the population appears to be so small that changes in our assumptions will have little effect on the overall consumption estimates.

We estimated that seals consumed a total of 3.8 million tonnes of prey in Atlantic Canada during 1996. Harp seals are the most important predator of the four species, accounting for 82% of this consumption, followed by grey seals and hooded seals which accounted for 7% to 10% of the overall consumption respectively. Regional differences in consumption were observed reflecting the differing importance of each area to individual seal species and their relative abundance. In the northern Gulf and off the coast of Newfoundland (2J3KL), where all four species are found, harp seals were the most important predator followed by hooded seals off Newfoundland and grey seals in the northern Gulf. Only grey and harbour seals occur in the southern Gulf and 4VsW. In these areas, the grey seals is the most important predator.

Differences in grey seal consumption between this study and Hammill and Mohn (1994) result from several factors including the lack of a correction factor for unidentified components in the diet, the absence of a specific cost for the heat increment of feeding which resulted in lower energy requirements, a Gulf grey seal population that is approximately 6% smaller than that used by Hammill and Mohn (1994), and a higher estimate of the contribution of cod to the diet of grey seals in the northern Gulf of St Lawrence (Proust and Hammill submitted). Also, the composition of the diet used in the southern Gulf and region Other was based on the average composition of all other diets and not assumed as in the previous study. There were also several differences in the harp seal model used in this study compared to that found in Stenson et al. (1995b). The major differences were related to the use of a population model which assumes that pup mortality is greater than that of older seals and incorporating seasonal and geographic variation in the diet of seals off Newfoundland (Appendix 1). The proportion of time spent in the Gulf and off Newfoundland was also corrected from the earlier model. The resulting estimates were similar to that presented in Stenson et al. (1995b) for the same time period although the proportion taken off Newfoundland is greater while that taken in the Gulf is less.

It is evident that seals consume large quantities of fish in eastern Canadian waters. The majority of this consumption consists of small forage species, such as capelin, arctic cod and sandlance, while major commercial species such as cod, form a relatively minor component in the overall seal diet. Little is known about factors affecting prey selection by seals. Recent diet information indicates that different species of seals may prey on different components of a prey population. For example in the case of Northern Gulf cod, harp seals appear to consume primarily fish 10-20 cm long (Lawson and Stenson 1996), grey seals appear to prefer fish around 15-30 cm (Benoit and Bowen 1990; Bowen et al. 1993), while hooded seals prefer fish 25-35 cm in length (Ross 1993). Thus it appears that in the northern Gulf, harp seals would be feeding largely on 1-2 year old cod, grey seals would consume 2-3 year old cod, whereas hooded seals would be consuming 2-4 year old cod.

There is also some evidence that seals will alter the size range of prey consumed (Proust and Hammill submitted). In the northern Gulf, Benoit and Bowen (1990) reported that 85% of the cod consumed by grey seals was too small to be taken by the commercial fishery. However, in 1992, Proust and Hammill (submitted) found that 51% of the cod consumed were >40 cm in length. They suggested that grey seals may have altered their preferred size in response to a decline in the availability of younger age classes of cod. Applying this change in the size composition of the diet would increase the estimate of grey seal consumption of commercial sized fish from 3400 tonnes (Table 3) to 31,777 tonnes in 1996.

An estimate of consumption is one of the first steps in trying to understand the dynamics between seal predation and commercial fisheries. On their own these estimates are of little use unless they can be placed within the context of a mortality rate (Mohn and Bowen 1996) and compared to mortality rates from other sources. Unfortunately, our understanding of natural mortality in many fish species is very poor. Traditional analyses have used a fixed rate of 0.2, without taking into consideration age specific or between year effects. Recently, Mohn and Bowen (1996) included mortality caused by grey seal predation and fishing mortality into a Virtual Population Analysis of eastern Scotian Shelf cod. Although the authors state that fish mortality resulting from seal predation is likely to be compensatory , the compensatory relationship among the different components of natural mortality is poorly understood. As a result, the authors (Mohn and Bowen 1996) assumed that mortality caused by seals was additive (i.e. non-compensatory) and adjusted total mortality accordingly. Nevertheless, they concluded that the mortality resulting from grey seal predation was relatively minor compared to fishing mortality, accounting for about 16% of fishing mortality over the period 1970-1992.

Given that seals consume primarily pre-recruits to the commercial fishery it is unlikely that they have played a major role in the failure of several commercial fisheries in Atlantic Canada. However, seal predation may have a more significant effect on the recovery of fish stocks. Improvements in our estimates of consumption and potential impact can be achieved by improving our information on the temporal and spatial distribution of seals, particularly in offshore areas, and continued monitoring of diet composition from different regions and at different times of the year. Information on the dynamics between seals, commercial fish species and prey species of both groups is also required. However, significant advances will not be achieved until more is known about the abundance of small fish and other sources of natural mortality in fish populations. This information would allow us to quantify mortality that could be attributed to seal predation and would also allow us to assess the importance of this mortality due to seal predation with respect to other sources of mortality.

Acknowledgments

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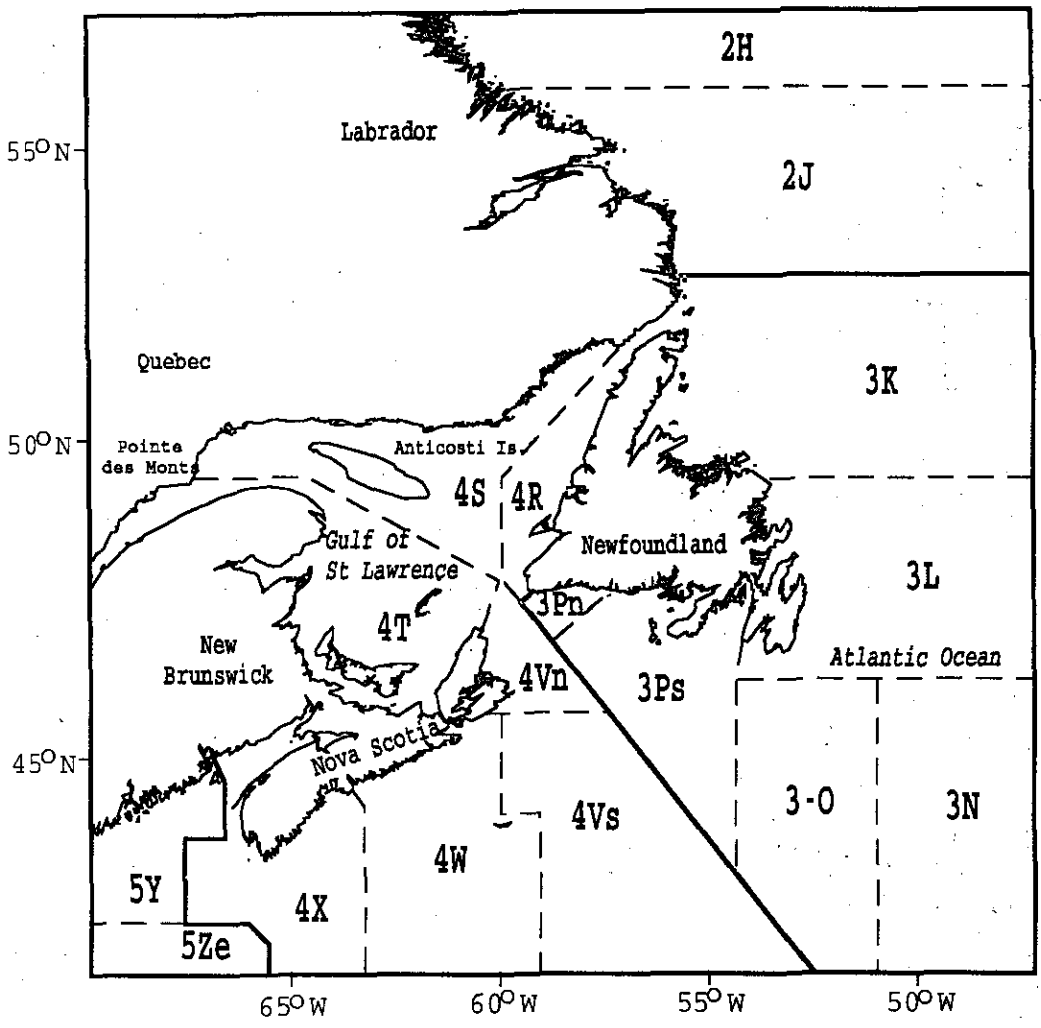

Figure 1. Northwest Atlantic Fisheries Organization (NAFO) fishing zones.

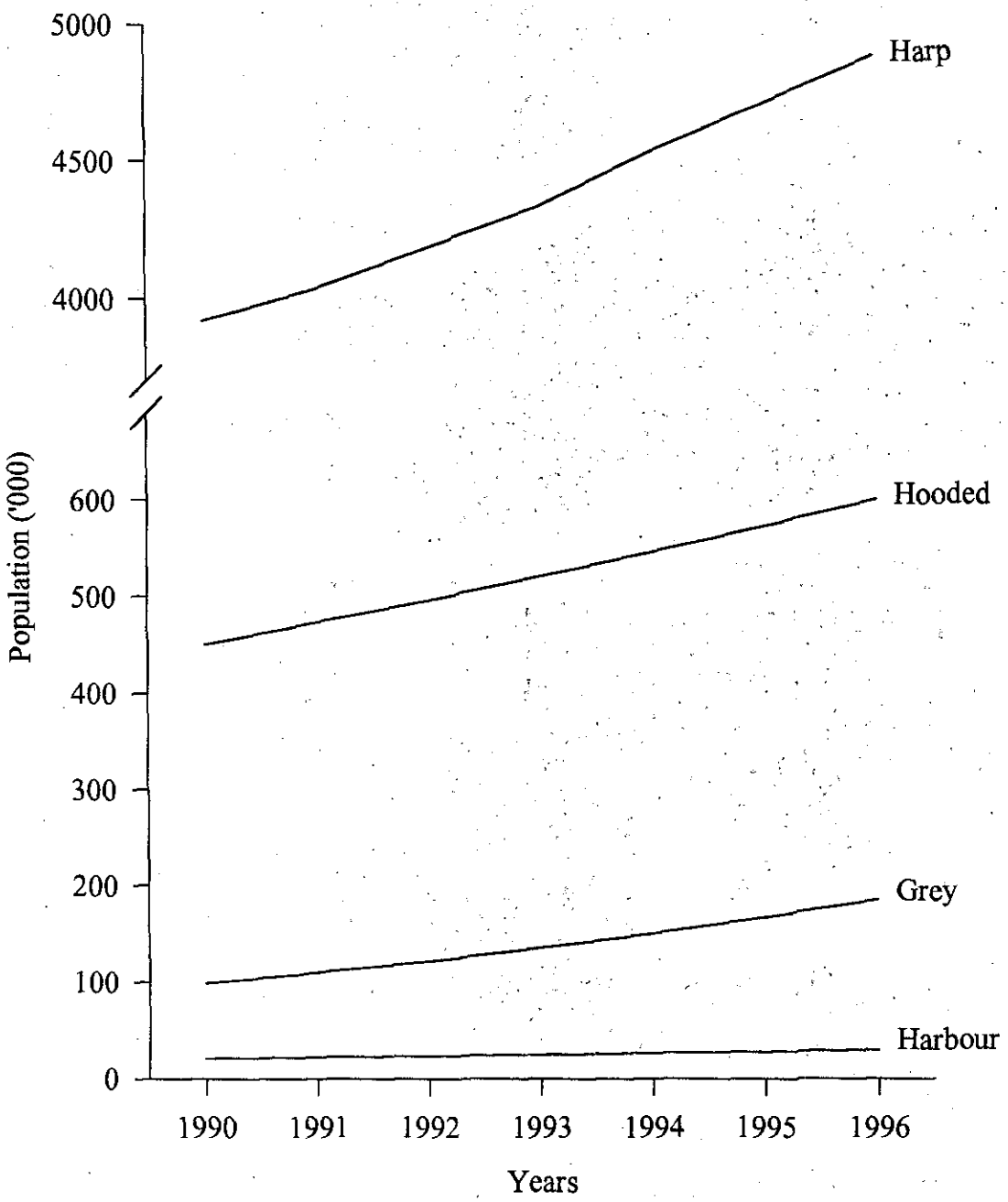

Figure 2. Changes in estimated size of harp, hooded grey and harbour seal populations between 1990 and 1996.

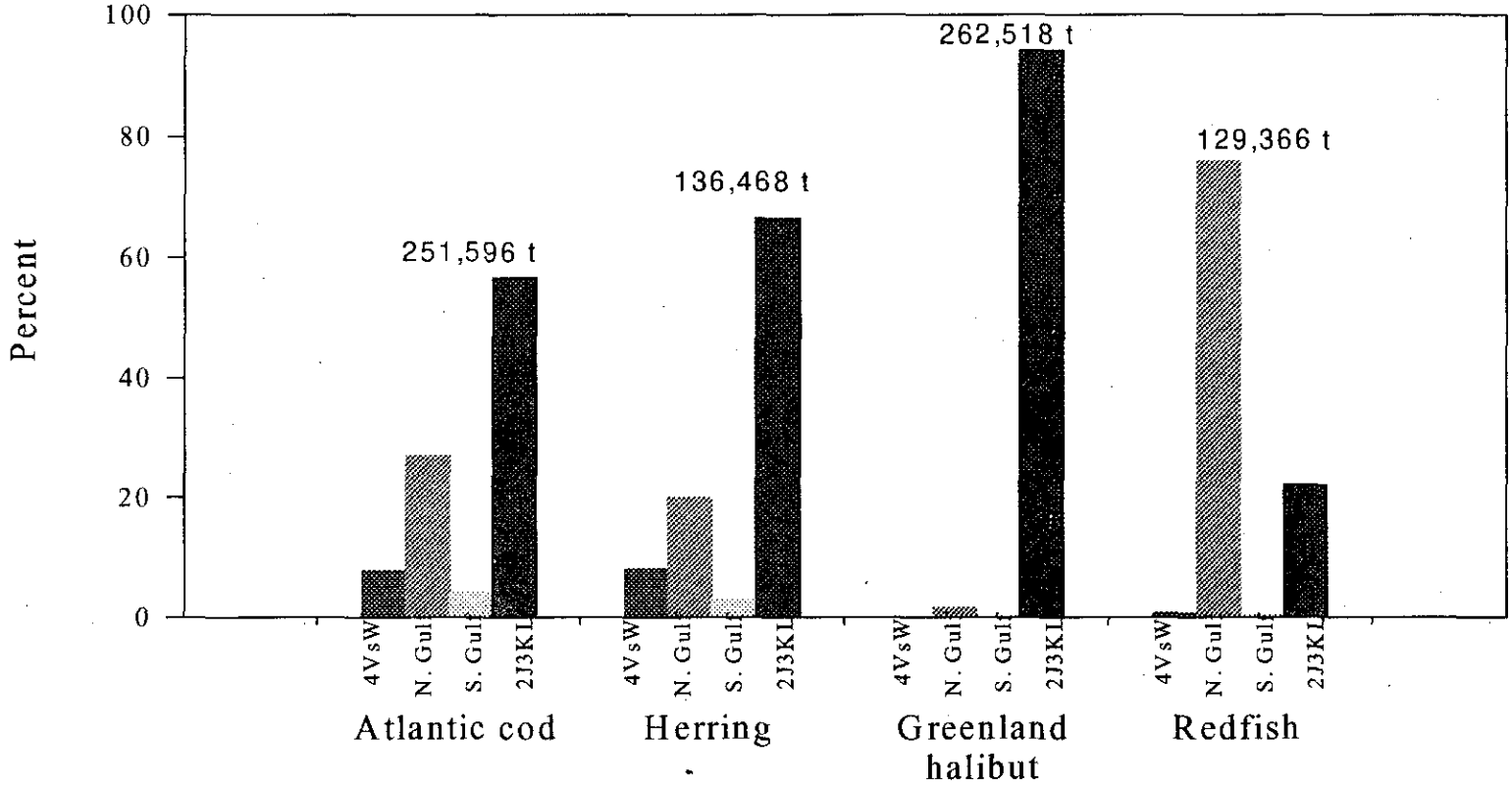

Figure 3. Consumption of Atlantic cod, Atlantic herring, Greenland halibut and Redfish by all seal species.

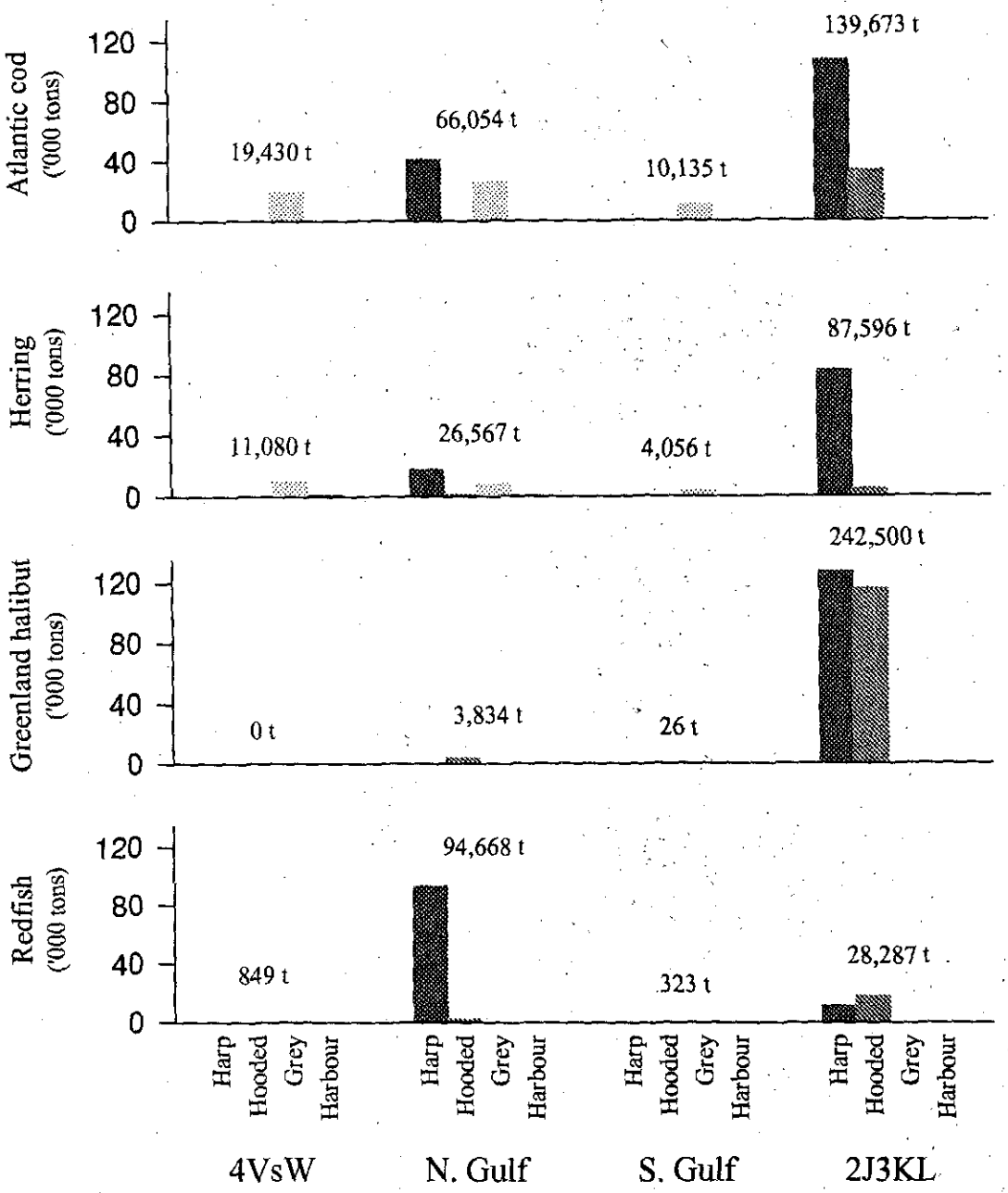

Figure 4. Consumption of four species of fish by Harp, Hooded, Grey and Harbour seals in NAFO fishing zones 4VsW, Northern Gulf (4R,S), southern Gulf (4T) and 2J3KL.

Appendix 1.

Description of biology and model parameters used to estimate prey consumption by grey, hooded, harbour, and harp seals.

A) Grey seals

Population Dynamics

Large concentrations of grey seals whelp on Sable Island and on the pack ice in the Gulf of St Lawrence. Although the two groups form a single stock (Boskovic et al. 1996), it is convenient to consider seals from the two areas as separate groups. There are no current estimates of pup production or population size. Estimates of pup production from the 1980's are available for both groups (Stobo and Zwanenburg 1990; Hammill et al submitted). The population was reconstructed using these estimates and projected forwards from 1990 to 1996. In the population model, age specific reproductive rates were 0.176, 0.86, and 0.876 for animals aged 4, 5 and 6 y respectively (Hammill and Gosselin 1995). Adult mortality rates were set at 0.96. To achieved the reported rate of increase in the Sable Island herd (12.6%, Zwanenburg and Bowen 1990) juvenile mortality was set at 0.787. The Sable Island component of the population has increased from 68,429 with a pup production of 11,938 in 1990 to 139,467 animals in 1996 with a pup production of 24,331. The Gulf component of the population is increasing at a lower rate of 6.8% (Hammill et al. submitted). This component has increased from 40,330 animals in 1990 to 59,712 in 1996. Pup production has increased from 8,645 in 1990 to 12,655 in 1996.

Body Mass

Separate growth curves were developed for males and females based on samples collected from the Gulf between June and September 1984-92 (Table 4).

Table 4. Parameters used in the Gompertz growth curves to estimate body size in grey seals, hooded seals, harbour seals and harp seals. N = Number of individuals measured.

Species/sex	N	Asymptotic weight (W_∞)	Weight at time 0 (W_0)	Growth rate (k_0)
Grey seal-male	95	250.44	48.58	19.5
Grey seal-female	166	188.21	53.92	12.54
Hooded seal-male	289	256.66	36.79	30.71
Hooded seal-female	744	187.07	38.22	19.54
Harbour seal-male	70	93.13	22.62	10.51
Harbour seal-female	53	74.91	19.52	10.35

Seasonal Distribution

The seasonal distribution of grey seals (Table 5) followed Hammill and Mohn (1994).

Table 5. Seasonal distribution of Gulf of St. Lawrence and Sable Island grey seals.

	Gulf herd					Sable herd			
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4
N_Gulf	0.1	0.35	0.6	0.5	N_Gulf	0	0.125	0.075	0.05
S_Gulf	0.7	0.35	0.1	0.3	S_Gulf	0	0.125	0.075	0
4VsW	0.1	0.2	0.2	0.1	4VsW	0.9	0.5	0.5	0.8
Other	0.1	0.1	0.1	0.1	Other	0.1	0.25	0.35	0.15

Diet

A number of studies have provided information on the diet of grey seals in the northern Gulf (Zones 4R, 4S) and the Scotian shelf (4VsW) (Table 6). However, our knowledge of the diet in the southern Gulf and other areas is based on very small samples. For the northern Gulf, all samples were combined and an average contribution for each species was used (Benoit and Bowen 1990; Murie and Lavigne1992; Proust and Hammill submitted). Diet information for the Scotian Shelf was divided into a summer (April-September) component and a winter (October-March) component (Bowen et al 1993; Bowen and Harrison 1994). The diet composition used for the southern Gulf, and 'Other' (which represents grey seal consumption in the Bay of Fundy, and off Newfoundland) was the average of all of the diet material.

Table 6. Composition of grey seal diets (proportion wet weight) used to estimate prey consumption.

	4VsW		Northern Gulf	Other
	Summer	Winter		
Atlantic cod	17.6	9.7	41.2	19.2
Atlantic herring	11.0	1.5	12.5	7.5
Capelin	0.0	0.0	6.0	1.2
Mackerel	0.1	7.9	5.7	4.3
Lumpfish	0.0	0.0	7.4	1.5
Wolfish	0.0	0.0	6.0	1.2
Sculpin	0.0	0.0	1.1	0.2
Haddock	0.0	0.0	1.2	0.2
Lycod	0.0	0.0	0.1	0.0
Sandlance	47.2	65.1	0.9	45.1
Yellow-tailed flounder	0.0	0.0	3.4	0.7
Winter flounder	0.0	0.0	0.2	0.0
American plaice	0.0	0.0	3.7	0.7
Witch flounder	0.0	0.0	0.1	0.0
Greenland Halibut	0.0	0.0	0.2	0.0
Cunner	0.0	0.0	0.1	0.0
Salmon	0.0	0.0	0.9	0.2
Redfish	0.6	0.9	0.1	0.6
Pollock	2.3	0.0	0.0	0.9
Alewife	0.0	0.0	1.1	0.2
Ray	0.0	0.0	2.2	0.4
Ocean pout	0.0	0.0	5.5	1.1
Pleuronectidae	8.1	7.0	0.0	6.0
Silver hake	7.1	0.6	0.0	3.1
White hake	0.0	0.0	0.3	0.1
Other fish	1.4	4.5	0.0	2.4
Squid	4.7	2.9	0.0	3.0
Mean energy	5.9	6.3	5.9	6.1

B) Hooded seals

Population Dynamics

Hooded seals whelp on the pack ice off the Newfoundland (Front) east coast and in the Gulf of St Lawrence (Gulf) and in Davis Strait during March (Sergeant 1976). Little is known about the stock relationships between the 3 groups. In 1984, pup production was estimated to be 62,400 at the Front and 19,000 in Davis Strait. Pup production was not determined in the Gulf. In 1990, pup production was estimated to be 83,100 (Stenson et al 1997) at the Front and 2,006 in the Gulf (Hammill et al 1992). No recent estimate is available for pup production in Davis St. There are no current estimates of pup production for the three whelping patches. A rate of increase of 4.8% was calculated from the two estimates of hooded seal pup production at the Front and applied to the Gulf hooded seal population. It was assumed that animals from the Davis Strait population did not migrate to the Front. Adult survival was set at 0.91. Juvenile mortality was initially set to 3 times the adult mortality rate and then adjusted to permit the population to increase at the rate of 4.8%. In 1990, there were an estimated 440,419 hooded seals at the Front. This estimate increased to 584,850 animals in 1996. In the Gulf there were an estimated 10,144 animals in 1990, increasing to 13,471 hooded seals in 1996.

Body Mass

Separate growth curves were developed for males and females based on samples collected during March at the Front (Table 4).

Seasonal Distribution

Seasonal distributions (Table 7) were based on satellite telemetry information from units deployed after reproduction at the Front and in the Gulf (Stenson and Hammill unpublished), and from observations from fishermen and hunters and historical accounts (Comeau 1945). We assumed that all pups and one-year-old seals remained in Arctic waters, only 20% of juveniles aged 2+ and 3+, and all adults returned to 2J3KL or the northern Gulf. Seals were assumed to move into 2J3KL on 1 December and remained until 30 April. From satellite telemetry (Stenson unpublished) it appears that after whelping, females move out to the Flemish Cap for May while males leave the region and migrate to an area just south of Iceland, where they remain for several weeks before moving to the eastern Greenland coast to moult. While in 2J3KL it was assumed that 10% of the population was found in inshore waters, and 90% was found offshore. In the Gulf, hooded seals were assumed to enter the Gulf on 15 December, and remained until the end of May.

Table 7. Seasonal distribution of the Gulf and Front hooded seal populations.

	Gulf herd				Front herd			
	1st_Q	2nd_Q	3rd_Q	4th_Q	1st_Q	2nd_Q	3rd_Q	4th_Q
N_Gulf	1	0.66	0	0.17	0.0	0.0	0	0.0
2J3Kl (offshore)	0	0.0	0	0.15	0.9	0.31	0	0.3
2J3KL(inshore)	0	0.1	0	0.01	0.1	0.03	0	0.03
Other	0	0.0	0	0.0	0.0	0.0	0	0.0
Arctic	0	0.34	1	0.67	0.0	0.49	1	0.67
Flemish Cap	0	0.0	0	0.0	0.0	0.17	0	0.0

Diet

The diet was divided into an inshore (Ross 1993) and an offshore component (Lawson and Stenson submitted) (Table 8). For the Gulf, we used the inshore diet that includes some animals taken along the south coast of Newfoundland. The 2J3KL inshore diet was used to estimate fish consumption in the Arctic. The 2J3KL offshore diet was used to calculate consumption by hooded seals in the Flemish Cap area.

Table 8. Hooded seal diet composition (% wet weight) used to estimate prey consumption.

Species	Gulf & 2J3KL Inshore	2J3KL Offshore
Atlantic cod	1.2	10.1
Herring	14.0	
Capelin	0.3	0.9
Witch		15.5
Greenland Halibut	42.2	31.6
Redfish	20.6	3.3
Pleuronectidae		8.3
Squid	7.2	12.6
Arctic cod	14.5	
Grenadier		5.7
Blue hake		4.2
Lancetfish		1.6
Eelpout		0.4
Other Fish		5.8
Mean energy (kj/g)	5.38	5.25

C) Harbour seals

Population dynamics

The harbour seal is distributed throughout Atlantic Canada. Unlike the other species, there do not appear to be any large-scale seasonal movements where animals form large whelping concentrations in traditional areas. The harbour seal is the only pinniped in eastern Canada for which there is no reliable estimate of abundance, or trends in abundance. Based on the results of interviews and questionnaires sent out to fisheries officers, Boulva and McLaren (1979) estimated an eastern Canadian population of 12,700 in 1973 and suggested that the population was declining at a rate of 4% per year due to a high bounty take. In 1976, the bounty program was cancelled. To reconstruct the dynamics of the Atlantic Harbour seal population, we assumed that there were 12,700 animals in 1973, and that this population declined at a rate of 4% per year until 1976, when the bounty on harbour seals was removed. On Sable Island, harbour seal numbers appear to be declining. However, in the Bay of Fundy, around the Nova Scotia coast and in the St Lawrence Estuary, their numbers appear to be increasing (Stobo and Fowler, 1994; Lesage unpublished data). In the absence of a bounty we assumed that the population has been increasing since 1976. Adult survivorship was set at 0.9, juvenile survivorship was set at 3 times the adult rate. Age specific reproductive rates were 0.27, 0.55, 0.79 and 0.94 for animals aged 4+, 5+, 6+ and >6+ respectively. This resulted in a rate of increase of 5.7%. This population would have increased from 20,667 animals in 1990 to 30,813 animals in 1996.

Body Mass

Separate growth curves were developed for males and females based on weights of animals captured live in the St Lawrence Estuary between May-October, 1994-96 (Table 4; V. Lesage, unpublished data).

Seasonal Distribution

The seasonal distribution of the population was based on the relative distribution found in Boulva and McLaren (1979; Fig 1). Limited satellite telemetry information indicates that harbour seals are relatively sedentary (V. Lesage unpublished data). Therefore we assumed that the distribution of the population did not change during the year (Table 9).

Table 9. Seasonal distribution of harbour seals used to calculate fish consumption in Atlantic Canada

Area	1st_Q	2nd_Q	3rd_Q	4th_Q
N_Gulf	0.253	0.253	0.253	0.253
S_Gulf	0.07	0.07	0.07	0.07
2J3KL	0.068	0.068	0.068	0.068
4VsW	0.47	0.47	0.47	0.47
Other	0.087	0.087	0.087	0.087

Diet

Quantitative diet information for Harbour seals is limited. Bowen and Harrison (1996) have examined the composition of harbour seal diets in the Bay of Fundy and on the Nova Scotia eastern shore. This diet was applied to seals in all areas for all seasons (Table 10).

Table 10. Harbour seal diet composition (% wet weight) used to estimate prey consumption.

Species	Annual
Atlantic cod	5.7
Herring	24.4
Capelin	5.5
Mackerel	1.4
Sculpin	0.2
Haddock	0.1
Winter flounder	1.3
Cunner	0.3
Redfish	0.4
Pollock	12.7
Alewife	1.7
Ocean pout	0.8
Silver hake	0.7
Squid	14.8
White hake	2.9
Blueback herring	0.1
Other Fish	19.1
Butterfish	0.1
Fourspot flounder	0.1
Crab	0.4
Other Invert.	6.3
Mean energy (kj/g)	5.32

D) Harp seal

Population dynamics

Harp seals in the Northwest Atlantic whelp on the pack ice off the Newfoundland east coast (Front), and in the Gulf of St. Lawrence (Sergeant 1991). Pup production in both areas increased from 578,000 (SE=38,000) in 1990 to 702,900 (SE=63,600) in 1994 (Stenson et al 1993, 1995a). Changes in population size were estimated using output from the model described in Shelton et al (1996). The form of the model that we used assumes that pup mortality was three times that of older seals. The model was extended to 1996 by including actual catches from 1994 -1996 obtained from the Dept. of Fisheries and Oceans Statistical Branch. The number of pups was taken directly from the statistics while the age composition of the seals one year of age and older (1+) was estimated based on the average age structure of the 1+ catch taken from 1990-1993.

Body Mass

Separate growth curves were developed for males and females based on samples of moulting harp seals collected at the Front in April (Table 4; Chabot et al. 1996).

Seasonal Distribution

Harp seals are highly migratory; our knowledge of their distribution is based primarily on historical data, tag returns, and more recently, satellite telemetry. The Gulf and Newfoundland components of the population overlap in their distribution during the non-breeding period, summering in the Canadian Arctic and/or West Greenland. Seals from both areas move southward along the Labrador coast during the fall or early winter. When the seals reach the Strait of Belle Isle one component of the population moves into the Gulf of St. Lawrence while the rest remain off the east coast of Newfoundland. In the Gulf harp seals whelp near the Magdalen Island in late February and early March. After whelping, seals move into the St Lawrence estuary or disperse to the west towards the Baie de Chaleur where presumably they feed for about 2-3 weeks (Sergeant 1991; Stenson and Hammill unpublished data). During April, animals move into the northern Gulf where they haulout to moult. After moulting they leave the Gulf and return to the Arctic.

During the winter the Newfoundland component disperse across inshore and offshore areas of the southern Labrador Shelf and northern Grand Banks to feed (Stenson and Sjare, unpublished data). Whelping occurs off the coast of southern Labrador in March, slightly later than in the Gulf. After whelping, harp seals undergo a short feeding period before hauling out to moult on the pack ice off the northeastern coast of Newfoundland. Once the moult is completed animals remain in southern waters until late spring or early summer before returning to the Arctic.

There is some indication that seals may move between the Gulf and Front whelping patches (Stenson et al. 1995a). Year to year changes in ice conditions or food availability (Sergeant 1991) may affect this movement.

The basic assumptions describing the movements of harp seals are found in Stenson et al. (1995b). Seals were assumed to remain in southern waters between 15 November and 15 June. In addition, 20% of the juveniles were assumed to remain in the Arctic year round, 25% of the total population moved into the Gulf of St Lawrence between 1 December and 31 May, and 5% of the animals were assumed to remain in southern waters throughout the year (Table 1i).

In this study, the distribution of harp seals off Newfoundland was further divided into inshore and offshore components. Seals were assumed to be randomly distributed across the continental shelf from shore to the 400m isobath contour. The inshore area was assumed to lie within a 100km band extending from shore and accounted for 45% of the area. The remaining 55% was classified as offshore. The proportion of the total area described the proportion of seals in each area.

Table 11. Seasonal distribution of harp seals in the Northwest Atlantic (Stenson et al 1995b).

	Pups/juveniles		Adults	
	Winter (Oct-March)	Summer (April-Sept)	Winter (Oct-March)	Summer (April-Sept)
2J3KL	0.2355	0.1416	0.2939	0.177
Northern Gulf	0.0676	0.0368	0.0850	0.046
Arctic	0.1956	0.3230	0.1197	0.2785

Diet

Diet composition of harp seals in the Gulf (Table 12) was determined by taking the mean proportions of each species in the diet samples described in Murie and Lavigne (1991), Beck et al (1993), and Lawson et al (1995). The data from Lawson et al. (1995) was supplemented by additional samples from the west coast of Newfoundland (Stenson and Lawson unpublished). The diets off Newfoundland were based on material from Lawson and Stenson (submitted), Lawson and Stenson (1995) and Lawson et al (1995). Samples were divided geographically (nearshore and offshore) and by season (summer and winter) (Table 13). The average seasonal diets in the nearshore area were estimated by averaging the proportion of each prey species in the yearly samples available (1982, 1986, 1990-1993, see Stenson et al. 1995b).

Table 12. Harp seal diet composition (proportion wet weight) used to estimate prey consumption.

	Newfoundland				Gulf
	Nearshore		Offshore		
Species	Summer	Winter	Summer	Winter	All
Arctic Cod	38.77	54.14	0.56	2.89	0.15
Atl. Cod	2.76	4.9	9.46	1.26	6.38
Capelin	19.29	18.02	29.61	55.73	47.66
Herring	12.33	4.49	0	0	2.71
Sand Lance	0.04	0.41	34.05	0	0.89
Redfish	0.02	0.01	1.85	0.11	14.42
Gr. Halibut	1.91	0.81	1.61	14.28	0
Am Plaice	0.75	0.05	0.09	3.07	0
Pleuronectidae	1.83	0.49	14.32	2.04	11.02
Windowpane	0	0	0	0	2.04
Salmon	0	0	0	0	0.37
Sculpin	0.24	2.35	0	0	0.81
Silver Hake	0	0	0	0	0.46
White Hake	0	0.16	0	0	0.07
Smelt	0	0.03	0	0	0.02
Alewife	0	0	0	0	0.01
Haddock	0	0	0	0	0.45
Gadus Sp	1.04	1.29	0	0	0.46
Other Fish	3.7	6.78	0.41	4.29	3.36
Shrimp	3.26	2.4	1.34	7.07	2.04
Squid	5.14	1.36	5.72	7.66	0.98
Euphausiid	4.65	0.97	0	0	0.01
Other Inv.	4.27	1.34	0.98	1.6	5.69
Mean Energy (Kcal/gm)	1.42	1.27	1.36	1.65	1.51

Comparison to earlier estimates

Stenson et al (1995b) provided estimates of fish consumption which are slightly different from the current estimates. Table 13 lists the different parameters used in the two models.

Table 13. Comparison between parameters used in this study and Stenson et al. (1995b)

Parameter		Stenson et al. 1995b	This study
Population	Mortality	Mo = M1+	Mo = 3M1+
	End year	1994	1996
Energy	Body Mass	Mean April mass	Gompertz
	Growth	Lavigne et al. 1986	Olesiuk 1991
Residency	Distribution		Corrected Gulf vs. Front Divided Nfld. into inshore (0.45) and offshore (0.55)
Diet	Energy of Prey	Published values	Local values
	Seasons	Annual	Winter and summer (Nfld.) Annual (Gulf)
	Geographical	Gulf - combined Nfld.	Gulf - combined Nfld. - inshore and offshore
	Samples		Additional samples for Nfld.

Appendix 2.
Estimated prey consumption (tonnes) for the years 1990-1996, by species, and region.

A) 1990

	4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish Cap	Total
Atlantic cod	10953	49105	6054	4276	111937	2747	185072
Atlantic herring	5880	20113	2434	1756	71202	0	101385
Capelin	116	252671	394	287	636075	245	889788
Mackerel	2462	2150	1367	966	4	0	6949
Lumpfish	0	2765	465	328	0	0	3557
Wolfish	0	2262	380	268	0	0	2910
Sculpin	4	4657	68	48	14825	0	19602
Haddock	2	2813	76	54	0	0	2945
Lycod	0	55	9	7	0	0	71
Sandlance	40923	5019	14204	10008	150994	0	221148
Yellow-tailed flounder	0	1292	217	153	0	0	1662
Winter flounder	27	90	17	14	4	0	152
American Plaice	0	1397	235	166	21534	0	23332
Smelt	0	109	1	0	179	0	289
Witch flounder	0	54	9	6	37537	4216	41823
Greenland halibut	0	2868	15	11	190649	8596	202140
Cunner	6	52	9	7	1	0	75
Salmon	0	2281	57	40	0	0	2378
Redfish	541	77134	193	137	21987	898	100888
Pollock	1297	144	330	254	39	0	2064
Alewife	36	488	75	56	5	0	661
Ray	0	807	136	96	0	0	1039
Ocean pout	17	2055	346	245	2	0	2666
Pleuronectidae	5745	57890	1899	1339	103703	2258	172835
Silver hake	3380	2424	972	686	2	0	7465
White hake	61	495	25	23	964	0	1568
Arctic cod	0	1742	0	0	474928	0	476671
Grenadier	0	0	0	0	13804	1551	15354
Blue hake	0	0	0	0	10171	1143	11314
Scaled lancetfish	0	0	0	0	3875	435	4310
Eelpout	0	0	0	0	969	109	1078
Windowpane	0	10716	0	0	0	0	10716
Gadus sp.	181	2514	27	34	11171	0	13927
Other fish	2238	17779	781	570	94251	1578	117197
Euphausiid	0	53	0	0	21187	0	21240
Shrimp	124	10783	19	23	73263	0	84211
Squid	3268	5790	993	725	128238	3428	142442
Other Invertebrate	17	29898	3	3	35981	0	65901
Total fish	73870	523943	30795	21832	1970815	23775	2645030
Total prey	77279	570465	31810	22583	2229484	27202	2958824

B)1991

	4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish Cap	Total
Atlantic cod	11041	52375	6600	4753	116309	2880	193959
Atlantic herring	6373	21487	2651	1948	73838	0	106296
Capelin	123	272647	429	318	659251	257	933024
Mackerel	1745	2234	1490	1073	5	0	6547
Lumpfish	0	2873	507	364	0	0	3744
Wolfish	0	2350	415	298	0	0	3062
Sculpin	4	5010	74	53	15364	0	20506
Haddock	2	3019	83	59	0	0	3163
Lycod	0	58	10	7	0	0	75
Sandlance	37565	5403	15484	11127	156493	0	226073
Yellow-tailed flounder	0	1342	237	170	0	0	1749
Winter flounder	29	94	18	15	4	0	160
American Plaice	0	1452	256	184	22318	0	24210
Smelt	0	118	1	1	186	0	304
Witch flounder	0	56	10	7	39354	4420	43848
Greenland halibut	0	3006	17	12	198633	9012	210680
Cunner	7	54	10	8	1	0	79
Salmon	0	2448	62	44	0	0	2555
Redfish	489	83217	210	152	22945	941	107953
Pollock	1439	153	358	279	41	0	2270
Alewife	38	510	82	62	5	0	697
Ray	0	839	148	106	0	0	1093
Ocean pout	18	2135	378	273	3	0	2806
Pleuronectidae	5545	62488	2071	1489	107720	2367	181680
Silver hake	3719	2617	1060	763	2	0	8161
White hake	65	530	27	24	999	0	1645
Arctic cod	0	1851	0	0	492255	0	494106
Grenadier	0	0	0	0	14472	1626	16098
Blue hake	0	0	0	0	10664	1198	11862
Scaled lancetfish	0	0	0	0	4062	456	4519
Eelpout	0	0	0	0	1016	114	1130
Windowpane	0	11567	0	0	0	0	11567
Gadus sp.	181	2706	27	34	11577	0	14524
Other fish	1900	19181	848	628	97849	1654	122060
Euphausiid	0	57	0	0	21959	0	22015
Shrimp	124	11634	19	23	75928	0	87728
Squid	3281	6231	1082	803	133295	3593	148285
Other Invertebrate	17	32271	3	3	37290	0	69584
Total fish	70284	563818	33561	24252	2045366	24926	2762207
Total prey	73706	614011	34663	25081	2313838	28519	3089819

C)1992

	4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish Cap	Total
Atlantic cod	12359	53845	7193	5284	121299	3020	203000
Atlantic herring	7114	21994	2887	2160	76916	0	111071
Capelin	130	272864	467	352	686503	269	960585
Mackerel	1937	2437	1624	1193	5	0	7196
Lumpfish	0	3134	552	405	0	0	4092
Wolfish	0	2564	452	331	0	0	3347
Sculpin	5	5048	81	59	15999	0	21192
Haddock	2	3061	90	66	0	0	3220
Lycod	0	63	11	8	0	0	82
Sandlance	41994	5436	16877	12374	162961	0	239642
Yellow-tailed flounder	0	1465	258	189	0	0	1912
Winter flounder	31	102	20	17	4	0	173
American Plaice	0	1584	279	205	23240	0	25307
Smelt	0	118	1	1	193	0	313
Witch flounder	0	61	11	8	41259	4634	45974
Greenland halibut	0	3156	18	13	207486	9448	220122
Cunner	7	58	11	8	1	0	86
Salmon	0	2480	67	49	0	0	2597
Redfish	545	83288	229	169	23991	987	109209
Pollock	1597	162	389	308	43	0	2499
Alewife	40	551	89	68	6	0	754
Ray	0	915	161	118	0	0	1194
Ocean pout	19	2329	412	303	3	0	3065
Pleuronectidae	6205	62489	2257	1655	112321	2482	187409
Silver hake	4172	2617	1155	848	2	0	8795
White hake	69	541	29	27	1041	0	1706
Arctic cod	0	1899	0	0	512618	0	514517
Grenadier	0	0	0	0	15173	1704	16877
Blue hake	0	0	0	0	11180	1256	12436
Scaled lancetfish	0	0	0	0	4259	478	4737
Eelpout	0	0	0	0	1065	120	1184
Windowpane	0	11567	0	0	0	0	11567
Gadus sp.	181	2706	27	34	12054	0	15001
Other fish	2091	19181	922	694	101994	1734	126615
Euphausiid	0	57	0	0	22866	0	22923
Shrimp	124	11634	19	23	79064	0	90864
Squid	3654	6266	1177	890	139043	3767	154797
Other Invertebrate	17	32271	3	3	38831	0	71125
Total fish	78498	567714	36568	26947	2131616	26132	2867475
Total prey	82294	617942	37766	27863	2411420	29900	3207184

D)1993

	4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish Cap	Total
Atlantic cod	13837	56916	7843	5877	126401	3166	214040
Atlantic herring	7944	23166	3146	2398	80043	0	116696
Capelin	138	283991	509	390	714125	282	999434
Mackerel	2150	2660	1771	1327	5	0	7913
Lumpfish	0	3421	602	451	0	0	4474
Wolfish	0	2799	493	369	0	0	3660
Sculpin	5	5275	88	66	16642	0	22076
Haddock	3	3210	98	74	0	0	3385
Lycod	0	69	12	9	0	0	90
Sandlance	46959	5675	18405	13766	169517	0	254320
Yellow-tailed flounder	0	1599	281	211	0	0	2091
Winter flounder	33	111	21	18	5	0	187
American Plaice	0	1729	304	228	24174	0	26435
Smelt	0	123	1	1	201	0	326
Witch flounder	0	67	12	9	43256	4859	48203
Greenland halibut	0	3313	20	15	216612	9906	229866
Cunner	8	64	12	9	1	0	93
Salmon	0	2600	74	55	0	0	2728
Redfish	609	86658	250	187	25074	1034	113813
Pollock	1773	171	423	340	46	0	2753
Alewife	43	597	97	76	6	0	819
Ray	0	999	176	132	0	0	1306
Ocean pout	20	2542	449	337	3	0	3351
Pleuronectidae	6945	65007	2461	1841	117020	2602	195876
Silver hake	4680	2723	1260	943	3	0	9608
White hake	73	569	31	29	1083	0	1784
Arctic cod	0	1985	0	0	533260	0	535245
Grenadier	0	0	0	0	15907	1787	17694
Blue hake	0	0	0	0	11721	1317	13038
Scaled lancetfish	0	0	0	0	4465	502	4967
Eelpout	0	0	0	0	1116	125	1242
Windowpane	0	12033	0	0	0	0	12033
Gadus sp.	181	2811	27	34	12537	0	15590
Other fish	2305	19948	1002	767	106219	1818	132060
Euphausiid	0	59	0	0	23786	0	23845
Shrimp	124	12100	19	23	82242	0	94508
Squid	4071	6526	1282	986	144926	3950	161742
Other Invertebrate	17	33571	3	3	40392	0	73986
Total fish	87705	592830	39865	29956	2219442	27397	2997195
Total prey	91918	645086	41169	30968	2510788	31347	3351276

E)1994

	4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish Cap	Total
Atlantic cod	15495	60479	8551	6538	132474	3319	226856
Atlantic herring	8874	24534	3427	2662	83883	0	123379
Capelin	146	297736	554	433	748360	296	1047524
Mackerel	2388	2903	1931	1476	5	0	8703
Lumpfish	0	3735	657	501	0	0	4893
Wolfish	0	3055	537	410	0	0	4003
Sculpin	5	5550	96	73	17439	0	23164
Haddock	3	3389	107	82	0	0	3580
Lycod	0	75	13	10	0	0	98
Sandlance	52518	5965	20068	15317	177644	0	271512
Yellow-tailed flounder	0	1745	307	234	0	0	2286
Winter flounder	34	120	23	20	5	0	202
American Plaice	0	1887	332	253	25333	0	27805
Smelt	0	129	1	1	211	0	341
Witch flounder	0	73	13	10	45350	5094	50540
Greenland halibut	0	3478	22	17	227043	10385	240945
Cunner	8	69	13	10	1	0	101
Salmon	0	2743	80	61	0	0	2884
Redfish	680	90818	272	209	26283	1085	119347
Pollock	1970	181	460	375	49	0	3034
Alewife	45	649	106	84	7	0	890
Ray	0	1090	192	146	0	0	1428
Ocean pout	21	2775	489	375	3	0	3663
Pleuronectidae	7775	68125	2683	2049	122641	2728	206001
Silver hake	5251	2853	1373	1050	3	0	10530
White hake	77	602	34	31	1135	0	1879
Arctic cod	0	2080	0	0	558825	0	560906
Grenadier	0	0	0	0	16677	1873	18550
Blue hake	0	0	0	0	12288	1380	13669
Scaled lancetfish	0	0	0	0	4681	526	5207
Eelpout	0	0	0	0	1170	131	1302
Windowpane	0	12610	0	0	0	0	12610
Gadus sp.	181	2941	27	34	13137	0	16320
Other fish	2545	20899	1089	848	111317	1906	138604
Euphausiid	0	62	0	0	24926	0	24988
Shrimp	124	12677	19	23	86183	0	99027
Squid	4538	6841	1396	1094	151892	4141	169902
Other Invertebrate	17	35182	3	3	42329	0	77533
Total fish	98015	623289	43455	33308	2325966	28724	3152757
Total prey	102694	678051	44873	34428	2631296	32864	3524206

F) 1995

	4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish Cap	Total
Atlantic cod	17349	63985	9305	7270	138154	3480	239541
Atlantic herring	9914	25865	3726	2954	87375	0	129835
Capelin	154	310176	602	480	779253	310	1090975
Mackerel	2650	3162	2101	1641	6	0	9560
Lumpfish	0	4069	715	558	0	0	5341
Wolfish	0	3329	585	456	0	0	4369
Sculpin	6	5805	104	82	18159	0	24155
Haddock	3	3558	116	91	0	0	3768
Lycod	0	82	14	11	0	0	107
Sandlance	58721	6234	21838	17035	184974	0	288803
Yellow-tailed flounder	0	1901	334	261	0	0	2496
Winter flounder	36	130	25	22	5	0	219
American Plaice	0	2056	361	282	26378	0	29077
Smelt	0	135	1	1	219	0	356
Witch flounder	0	80	14	11	47545	5341	52991
Greenland halibut	0	3652	24	18	237162	10888	251743
Cunner	8	75	14	11	1	0	110
Salmon	0	2878	87	68	0	0	3033
Redfish	760	94581	296	232	27481	1137	124487
Pollock	2190	192	499	413	52	0	3345
Alewife	48	703	115	93	7	0	965
Ray	0	1188	209	163	0	0	1559
Ocean pout	22	3023	532	417	3	0	3997
Pleuronectidae	8701	70938	2920	2279	127875	2860	215572
Silver hake	5890	2971	1494	1167	3	0	11526
White hake	81	633	37	34	1182	0	1967
Arctic cod	0	2174	0	0	581910	0	584085
Grenadier	0	0	0	0	17484	1964	19448
Blue hake	0	0	0	0	12883	1447	14330
Scaled lancetfish	0	0	0	0	4908	551	5459
Eelpout	0	0	0	0	1227	138	1365
Windowpane	0	13131	0	0	0	0	13131
Gadus sp.	192	3064	29	36	13679	0	17000
Other fish	2825	21764	1184	941	116031	1998	144744
Euphausiid	0	64	0	0	25954	0	26019
Shrimp	132	13202	20	24	89739	0	103117
Squid	5059	7132	1518	1213	158438	4341	177700
Other Invertebrate	18	36634	3	3	44075	0	80733
Total fish	109552	651534	47280	37026	2423957	30114	3299462
Total prey	114760	708565	48820	38266	2742164	34455	3687031

G) 1996

	4VsW	Northern Gulf	Southern Gulf	Other	2J3KL	Flemish Cap	Total
Atlantic cod	19430	67645	10135	8088	142649	3648	251596
Atlantic herring	11080	27243	4056	3281	90808	0	136468
Capelin	163	322369	655	533	805856	325	1129902
Mackerel	2944	3448	2288	1826	6	0	10512
Lumpfish	0	4437	779	620	0	0	5836
Wolfish	0	3630	637	508	0	0	4775
Sculpin	6	6061	113	91	18863	0	25134
Haddock	3	3730	127	101	0	0	3961
Lycod	0	89	16	12	0	0	117
Sandlance	65682	6502	23788	18958	187954	0	302884
Yellow-tailed flounder	0	2074	364	290	0	0	2727
Winter flounder	39	141	27	24	6	0	237
American Plaice	0	2243	393	314	27390	0	30339
Smelt	0	140	1	1	228	0	370
Witch flounder	0	87	15	12	49847	5599	55560
Greenland halibut	0	3834	26	20	247223	11415	262518
Cunner	9	82	15	12	1	0	120
Salmon	0	3015	95	76	0	0	3186
Redfish	849	98265	323	258	28480	1192	129366
Pollock	2436	203	541	457	55	0	3691
Alewife	50	763	125	103	7	0	1048
Ray	0	1295	227	181	0	0	1704
Ocean pout	24	3296	580	463	3	0	4366
Pleuronectidae	9742	73687	3181	2536	131315	2998	223459
Silver hake	6609	3087	1628	1299	3	0	12625
White hake	86	666	39	37	1228	0	2057
Arctic cod	0	2270	0	0	604454	0	606724
Grenadier	0	0	0	0	18331	2059	20390
Blue hake	0	0	0	0	13507	1517	15024
Scaled lancetfish	0	0	0	0	5145	578	5723
Eelpout	0	0	0	0	1286	144	1431
Windowpane	0	13640	0	0	0	0	13640
Gadus sp.	203	3185	30	38	14211	0	17667
Other fish	3139	22610	1289	1045	120653	2095	150830
Euphausiid	0	67	0	0	26961	0	27028
Shrimp	139	13715	21	26	93055	0	106956
Squid	5642	7418	1651	1345	164274	4552	184882
Other Invertebrate	19	38054	3	4	45664	0	83743
Total fish	122494	679738	51493	41183	2509509	31572	3435988
Total prey	128294	738992	53168	42558	2839462	36123	3838597

Appendix 3.
Prey consumption (tonnes) by individual seal species during 1990-96 in Atlantic Canada.

A) Grey Seals

	1990				1991				1992				1993			
	4VsW	N_Gulf	S_Gulf	Other	4VsW	N_Gulf	S_Gulf	Other	4VsW	N_Gulf	S_Gulf	Other	4VsW	N_Gulf	S_Gulf	Other
Atlantic cod	10832	15448	6037	4253	10914	16049	6581	4729	12224	17511	7173	5259	13695	19115	7822	5850
Atlantic herring	5365	4680	2357	1661	5828	4862	2570	1847	6537	5305	2801	2054	7333	5791	3055	2285
Capelin	0	2240	377	265	0	2327	411	295	0	2539	448	328	0	2772	488	365
Mackerel	2432	2134	1362	960	1714	2217	1485	1067	1904	2419	1619	1187	2115	2641	1765	1320
Lumpfish	0	2765	465	328	0	2873	507	364	0	3134	552	405	0	3421	602	451
Wolfish	0	2262	380	268	0	2350	415	298	0	2564	452	331	0	2799	493	369
Sculpin	0	400	67	47	0	415	73	53	0	453	80	59	0	495	87	65
Haddock	0	448	75	53	0	466	82	59	0	508	90	66	0	555	98	73
Lycod	0	55	9	7	0	58	10	7	0	63	11	8	0	69	12	9
Sandlance	40923	344	14204	10008	37565	357	15484	11127	41994	389	16877	12374	46959	425	18405	13766
Yellow-tailed flounder	0	1292	217	153	0	1342	237	170	0	1465	258	189	0	1599	281	211
Winter flounder	0	75	13	9	0	78	14	10	0	85	15	11	0	93	16	12
American Plaice	0	1397	235	166	0	1452	256	184	0	1584	279	205	0	1729	304	228
Smelt	0	4	1	0	0	4	1	1	0	5	1	1	0	5	1	1
Witch flounder	0	54	9	6	0	56	10	7	0	61	11	8	0	67	12	9
Greenland halibut	0	91	15	11	0	95	17	12	0	103	18	13	0	113	20	15
Cunner	0	48	8	6	0	50	9	6	0	55	10	7	0	60	11	8
Salmon	0	337	57	40	0	351	62	44	0	382	67	49	0	418	74	55
Redfish	532	28	192	135	480	29	209	150	536	31	228	167	599	34	248	186
Pollock	1030	0	290	204	1155	0	316	227	1297	0	344	252	1455	0	375	281
Alewife	0	417	70	49	0	433	76	55	0	472	83	61	0	516	91	68
Ray	0	807	136	96	0	839	148	106	0	915	161	118	0	999	176	132
Ocean pout	0	2046	344	242	0	2125	375	269	0	2319	409	300	0	2532	446	333
Pleuronectidae	5737	0	1898	1337	5536	0	2069	1487	6196	0	2255	1654	6935	0	2460	1840
Silver hake	3365	0	970	684	3704	0	1058	760	4155	0	1153	845	4662	0	1257	940
White hake	0	95	16	11	0	98	17	12	0	107	19	14	0	117	21	15
Other fish	1998	0	745	525	1659	0	813	584	1851	0	886	649	2065	0	966	722
Squid	2956	0	947	667	2950	0	1032	742	3304	0	1125	825	3701	0	1227	918

Grey seal (con't)

	1994				1995				1996			
	4VsW	N_Gulf	S_Gulf	Other	4VsW	N_Gulf	S_Gulf	Other	4VsW	N_Gulf	S_Gulf	Other
Atlantic cod	15344	20865	8529	6510	17189	22733	9281	7240	19261	24792	10110	8057
Atlantic herring	8227	6321	3331	2542	9229	6886	3624	2827	10355	7510	3948	3146
Capelin	0	3026	532	406	0	3297	579	452	0	3595	631	503
Mackerel	2351	2883	1925	1469	2611	3141	2095	1634	2902	3425	2282	1819
Lumpfish	0	3735	657	501	0	4069	715	558	0	4437	779	620
Wolfish	0	3055	537	410	0	3329	585	456	0	3630	637	508
Sculpin	0	540	95	72	0	588	103	81	0	642	113	90
Haddock	0	606	107	81	0	660	116	90	0	720	126	101
Lycod	0	75	13	10	0	82	14	11	0	89	16	12
Sandlance	52518	464	20068	15317	58721	505	21838	17035	65682	551	23788	18958
Yellow-tailed flounder	0	1745	307	234	0	1901	334	261	0	2074	364	290
Winter flounder	0	102	18	14	0	111	19	15	0	121	21	17
American Plaice	0	1887	332	253	0	2056	361	282	0	2243	393	314
Smelt	0	5	1	1	0	6	1	1	0	6	1	1
Witch flounder	0	73	13	10	0	80	14	11	0	87	15	12
Greenland halibut	0	123	22	17	0	134	24	18	0	146	26	20
Cunner	0	65	11	9	0	71	12	10	0	77	14	11
Salmon	0	456	80	61	0	497	87	68	0	541	95	76
Redfish	670	37	271	207	749	41	294	230	837	44	321	256
Pollock	1634	0	409	312	1834	0	446	348	2059	0	485	387
Alewife	0	563	99	76	0	613	108	84	0	669	117	93
Ray	0	1090	192	146	0	1188	209	163	0	1295	227	181
Ocean pout	0	2763	486	371	0	3011	529	413	0	3283	576	459
Pleuronectidae	7764	0	2682	2047	8690	0	2918	2277	9730	0	3179	2533
Silver hake	5232	0	1371	1046	5871	0	1492	1163	6588	0	1625	1295
White hake	0	128	22	17	0	139	24	19	0	152	27	21
Other fish	2304	0	1053	804	2571	0	1146	894	2869	0	1248	995
Squid	4146	0	1338	1021	4643	0	1456	1136	5202	0	1586	1264

B) Hooded Seals

	1990			1991			1992			1993		
	Gulf	2J3KL	Flemish	Gulf	2J3KL	Flemish	Gulf	2J3KL	Flemish	Gulf	2J3KL	Flemish
Atlantic cod	79	24759	2747	83	25958	2880	87	27214	3020	91	28532	3166
Atlantic herring	921	3498	0	966	3667	0	1013	3845	0	1062	4031	0
Capelin	20	2255	245	21	2364	257	22	2478	269	23	2598	282
Witch flounder	0	37537	4216	0	39354	4420	0	41259	4634	0	43256	4859
Greenland halibut	2777	87070	8596	2912	91285	9012	3053	95704	9448	3201	100337	9906
Redfish	1356	13138	898	1421	13774	941	1490	14441	987	1562	15140	1034
Pleuronectidae	0	20100	2258	0	21073	2367	0	22094	2482	0	23163	2602
Silver hake	0	0	0	0	0	0	0	0	0	0	0	0
Squid	474	32313	3428	497	33877	3593	521	35517	3767	546	37236	3950
White hake	0	0	0	0	0	0	0	0	0	0	0	0
Arctic cod	954	3623	0	1001	3798	0	1049	3982	0	1100	4175	0
Grenadier	0	13804	1551	0	14472	1626	0	15173	1704	0	15907	1787
Blue hake	0	10171	1143	0	10664	1198	0	11180	1256	0	11721	1317
Scaled lancetfish	0	3875	435	0	4062	456	0	4259	478	0	4465	502
Eelpout	0	969	109	0	1016	114	0	1065	120	0	1116	125
Other fish	0	14046	1578	0	14726	1654	0	15439	1734	0	16186	1818

Hooded seals (Cont'd)

	1994			1995			1996		
	Gulf	2J3KL	Flemish	Gulf	2J3KL	Flemish	Gulf	2J3KL	Flemish
Atlantic cod	95	29913	3319	100	31361	3480	105	32879	3648
Atlantic herring	1113	4226	0	1167	4430	0	1224	4645	0
Capelin	24	2724	296	25	2856	310	26	2994	325
Witch flounder	0	45350	5094	0	47545	5341	0	49847	5599
Greenland halibut	3356	105193	10385	3518	110286	10888	3688	115624	11415
Redfish	1638	15873	1085	1717	16641	1137	1800	17447	1192
Pleuronectidae	0	24284	2728	0	25460	2860	0	26692	2998
Silver hake	0	0	0	0	0	0	0	0	0
White hake	0	0	0	0	0	0	0	0	0
Arctic cod	1153	4377	0	1209	4589	0	1267	4811	0
Grenadier	0	16677	1873	0	17484	1964	0	18331	2059
Blue hake	0	12288	1380	0	12883	1447	0	13507	1517
Scaled lancetfish	0	4681	526	0	4908	551	0	5145	578
Eelpout	0	1170	131	0	1227	138	0	1286	144
Other fish	0	16970	1906	0	17791	1998	0	18652	2095
Squid	573	39039	4141	600	40928	4341	629	42909	4552

C) Harbour seal

	1990					1991					1992					1993				
	N Gulf	S Gulf	2J3KL	4VsW	Other	N Gulf	S Gulf	2J3KL	4VsW	Other	N Gulf	S Gulf	2J3KL	4VsW	Other	N Gulf	S Gulf	2J3KL	4VsW	Other
Atlantic cod	65	18	17	120	22	69	19	18	127	24	73	20	19	135	25	77	21	21	143	26
Atlantic herring	277	77	74	515	95	293	81	79	545	101	310	86	83	577	107	329	91	88	611	113
Capelin	62	17	17	116	21	66	18	18	123	23	70	19	19	130	24	74	21	20	138	25
Mackerel	16	4	4	30	5	17	5	5	31	6	18	5	5	33	6	19	5	5	35	6
Sculpin	2	1	1	4	1	2	1	1	4	1	3	1	1	5	1	3	1	1	5	1
Haddock	1	0	0	2	0	1	0	0	2	0	1	0	0	2	0	1	0	0	3	0
Winter flounder	15	4	4	27	5	16	4	4	29	5	17	5	4	31	6	18	5	5	33	6
Cunner	3	1	1	6	1	4	1	1	7	1	4	1	1	7	1	4	1	1	8	1
Redfish	5	1	1	8	2	5	1	1	9	2	5	1	1	9	2	5	1	1	10	2
Pollock	144	40	39	268	50	153	42	41	284	52	162	45	43	300	56	171	47	46	318	59
Alewife	19	5	5	36	7	20	6	5	38	7	22	6	6	40	7	23	6	6	43	8
Ocean pout	9	3	2	17	3	10	3	3	18	3	10	3	3	19	4	11	3	3	20	4
Pleuronectidae	5	1	1	8	2	5	1	1	9	2	5	1	1	9	2	5	1	1	10	2
Silver hake	8	2	2	15	3	8	2	2	16	3	9	2	2	17	3	9	3	3	18	3
White hake	33	9	9	61	11	35	10	9	65	12	37	10	10	69	13	39	11	11	73	13
Gadus sp.	98	27	26	181	34	98	27	26	181	34	98	27	26	181	34	98	27	26	181	34
Other fish	129	36	35	240	45	129	36	35	240	45	129	36	35	240	45	129	36	35	240	45
Euphausiid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp	67	19	18	124	23	67	19	18	124	23	67	19	18	124	23	67	19	18	124	23
Squid	168	46	45	312	58	178	49	48	330	61	188	52	51	350	65	199	55	54	370	69
Other Invertebrate	9	3	2	17	3	9	3	2	17	3	9	3	2	17	3	9	3	2	17	3

Harbour seal (cont'd)

	1994					1995					1996				
	N_Gulf	S_Gulf	2J3KL	4VsW	Other	N_Gulf	S_Gulf	2J3KL	4VsW	Other	N_Gulf	S_Gulf	2J3KL	4VsW	Other
Atlantic cod	81	22	22	151	28	86	24	23	160	30	91	25	24	169	31
Atlantic herring	348	96	94	647	120	368	102	99	684	127	390	108	105	725	134
Capelin	78	22	21	146	27	83	23	22	154	29	88	24	24	163	30
Mackerel	20	6	5	37	7	21	6	6	39	7	22	6	6	42	8
Sculpin	3	1	1	5	1	3	1	1	6	1	3	1	1	6	1
Haddock	1	0	0	3	0	2	0	0	3	1	2	0	0	3	1
Winter flounder	19	5	5	34	6	20	5	5	36	7	21	6	6	39	7
Cunner	4	1	1	8	1	5	1	1	8	2	5	1	1	9	2
Redfish	6	2	2	11	2	6	2	2	11	2	6	2	2	12	2
Pollock	181	50	49	336	62	192	53	52	356	66	203	56	55	377	70
Alewife	24	7	7	45	8	26	7	7	48	9	27	8	7	50	9
Ocean pout	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleuronectidae	11	3	3	21	4	12	3	3	22	4	13	4	3	24	4
Silver hake	6	2	2	11	2	6	2	2	11	2	6	2	2	12	2
White hake	211	58	57	392	73	223	62	60	415	77	237	65	64	440	81
Gadus sp.	41	11	11	77	14	44	12	12	81	15	46	13	12	86	16
Other fish	98	27	26	181	34	103	29	28	192	36	109	30	29	203	38
Euphausiid	129	36	35	240	45	137	38	37	255	47	145	40	39	269	50
Shrimp	67	19	18	124	23	71	20	19	132	24	75	21	20	139	26
Squid	10	3	3	19	3	11	3	3	20	4	11	3	3	21	4
Other Invertebrate	9	3	2	17	3	10	3	3	18	3	10	3	3	19	4

D) Harp seal

	1990		1991		1992		1993		1994		1995		1996	
	2J3KL	NGulf	2J3KL	NGulf	2J3KL	NGulf	2J3KL	NGulf	2J3KL	NGulf	2J3KL	NGulf	2J3KL	NGulf
Arctic cod	471306	788	488457	817	508636	851	529085	885	554449	927	577322	965	599643	1003
Atlantic cod	87160	33513	90333	34736	94065	36175	97848	37632	102539	39438	106770	41066	109745	42657
Capelin	633804	250349	656870	259488	684006	270233	711507	281122	745615	294608	776375	306771	802839	318660
Atlantic herring	67630	14235	70092	14755	72988	15366	75924	15985	79564	16752	82846	17443	86059	18119
Sandlance	150994	4675	156493	4846	162961	5046	169517	5250	177644	5501	184974	5729	187954	5951
Redfish	8847	75745	9170	78511	9549	81762	9933	85056	10409	89136	10838	92817	11031	96414
Greenland halibut	103579	0	107348	0	111782	0	116276	0	121850	0	126876	0	131599	0
American Plaice	21534	0	22318	0	23240	0	24174	0	25333	0	26378	0	27390	0
Pleuronectidae	83601	57886	86646	59999	90226	62484	93855	65001	98355	68120	102413	70932	104621	73681
Windowpane	0	10716	0	11107	0	11567	0	12033	0	12610	0	13131	0	13640
Salmon	0	1944	0	2014	0	2098	0	2182	0	2287	0	2382	0	2474
Sculpin	14824	4255	15363	4410	15998	4593	16641	4778	17439	5007	18158	5214	18862	5416
Silver hake	0	2416	0	2505	0	2608	0	2713	0	2843	0	2961	0	3076
White hake	955	368	990	381	1031	397	1072	413	1124	433	1170	451	1215	468
Smelt	179	105	186	109	193	113	201	118	211	124	219	129	228	134
Alewife	0	53	0	54	0	57	0	59	0	62	0	64	0	67
Haddock	0	2364	0	2450	0	2552	0	2654	0	2782	0	2896	0	3009
Gadus sp.	11145	2416	11550	2505	12027	2608	12511	2713	13111	2843	13652	2961	14181	3076
Other fish	80170	17649	83088	18294	86520	19051	89998	19819	94312	20770	98203	21627	101961	22465
Shrimp	73245	10716	75910	11107	79046	11567	82224	12033	86165	12610	89720	13131	93035	13640
Squid	95880	5148	99370	5336	103476	5557	107637	5781	112797	6058	117450	6308	121301	6552
Euphausiid	21187	53	21959	54	22866	57	23786	59	24926	62	25954	64	26961	67
Other Invertebrate	35978	29888	37288	30980	38829	32262	40390	33562	42326	35172	44072	36625	45661	38044