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REPORT OF THE

WORKING GROUP ON MARINE MAMMAL POPULATION DYNAMICS AND TROPHIC INTERACTIONS

ICES Headquarters
12–15 March 1999

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1 INTRODUCTION

The Working Group on Marine Mammal Population Dynamics and Trophic Interactions (WGMMPD) met from 12–15 March 1999, including a joint session on 12 March with the Working Group on Marine Mammals Habitats (WGMMHA), at ICES Headquarters. Dr. G.T. Waring chaired the meeting. The ICES Assistant to the Fisheries Adviser, Mette Bertelsen, welcomed the Working Group to ICES and presented the practical arrangements and the facilities available at the ICES Secretariat. The Working Group and its terms of reference were established by Council Resolution at the 1998 ICES Annual Science Conference. A list of meeting participants is given in Annex 1 and the agreed agenda is presented in Annex 2. The list of Working Papers and documents is given in Annex 3.

2 APPOINTMENT OF RAPPORTEURS

Members of the Working Group assisted the Chair as rapporteurs.

3 TERMS OF REFERENCE

Terms of reference (TORs) (ICES C.Res.1998/2:45) for this meeting were to:

A **Working Group on Marine Mammal Population Dynamics and Trophic Interactions** [WGMMPD] under the chairmanship of Dr G.T. Waring (USA) will meet at ICES Headquarters from 12–15 March 1999 to:

a) complete Tables 2 and 3 (in Doc. ICES C.M. 1998/G:6) on cetacean prey for ICES/NAFO areas, which will provide a broad-scale summary of preferred prey;

b) continue the review of seasonal and spatial distribution and abundance data for several focal species (harbour porpoise, bottlenose dolphin, beluga whale (three IWC candidate species), grey seals and harbour seals) and their prey;

c) review data on prey size and compare these to size frequency in commercial catches and/or fisheries survey data;

d) review infestation levels and transmission rates of cod worm, relative to grey seal population growth and expansion in the east and west Atlantic;

e) review and evaluate information on potential ecological effects of fishing on marine mammal trophic interaction;

f) obtain peer review of the Working Group Report by a member of the Living Resources Committee prior to the 1999 Annual Science Conference;

g) comment on the draft objectives and activities in the Living Resources Committee component of the ICES Five-Year Strategic Plan, and specify how the purpose of the Working Group contributes to it.

WGMMPD will report to ACFM and ACME before their meetings in May/June 1999, and to the Living Resources Committee at the 1999Annual Science Conference.

Justification:

a-b) Tables 2 and 3 (established at the 1999 WGMMPD meeting) summarise data on cetacean diets for trophic models, but are incomplete:

i. The focus on the three IWC candidate species will support collaborative ICES/IWC efforts to understand the population dynamics of species impacted, throughout their range, by human activities,

ii. Several grey seal and harbour seal populations in the east and west Atlantic are both increasing and undergoing range expansions. Concomitant changes in diet may be occurring, but the trophic factors contributing to pinniped population changes are not well described. These are important for evaluating fishery and other human interactions (i.e., aquaculture, habitat use, coastal pollution), and carrying capacity;

c) Evaluation of two-way interactions require data on prey size relative to both size range in commercial catches and prey population size structure based on research surveys;

d) Examination of cod worm infestation levels in growing and expanding grey seal populations will provide information required to help evaluate the potential impact on demersal fishery resources;

e) This issue was addressed in 1992 (Anon., 1992), but considerable new information is available from by-catch monitoring and directed field programs.

4 MARINE MAMMAL TROPHIC ECOLOGY

4.1 Review of Diet Studies

The following Working Papers presented new information on marine mammal diet studies.

Grey Seals

WP/2 (Mohn, Fanning and Bowen) presented analyses of grey seal diet data and their implications to cod stock status in NAFO area (4VsW) off Canada. These new analyses have used a new cod otolith length to fish length regression based on data collected specifically in the vicinity of Sable Island that have been the source of almost all diet samples. This new regression indicates that the sizes of the cod eaten by seals are shorter and lighter than previously estimated. There is a sequence of steps to estimating the number of cod consumed by seals: 1) how many they are, 2) how much they eat, 3) how much of it is cod, and 4) the age distribution of the cod eaten. Three consumption models were used. Sensitivities to model choice and use of a single versus annual age-length key were investigated.

The conclusion is that better data and better models did not affect the overall conclusions in the earlier work, aside from the fact that the new data suggest a smaller and younger distribution of cod in the diet. The work also indicates that choice of functional response model and spatial effects due to seal distribution and annual migration are more significant factors in the assessments than improved precision in the application of diet size composition data.

In the discussion it was noted that the size of cod eaten, mainly reconstructed from scat samples, were mostly between 10 and 40 cm. Few of these cod would be mature and seal predation may reduce recruitment to the spawning population. In contrast, recent analysis of stomach contents of harbour seals (mostly young animals) bycaught in the Gulf of Maine (NAFO area 5Y) sink gillnet fishery revealed that cod was not an important component of the diet. Also, cod were not an important prey item in harbour seal scats collected off Cape Cod (mid-1980's) and grey seal scats from Nantucket Island (NAFO area 5Zw) (mid-1990's).

WP/3 (Mikkelsen and Haug) reported on the ecological role of grey seals as predators in Faroese waters. Grey seal diet was based on reconstruction of the diet composition from stomach contents obtained from animals taken for scientific purposes during the summers in 1993-1995. Gadoids, sandeels (*Ammodytes* sp.) and catfish (*Anarhichas lupus*) dominated (>80%) the seal diet in all three years sampled. Observed year-to-year variation in diets could be explained by shifts in relative importance of the three main prey groups. Geographical variation was also found. Feeding habits varied between age groups both with respect to choice of prey species and preferred sizes of prey. Faroese grey seals generally fed on fish smaller than 30 cm, although fish up to a maximum of 85 cm (catfish) have been recorded.

In the discussion, it was explicitly stated that sample sizes in this study were very small, thus we must be careful about the conclusions. It was noted that the sampling sites are exposed, therefore very difficult to obtain samples. Numbers of seals are basically unknown because no surveys have been conducted. Length frequencies of prey in stomachs would be useful, but their value is questionable given the small sample size.

Harbour Seals

WP/4 (Berg, Haug, and Nilssen) reported on diet composition as determined from stomach and faeces samples from harbour seals in Vesterålen. The Vesterålen area is in northern Norway and is the habitat for one of the largest colonies of harbour seals in Norway, the minimum estimate is about 1,000 animals. In the stomachs and faeces samples taken from haulout sites, a total of 19 different prey species were found. Thirteen of 37 seal stomachs were empty, while 11 of 53 faeces samples were without any hard (otoliths, beaks) remains. Saithe (*Pollachius virens*) was the dominant prey both with respect to numbers and biomass. Individual meal diversity was low, most commonly only one or two prey species were found in each sample. Further, for the first time, sea scorpion (*Myoxocephalus scorpius*) has been shown to be on the harbour seal diet. The sea scorpion has been suspected to be a major source of keeping the seal worm *Pseudoterranova* cycle running. Although of minor dietary importance, a small amount may be enough to ensure the infection cycle continues.

One male harbour seal had been fed in the aquarium in Bergen to establish recovery rates of food items. The experiment showed that the number of ingested specimens are grossly underestimated as recovery rates of otoliths from this single experiment were approximately 5%, 48% and 47% respectively for herring, haddock and cod. The results were used to correct the observed diet, based on faeces, in the field study. The length distributions of prey in the diet were mostly within the range 10-30 cm.

There was a consensus that further recovery rate experiments should be conducted through out the North Atlantic, owing to the potentially serious implications in dietary studies. Dietary reconstruction may be further complicated by factors such as otolith aggregation during feeding; these may be voided during non-feeding periods.

Cetaceans

WP/1 (Haug, Lindström and Nilssen) reported results on dietary investigations undertaken on minke whales taken since 1992 in northern Norway and Svalbard waters. During the period 1992 - 1997 inclusive, in the Spitsbergen and Bear Island areas, minke whales switched from a capelin-dominated *(Mallotus villosus)* diet to one comprising krill, *Thysanoessa spp.*, following the capelin stock collapse in 1992-93. In the Barents Sea area, during the same period up to 1998 inclusive, minke whales switched from a predominantly herring *(Clupea harengus)* diet to one where gadoids, capelin and krill were dominant. The paper reported the rapid crash in the abundance of immature herring in the southern Barents Sea after 1994. It was noted that whales were sampled on the continental shelf and close to the continental shelf edge, as part of initially scientific and subsequently commercial whaling. Krill forms an important prey item for capelin, which, like herring, is consumed by other fish predators such as cod *(Gadus morhua)*. It is reasonable to assume that the rapid changes in availability of capelin and herring in these areas led to the extreme change in minke whale diet over the 7-year period.

The Group discussed the possibility that such dietary changes from a fish (energy-rich) to krill dominated diet might be reflected in changes in body condition, fecundity and neonate size, as reported in fin whales off Iceland in the mid-1970s and 1980s where changes in krill abundance were correlated with such parameters (Lockyer, 1990).

4.2 Identification of Marine Mammal Prey in the North Atlantic

Data on prey species are provided in Tables 1, 2, and 3; for baleen whales, odontocetes, and pinnipeds (grey and harbour seals). The data in Tables 1 and 2 are updates of Tables 2 and 3 (in Doc. C.M. 1998/G:6), whereas Table 3 was constructed at this meeting. Data in all tables are derived from various sources, and references carried forward from the 1998 report of WGMMPD (ICES C. M. 1998/G:6) are preceded by an asterisk. Most information on baleen whales has come from commercial whaling and research whaling operations. Information for sperm whales (*Physeter macrocephalus*) is derived from whaling and also strandings. Information on most smaller cetaceans come from incidental catches and/or strandings. The data cover many years and seasons and there are known wide variations in dietary preference between areas and seasons and from year to year. The tables are not a fully comprehensive compilation of predators and prey items at this stage, and do not include all known prey species for those predators listed. The focus has been on the predators that are most known and important in conservation and management and their main prey. (Note that for killer whales (*Orcinus orca*), in some areas such as the Faroes (Bloch and Lockyer, 1988), large prey such as seabirds, seals, and even other cetaceans form part of the diet. However, this is not recorded in the prey table.)

The WGMMPD summarised prey size data from various sources that were available at the meeting (Tables 4 and 5). Although these tables are incomplete, they provide some insight to the broad size range of prey taken by marine mammals. However, at this stage they are insufficient for evaluating potential competition between marine mammals and commercial fisheries for similar size prey, or ecological impacts of marine mammal foraging on fishery resources. Completion of these tables will require additional work via correspondence by WGMMPD members, and assistance by other ICES Working Groups to obtain fishery and survey prey size/ weight data.

4.3 Utility of Compiling a Comprehensive Dataset on North Atlantic Cetacean and Seal Prey

As indicated in the 1998 report of WGMMPD (ICES C. M. 1998/G:6), the tables of marine mammal prey compiled by this working group should be regarded as a starting point. The data therein are not comprehensive and, in any case, only provide the main prey species taken in different areas. It is clear that although marine mammals have general food preferences, the actual composition of prey can vary from area to area. Therefore the tables here detail prey type by ICES (Figure 1) and/or NAFO (Figure 2) area. These tables could be developed and updated regularly. Potential uses of these types of data are developing ecosystem management plans and multispecies models. Other information useful for modelling would be spatial/temporal data on quantities and energetic value of food consumed by marine mammal species. Broad scale biopsy sampling for fatty acid analyses may provide a cost-effective method to understand marine mammal foraging ecology.

5 SEAL ABUNDANCE STUDIES

WP/5 (Härkönen and Heide-Jørgensen) reported on recovery of seal stocks in the Kattegat-Skagerrak and the Limfjord after the seal epizootic in 1988. In the period 1979-1987 the harbour seals in the Kattegat-Skagerrak increased at an exponential rate of 0.12. In spring 1998, about 60% of the population died due to an epizootic event, which was the worst ever described for a marine mammal population. 5,378 and 391 dead seals were recorded in the Skagerrak-Kattegat and in the Limfjord, respectively. Mature seals were affected more than immature and more males than females died.

Aerial surveys have been used to track the recovery of the seal population and counts have been compared to Leslie matrix model results. The surveys indicated that the population was stable in the years 1988-1990 but thereafter increased rapidly. In the original model projections three levels of pup mortality were investigated (0.20, 0.25, 0.30), but projections were found to be insensitive to pup mortalities exceeding 25% so that value was used in comparison with survey results. Survey data and the projection model coincide, showing a peak in growth rate in 1990-1992, and then gradually approach pre-epizootic values. The reason for this is a very skewed age distribution in the population, which was caused by the large 1985-1987 cohorts of females. Most of this cohort largely escaped the epizootic in 1988 and contributed substantially to the reproduction of the stock from 1990 onwards. Population growth in the Limfjord has been somewhat different from that in Kattegat-Skagerrak with a lower rate of increase. This may be a symptom of the approach of the population in the Limfjord region to the carrying capacity of the system. Apparently the seal epizootic also affected the Limfjord seals on a later stage than the other areas, and also had a less detrimental effect on the reproductive capacity of Limfjord seals in 1989.

The discussion focused on the input values used for the Leslie matrix model. One result of the modelling was that growth rate was projected to show a flux in the net reproductive rate and thereby pup production. Surveys of pup production in selected areas were in good agreement with this projection. The body growth rate of weaned pups changed before and after the epizootic as the mean weight of 4-5 month old pups was 22.5 kg before the epizootic compared with 28 kg for pups caught during 1991-1993. One contributory factor for this finding could be an invasion of saithe into coastal waters. Prior to the epizootic mortality rate for pups of the year from ages 4-5 months to one year was 7-8%. In contrast, no mortality was recorded for this segment during the same season for freeze branded animals in cohorts born in 1990-1993.

6 REVIEW AND EVALUATION OF INFORMATION ON POTENTIAL ECOLOGICAL EFFECTS OF FISHING ON MARINE MAMMAL TROPHIC INTERACTION

6.1 Introduction

Five categories of potential ecological effects from fishing might affect the feeding of marine mammals:

a) a directed fishery on a marine mammal prey species causing a reduction in prey stocks;

b) a change in species assemblage as a consequence of fisheries;

c) a general increase in small fish, and a decrease in large fish;

d) a concentration of fish by fishing gear, making foraging easier;

e) an increased provision of dead, or injured fish, either through discards or escapes from nets.

A further, but different, effect is that of shark fisheries: if the stocks of the larger predatory sharks are reduced, then predation on marine mammals, especially immature animals, will be reduced as well.

In contrast to the literature on the direct interactions of fisheries with cetaceans (by-catch), there has been little published on the indirect effects that might occur due to changes in fish stock sizes and structure that have resulted from fisheries. This is partly due to incomplete information, but also due to the inability to detect some changes. Lowry and

Frost (1985) suggest that a four-stage process is required to establish the indirect effects of fishery. Firstly, stocks of prey species must be significantly depleted beyond the predatory effect of marine mammals, secondly, the consequential changes in abundance of the prey must affect amounts consumed by the marine mammal, thirdly, such a change should affect the marine mammal's life or behaviour. Finally, these changes should affect the population characteristics of the marine mammal. There is a shortage of information on all of these areas.

Dietary changes can affect marine mammal life and behaviour. Lockyer (1990) correlated increases in krill abundance during the mid 1970s and 1980s off Iceland with improved body condition in fin whales, and a time-lagged improvement in fecundity and neonate size. Although krill abundance is not linked to fisheries (see section 6.3), it might be possible to monitor changes in body condition in the future using blubber thickness, girth and lipid content as has been done for minke whales (Næss *et al*. 1998). Further information on diet might be obtained from fatty acid profiles (Iversen *et al*., 1997).

6.2 Effects of Directed Fsheries on Marine Mammal Prey Stocks

Lowry and Frost (1985) examined the interactions between fisheries and marine mammals in the Bering Sea. In this area, heavy exploitation of marine mammals preceded exploitation of fish stocks and early models indicated that marine mammals consumed more fish than were landed by the fishery (Lowry *et al*., 1979). Lowry and Frost (1985) considered that four factors were important in assessing the likelihood of marine mammal-fishery interaction:

a) diet composition in relation to commercially-caught species,

b) feeding strategy,

c) overall importance of the study area to the marine mammal, and

d) the relationship of the present population to the carrying capacity, i.e. is per capita food availability presently limiting population size?

Obviously if diet does not overlap with fisheries, then interaction is less likely; feeding strategy describes the degree of specialisation in prey species. We used a modified version of this approach to examine the likelihood of fisheries having indirect effects on marine mammal populations in the north-east Atlantic and on the continental shelf of eastern North America (Tables 6.1, 6.2, 6.3). In order to emphasise the trophic aspects of this, we multiplied the first two factors by two and then added all values together by species. There is reasonable information available for some values in Tables 6.2 and 6.3 – these are emboldened. Other values are based on information from outside the region concerned, or on best guesses from the Working Group. *The lack of information on some aspects in this evaluation means that results must be treated cautiously*.

The evaluation of the eastern shelf of North America would indicate that long-finned pilot whales and the inshore groups of bottlenose dolphins are most likely to be affected by fisheries targeting their prey species. The more offshore and the rarer species are much less likely to be affected. In the eastern North Atlantic, the two seal species and harbour porpoise appear higher in the ranking than the inshore groups of bottlenose dolphins, white-beaked dolphins and long-finned pilot whales. Differences in evaluations between the two areas reflect not only differences in marine mammal diets (see earlier Tables) but also differences in species harvested commercially.

Table 6.1 Criteria for assigning ranked values of the likelihood of marine mammal- fishery interactions in the Bering Sea. Low values indicate that the described characteristics suggest a low probability of significant interactions (after Lowry and Frost, 1985).

Rank value	Dietary composition	Feeding strategy	Importance of area to marine mammal	Relative population size	Biomass relative to other marine mammals
1	Feed principally on non-commercial species	Omnivorous with high mobility	Important for feeding during only a small period of year	Seriously depleted	Low
2	Feed moderately on commercial species	Moderately diverse diet	Moderately important	Slightly reduced	Medium
3	Feed heavily on commercial species.	Stenophagous or with low mobility	Major feeding area without alternative feeding grounds	Comparable to historic	High

Table 6.2. Ranked value of the likelihood of marine mammal and indirect fishery interactions on the eastern shelf of North America, based on feeding characteristics and population status. Emboldened figures are based on some information from within the area. Other values are based on information from outside the region concerned, or on best guesses from the Working Group. Highlighted lines are those where all factors are based on local information. The lack of information on some aspects in this evaluation means that results must be treated cautiously.

	Diet	Feeding strategy	Importance of area	Relative size of pop.	Biomass	Weighted Total
Right whale	**1**	**3**	**3**	**1**	**1**	13
Humpback whale	**2**	**2**	**3**	**1**	**2**	14
Fin whale	**2**	**1**	**2**	**2**	**2**	12
Sei whale	**1**	3	1	2	1	12
Minke whale	**2**	**2**	**2**	**2**	**2**	14
Blue whale	1	2	1	1	1	9
Sperm whale	1	1	2	2	3	11
Dwarf sperm whale	1	2	1	2	1	10
Pygmy sperm whale	1	2	1	2	1	10
Killer whale	1	1	1	2	1	8
Bottlenose whale	1	**2**	**3**	**1**	**1**	11
Cuvier's beaked whale	1	2	**2**	2	1	11
Mesoplodon spp.	1	2	**2**	2	1	11
Risso's dolphin	2	2	**2**	2	2	14
Long-finned pilot whale	**3**	**2**	**3**	**2**	**2**	17
Short-finned pilot whale	1	2	2	2	1	12
White-beaked dolphin	2	2	**3**	2	2	15
White-sided dolphin	**2**	**2**	**3**	**2**	**2**	14
Common dolphin	**2**	**2**	**3**	**2**	**2**	15
Atlantic spotted dolphin	2	2	2	2	1	13
Pantropical spotted dolphin	1	2	1	2	1	10
Striped dolphin	1	2	2	2	1	11
Spinner dolphin	1	2	1	2	1	10
Bottlenose dolphin (offshore)	**2**	**2**	**3**	**2**	**1**	14
Bottlenose dolphin (inshore)	**3**	**2**	**3**	**1**	**2**	16
Harbour porpoise	**2**	**2**	**3**	**1**	**2**	14
Harbour seal	**1**	**2**	**3**	**2**	**2**	13
Grey seal	**1**	**2**	**3**	**3**	**3**	15

Table 6.3. Ranked value of the likelihood of marine mammal and indirect fishery interactions in the eastern North Atlantic and North Sea (42ºN – 62ºN, mainland to 15ºW), based on feeding characteristics and population status. Emboldened figures are based on some information from within the area. Other values are based on information from outside the region concerned, or on best guesses from the Working Group. Highlighted lines are those where all factors are based on local information. The lack of information on some aspects in this evaluation means that results must be treated cautiously.

	Diet	Feeding strategy	Importance of area	Relative size of pop.	Biomass	Weighted Total
Humpback whale	2	2	2	**1**	**1**	12
Fin whale	**1**	1	2	**2**	**2**	10
Sei whale	**1**	3	1	2	1	12
Minke whale	**2**	2	**2**	**2**	**3**	15
Blue whale	1	2	**2**	**1**	**1**	10
Sperm whale	**1**	**2**	**2**	2	3	13
Killer whale	2	1	1	3	1	11
Bottlenose whale	2	2	3	1	1	13
beaked whale spp.	1	2	2	3	1	12
Risso's dolphin	**1**	**2**	**1**	2	1	10
Long-finned pilot whale	**3**	**2**	**1**	2	3	16
Short-finned pilot whale	**2**	**2**	**1**	3	1	13
White-beaked dolphin	**2**	**2**	**3**	**3**	**2**	16
White-sided dolphin	2	2	2	3	2	15
Common dolphin	**2**	**2**	**1**	**2**	**2**	13
Striped dolphin	**2**	**2**	**1**	**2**	**2**	13
Bottlenose dolphin (offshore)	2	1	3	2	1	12
Bottlenose dolphin (inshore)	**3**	**2**	**3**	**2**	**1**	16
Harbour porpoise	**3**	**2**	**3**	**2**	**2**	17
Harbour seal	**3**	**2**	**3**	**3**	**2**	18
Grey seal	**3**	**2**	**3**	**3**	**2**	18

6.3 Change in Species Assemblage

Fisheries have the potential to change the overall species assemblage in an area. In the North Sea, stocks of species such as mackerel, most rays and most demersal species have been greatly reduced in biomass (Rijnsdorp *et al*., 1996; Walker and Heessen, 1996; Heessen and Daan, 1996; Greenstreet and Hall, 1996). It is likely that stocks of sandeels have increased (Sherman *et al*., 1981). On Georges Bank stocks of demersal finfish were severely reduced during the past three decades, and concomitantly there has been an increase in elasmobranchs, particularly dogfish (Murawski and Idoine, 1992). These changes might be expected to affect diet and therefore possibly life history parameters of marine mammals. Unfortunately there have been no studies of marine mammal diet that cover the time frame of the above changes, so it is not possible to evaluate the effects of fisheries.

Off the eastern coast of the United States, the commercial depletion of herring and mackerel stocks led to an increase in sandeels in the southwestern Gulf of Maine in the mid 1970s (Sherman *et al.*, 1981). Concurrent with these changes, humpback whales decreased in the northern Gulf of Maine and increased in the southwestern Gulf of Maine (Payne *et al*., 1986). An apparent reversal of this began in the mid 1980s when herring and mackerel abundance increased along with humpback whale numbers in the northern Gulf of Maine (Payne *et al*., 1990; Waring *et al*., 1999).

In a study of both diet of harbour seals and fish abundance as estimated from fisheries surveys in the Moray Firth in north-east Scotland, Tollit *et al.* (1997) found that the most abundant fish species contributed most to seal diet, but this did not hold true for other species. Should fisheries thus affect abundance of the commonest species (sandeel or sprat) in this area, an effect should be detected in the seal diet. This may in turn affect seal behaviour (Thompson *et al*., 1996).

The Barents Sea provides an instructive case on the difficulty in determining effects of changes in prey assemblage. In this sea, the main fishery is for cod, with small amounts of capelin taken in recent years. Capelin and immature herring are an important part of cod diet in the Barents Sea. The two main marine mammal species, minke whale and harp seal, have a diet that varies dramatically between years. The diet of both species includes capelin and herring as a component of varying importance (WP1 Haug *et al.*, 1999, Nilssen *et al.*, 1999). In years when capelin and herring abundance were low (e.g., 1997 and 1998 in minke whale management area EB - Barents Sea and coastal areas of Finnmark and Kola), krill (*Thysanoessa* spp.) became an important alternative food source for minke whales. In contrast, harp seals, which are more stenophagus, responded to the capelin collapse by invading coastal areas of northern Norway in search of suitable food (Nilssen *et al.*, 1996). Capelin is an important predator on krill, and when capelin abundance is low krill biomass increases. Multispecies modelling has indicated that when cod abundance is low, there may be more capelin and herring available for other predators, including marine mammals. However, the very large changes in oceanography in the area appear to have effects that mask any signal that might be generated in the capelin or herring stock as a consequence of the cod fishery. It might be possible to use the Barents Sea multispecies model (MULTSPEC) (Bogstad *et al*., 1997) to model changes in minke whale and harp seal diets if stocks of prey species were reduced by fisheries.

6.4 Effects of Changes in Prey Fish Size/Age Structure

Intensive fisheries in the North Sea and elsewhere have changed the size and age structure of fish populations (Pope *et al*., 1987; Pope and Knights, 1982; Rice and Gislason, 1996; Gislason and Rice, 1996). In general, the fish assemblage of exploited areas has an increased number of small fish and a decreased number of larger fish, when compared with assemblages prior to exploitation. If marine mammal species were size selective over a narrow range, this effect would be expected to affect marine mammal population parameters. The effect could be positive (if smaller fish were preferred) or negative (if larger fish were preferred). Lindstrøm *et al*. (1998) suggested that in some years, minke whales preferred the smaller size classes of herring in Barents Sea during summer. Tollit *et al*. (1997) found some evidence of size selection in harbour seals, but the extent of this selection (with the exception of cod) was dependent on the factors used to compensate for otolith erosion in stomachs. There is no evidence at presence of a generally narrow range of size selectivity for fish size in these species or in other marine mammals (see Tables 4 and 5).

6.5 Effects of Concentration of Food at Fishing Gear

Fertl and Leatherwood (1997) review the exploitation of fishing activities for food. Bottlenose dolphins have been recorded taking fish from gillnets and from hooks (Cato and Prochaska, 1976). Lien (1994) found long-finned pilot whales taking squid from traps. Fertl and Leatherwood (1997) document 15-16 cetacean species feeding in association with trawling activity. Cetaceans have been recorded moving in and out of trawl mouths to take fish. Off Scotland, unpublished film of the SOAEFD Marine Laboratory shows white-beaked dolphins taking fish from commercial trawls, and Steward (1998) shows grey seals feeding on fish escaping from trawl nets. Crespo and Corcuera (1990) report on dolphins moving in and out of trawls off Argentina. Trawling has the effect of concentrating food so that cetaceans need spend less time foraging, and presumably use less energy in doing so. Some cetaceans presumably also take escapees from trawls that in many cases will be injured or damaged.

Fishing operations may make some foods available that are not normally available to cetaceans. Killer whales take sablefish (*Anaplopoma fimbria*) from long-lines in Prince William Sound (Matkin *et al*., 1986); these fish usually live too deep for killer whales to catch. There is some evidence that minke whales take cod from long lines off northern Norway (Nilssen, pers. comm.). Pilot whales, Risso’s dolphin and false killer whales have been recorded taking tuna fish, particularly bigeye tuna (*Thunnus obesus*), off longlines elsewhere.

6.6 Scavenging on Discarded Fish

Both killer whales and bottlenose dolphins have been reported feeding on discarded by-catch. Couperus (1994) recorded killer whales feeding on discarded fish from freezer trawlers north-west of Shetland. This interaction has also been reported in the Bering Sea (Teshima and Ohsumi, 1983). Bottlenose dolphins have been recorded waiting alongside vessels for by-catch to be discarded off the south-eastern United States (Davis, 1988) and in Moreton Bay, Australia (Wassenberg and Hill, 1990). These latter authors reported that the dolphins ate about 86% of the fish discarded from a single trawl, and appeared to show some preference for species consumed. Common dolphins have also been recorded taking discards from fishery research vessels off the north-eastern U.S. (Waring, pers. comm.).

7 EVALUATION OF COD WORM INFESTATION RATES

The WGMMPD did not address this TOR, as no studies were presented addressing the infestation levels and transmission rate of the seal worm based on grey seal population dynamics. Aspects of this issue were reviewed by the WGMMHA, and WGMMPD will review their report prior to making further recommendations on this topic.

8 COMMENT ON LIVING MARINE RESOURCES COMMITTEE CONTRIBUTION TO ICES FIVE- YEAR STRATEGIC PLAN

The WGMMPD did not address this TOR. Draft objectives and activities were submitted by the ICES Committees to the Consultative Committee in October 1998. The review of these objectives by the Bureau had not been finalised prior to this meeting and hence there was no input for discussion.

9 JOINT SESSION OF WGMMPD AND WGMMHA

The Working Group on Marine Mammal Population Dynamics and Trophic Interactions (WGMMPD) and the Working Group on Marine Mammal Habitats (WGMMHA) met jointly on 12 March. A. Bjørge, Chairman of WGMMHA, welcomed members of WGMMPD to the joint session.

Committee members reviewed the utility of joint sessions, timing of future meetings, and coordination of requests for working papers. It was suggested that the two Working Groups would need to meet for two days in 2000 to deal with joint issues pertaining to the HELCOM request. Working Group Chair's will work closely to solicit working papers, and participation by individuals conducting studies in the Baltic. Information will be required on by-catch, abundance surveys, food habitats, contaminants and pollution, trophic interactions, and habitat conflicts (i.e., aquaculture and beach haul-out site interactions with humans). The Working Groups recommended that the next meeting should be in February 2000, in a Baltic country. Both Helsinki, Finland and Hell, Poland were recommended to ensure participation by eastern Baltic countries. A 5-day period should provide sufficient time for both Working Groups to complete their activities. Decisions regarding the dates and venue will be made prior to the ICES Annual Science Conference, preferably by spring 1999. If no other venue is found, it is hoped that ICES can host the 2000 meeting.

There was consensus that after the 2000 meeting, it is not necessary to meet every year. It was agreed that a biennial meeting would be the best option, with email correspondence meetings when necessary in the intervening years. The biennial meetings should correspond with new data, or relate to a request to ICES (e.g., HELCOM). The Chair of the WGMMPD will liaise with the Chair of the WGMMHA to explore possibilities for convening the working groups at times and venue that facilitate optimal participation of the groups.

Committee members agreed that at joint meetings with overlapping agendas, each WG should approach the topic from different perspectives. For example, on contaminants the WGMMHA should examine biological effects and WGMMPD the effects on population dynamics. For topics that fall in between these two areas, WGMMHA will take a qualitative approach and the WGMMPD will take a quantitative/assessment approach. It was agreed that this overlap is a good reason to meet jointly at the next meeting. This will allow overlapping topics to be addressed. E.g. feeding ecology and spatial foraging behaviour. WGMMHA would evaluate contaminant exposure and parasite exposure, and WGMMPD would investigate effects on population dynamics, ecosystem management, fishery interactions, and resource management plans. This is useful because marine mammals are being incorporated into ecosystem models without the relevant information.

Arne Bjørge, Chair, WGMMHA reviewed the aspects of the contaminant proposal that the WG will submit to the European Union. He indicated that the proposal goal is to cover topics from a cellular to a population level, and to set up a framework which can be used to evaluate contaminants through indicators. It is hoped that the AMAP (Arctic Monitoring and Assessment Programme) and the International Whaling Commission will be involved.

10 RECOMMENDATIONS

10.1 Future Activities of the Working Group

Members of the Working Group agreed that in addition to future meetings to address specific requests to ICES (e.g. HELCOM, OSPAR), the group should meet on a biennial schedule to review topics identified in the remit of the WGMMPD. During intervening years the group will meet via correspondence. The group strongly supports joint meetings with the WGMMHA, and further, recommends that activities of both groups be accomplished within a five-day lapping period.

The Working Group on Marine Mammal Population Dynamics and Trophic Interactions (WGMMPD) (Chair: Dr. G. Waring, USA) will meet in 2000 at a venue and date yet to be decided to:

a) evaluate, in cooperation with the WGMMHA, the populations of grey (*Halicheorus grypus*), harbour (*Phoca vitulina*) and ringed (*Phoca hispida bothnica*) seals harbour porpoises (*Phocoena phocoena*) in the Baltic Sea, including the size of the populations, distribution, migration, reproductive capacity, effects of contamination, and health status, and additional mortality owing to interactions with commercial fisheries (by-catch, intentional killing);

b) review invited papers and other information on techniques and methodology on seal abundance, particularly, grey seal and harbour seals, including census methodologies and techniques, population growth rates and trends, mortality and by-catches;

c) review progress, and new techniques and methodology in marine mammal dietary studies, including sampling design, sample processing, reconstructive techniques, data biases, and consumption models.

The Chair of WGMMPD will work closely with the Chair of WGMMHA to seek joint sessions to conduct a comprehensive review of the status of Baltic marine mammal populations. The Chair of the WGMMPD will liaise with the Chair of WGMMHA to explore possibilities for convening the working groups at times and venue that facilitate optimal participation of the groups.

[Justifications: item a is justified by the request from HELCOM. Item b is justified by the ICES Five-Year Science Plan.]

11 OTHER BUSINESS

WGMMPD wishes to thank ICES for its use of their fine facilities and staff assistance.

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[1] References with a preceding asterisk were carried forward from the 1998 report of WGMMPD, and primarily pertain to information contained in Tables 2 and 3.

ANNEX 1

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ANNEX 2

AGENDA

1 Introduction and opening comments

2 Appointment of rapporteurs

3 Terms of reference

4 Marine mammal trophic ecology
   4.1 Review studies on marine mammal diets in the North Atlantic
   4.2 Identification of marine mammal prey in the North Atlantic
   4.3 Utility of compiling a comprehensive data set on North Atlantic marine mammal prey

5 Seal abundance studies

6 Ecological effects of fishing on marine mammal trophic interactions
   6.1 Introduction
   6.2 Effects of directed fisheries on marine mammal prey stocks
   6.3 Change in species assemblage
   6.4 Effects of changes in prey fish size/age structure
   6.5 Effects of concentration of food at fishing gear
   6.6 Scavenging on discarded fish

7 Evaluation of cod worm infestation rates

8 Comment on Living Marine Resources Committee contribution to ICES Five-Year Strategic Plan

9 Joint session of WGMMPD and WGMMHA

10 Recommendations for future activities

11 Other business

ANNEX 3

LIST OF WORKING PAPERS AND DOCUMENTS

WP1	Haug, T., U. Lindstrøm and K. T. Nilssen. 1999. Variations in minke whale *Balaenoptera acutorostrata* diets in response to environmental change in the Barents Sea. 13 pp.
WP2	Mohn, R. K., L. P. Fanning and W. D. Bowen 1999. New analyses of seal diet data and their implications to 4VsW cod stock status. 15 pp.
WP3	Mikkelsen, B. and T. Haug. 1999. Summer diet of grey seals in Faroese waters. 19 pp.
WP4	Berg, I., T. Haug, and K. T. Nilssen. 1999. Harbour seals (*Phoca vitulina*) in Vesterålen, North Norway: Diet composition as determined from stomach and faeces samples. 25 pp.
WP5	Härkönen, T. and M. P. Heide-Jørgensen. 1999. Recovery of seal stocks in the Kattegat-Skagerrak and the Limfjord after the seal epizootic. 14 pp.

Table 1. Principal prey for several odontocete whales in the ICES and/or NAFO areas.

Prey species	Sperm whale	Pilot whale	Northern bottlenose whale	Killer whale	Harbour porpoise	White-beaked dolphin	White-sided dolphin	Striped dolphin	Common dolphin	Beluga	Narwhal	Risso's dolphin	Bottlenose dolphin	Sowerby's beaked whale
CEPHALOPODA	Va, IVa, VIIIc			IIa		IVa	IVa	IVa, VIIIc, VIIg	VIIg	1A, B, C–F		IVa, VIIIc, IXa	IVa	
Todarodes sagittatus		VIIIc, Vb1, Vb2,Va												
Gonatus fabricii	IIa, IIb	Vb1, Vb2	Vb1, Vb2,IVb					VIIg	VIIg					
Brachioteuthis sp.		Vb1, Vb2												
Illex illecebrosus		3P			4X				5Z, 6A, 6B	4S, 4T				
I. coindetii		VIIIc, IXa												
Sepiola atlantica		Vb1, Vb2			Va, VIIg									
Mastigoteuthis sp.	VIIIc, IXa													
Teuthowenia megalops	VIIIc, IXa													
Loligo forbesi					VIIg				VIIg					
L. pealei		5Zw, 6A							6A, 6B					
Sepietta					IIIan									
Allotheuris					IIIas, IVb									
Histioteuthidae	VIIIc, IXa								VIIIc, IXa					
Histioteuthis reversa		6A, 6C												
Chiroteuthis veranyi		6A, 6C												
Ommastrephidae		VIIIc, IXa												
Eledone cirrhosa		VIIIc, IXa												
Octopoteuthidae	VIIIc, IXa													
Octopus vulgaris		VIIIc, IXa												
PISCES														
Arctogadus glacialis										1A, B, C–F	1A, B, C			
Boreogadus saida										1A, B, C–F, I	1A, B, C			
Trachurus trachurus					VIIg, VIIIc, IXa		VIIg		VIIj			VIIIc, IXa	VIIj	
Sebastes marinus	IIa, Va				4X						1A, B, C			
Mallotus villosus					I, Va					4S, 4T				
Clupea harengus				IIa, Va	I, IIa, IIb, IVb, IIIan+s, IIIb, IIIc, IVa, VIIg, 4X, 5Y, 6A	VIIg								
Sardina pilchardus					VIIIc, IXa			VIIIc, IXa	VIIIc, IXa					
Argentina silus		Vb1, Vb2												
A. sphyraena							VIIg		VIIg					
Micromesistius poutassou		Vb1, Vb2			IIa, IIb, IIIan+s	VIIg	VIIIc, IXa		VIIIc, VIIId, VIIIe, IXa			VIIIc, IXa	VIIIc, IXa	
Maurolicus muelleri					IIa, IIb, IIIan+s		VIIj		VIIj, VIIId, VIIIe					
M. wietzmoni					5Y									
Trisopterus sp.					IIIan, IVb									
Trisopterus minutus					IIa, IIIan+s, IIIc, IVb, VIIg		VIIg	VIIg	VIIg, VIIIc, IXa					
T. esmarkii					IIIan									
Merlangius merlangus					IIIan+s, IVa, IVb, VIIg			VIIg	VIIg					
Gobiidae sp.				IIa	IIIan+s, IIIb, IIIc, IVb, VIIg			VIIg	VIIIc					
Gadiculus argenteus							VIIj							

Prey species	Sperm whale	Pilot whale	Northern bottlenose whale	Killer whale	Harbour porpoise	White-beaked dolphin	White-sided dolphin	Striped dolphin	Common dolphin	Beluga	Narwhal	Risso's dolphin	Bottlenose dolphin	Sowerby's beaked whale
Gadidae sp.				IIa	I, IIa, IIb, IVb, IIIan+s, IIIb, IIIc, IVa, Va, VIIIc	IVa, Va	IVa	IVa, VIIIc	VIIIc				IVa, VIIIc	
Gadus morhua	Va				IIIan+s, IIIb, IIIc, IVb, VIIg, 4X				IVa					
Melanogrammus aeglefinus					IIIan+s, IVb, VIIg									
Pollachius pollachius					IIIas, IVb									
Ammodytes sp.					IIIan+s, IIIc, IVa, IVb, Va				IVa	4S, 4T				
Laemonema barbatulum														5Ze
Godella imberbis														5Ze
Nezomia bairdi														5Ze
Merluccius merluccius					IIIan+s, IVb				VIIIc, IXa				VIIj, VIIIc, IXa	
M. bilinearis					4X, 5Y	VIIg								
Mytophidae									5Ze					5Ze
Sprattus sprattus					IIIan+s, IVb, VIIg			VIIg						
Scomber scombrus		5Zw, 6A, 6C			IVb, 4X		VIIg, VIIj		VIIg				VIIj	
Rhinonemus cimbrius					IIIan									
Osmerus mordax					4X					I				
Urophysis sp.					4X									
Cyclopterus lumpus	IIa, IIb, Va													
Salmo salar										I			IVa	
Reinhardtius hippoglossoides				Va										
Labridae					IIIan									
Plearonectidae					IIIc									
Solea solea					IVb									
Limanda limanda					IVb									
Lycodes esmarkii					IIIan+s, IIIc									
Anguilla anguilla					IIIan+s, IIIc									
Belone belone					IIIc									
CRUSTACEA								VIIg, VIIId, VIIIe	VIIId, VIIIe					

Table 2. Principal prey for several large baleen whales in ICES/NAFO areas.

Prey Species	Minke whale	Fin whale	Humpback whale	Sei whale	Right whale	Blue whale
PISCES						
Mallotus villosus	IIa, IIb, Va, XIVb, 1A-F	I, IIa, Va	IIa, Va	Va		
Clupea harengus	IIa, I, 5Y, 4X	4X, 5Y, 5Z	4X, 5Y, 5Z			
Gadidae sp.	Va					
Gadus morhua	IIa, IIb, I, XIVb, Va					
Melanogrammus aeglefinus	IIa					
Ammodoytes sp.	I, 1A-F, Va	Va, 5Y, 5Z	5Y, 5Z	Va		
Merluccius merluccius						
Scomber scombrus	5Y	5Y, 6A	5Y, Va			
CRUSTACEA						
Euphausidae		VIIIc, IXa				
Thysanoessa inermis	IIa, IIb, Va, XIVb, 1A-F	I, IIa, IIb	IIa	I, IIa	I, IIb	I, IIa
Meganyctiphanes norvegica	Va	I, IIa, Va		Va		
Calanus finmarchicus		I, IIa, IIb		I, IIa	5Y, 5Z	

Table 3. Principal prey species for grey and harbour seal in ICES/NAFO areas. The cut-off for inclusion was approximately 5% in terms of numerical frequency or biomass.

Prey item	Grey Seal	Harbour Seal
Clupea harengus	IIId,4T,4X	IIa,IIIa,IIId,Va,IVa,VsW,4X, 5Y,5Zw,6A
Sprattus sprattus		IIIa,Iva
Gadus morhua	I,IIId,4W, Va,Vb1,4T	I,IIa,IIIa,IIId,IVa,IVb,Va, 4VsW,4X, 5Y
Melanogrammus aeglefinus	I,Vb1	IIIa
Pollachius virens	I,Va,Vb1	IIa,IIIa,Va,4VsW,5Y
Merlangius merlangus	Vb1,4W	IIIa,IVa
Micromesistius poutassou		IIIa
Merluccius bilinearis	5Zw	5Y
Molva molva		IIIa
Urophycis sp.	Vb1	5Y
Lycodes sp.	Vb1	
Mallotus villosus	4T	
Anarchichas lupus	I,Va,Vb1	Va
Ammodytes sp.	I,Va,Vb1,4W,5Zw	I,Va,IIa,IIIa,Iva, 5Y,5Zw
Microstomus kitt	Vb1	IIIa
Limanda limanda		IIIa,IVa
Pleuronectes platessa	Vb1	IVa,IVb
Pleuronectidae sp.	I,4W,5Zw	IIa,IIIa,Va,4X
Platichthys flesus		IVb
Sebastes sp.		I,Va,5Y
Macrozoarces americanus		5Y
Tripsopterus esmarkii	Vb1	**13 IIA,IIIA**
Salmo salmar	IIId	
Osmerus eperlanus		IVb
Salvelinus sp.	IIId	IIId
Perca fluviatilis		IIId
Rutilus rutilus		IIId
Cyclopterus lumpus	Va	
Myoxocephalus scorpius	Va	
Raja sp.	5Zw	
Loligo sp.		4VsW,4X,5Y
Illex sp		4VsW,4X,5Y

Table 4. Available data concerning sizes or weights of the preys of some cetacean species taken from stomach contents studies. The values refer to ranges or size/weight averages reconstructed from prey hard parts (beaks of cephalopods or fish otoliths) contained in the stomachs. Also, size (average or range) or weight of the prey species in commercial fisheries or surveys are provided.[1]

Cetacean species	Month/ year	ICES/ NAFO Area	Prey	Stomach size range/ average (cms)	Stomach average weight (grs)	Fishery size range (cms)	Fishery weight range (grs)	Survey size range (cms)
Tursiops truncatus (3)	XII/90V III/95	VIIIc, IXa	*Micromesistius poutassou*	1.5- 37.5		14-40		
	XII/90- VIII/95	VIIIc, IXa	*Merluccius merluccius*	5.5-57.5		10-94		4-71 (1990) 5-75 (1995)
T. truncatus (4)	XII/90- III/93	VIIIc, IXa	*Todarodes sagittatus*		76.0			
	XII/90- III/93	VIIIc, IXa	*Illex coindetii*		48.0		30-1,000	
	XII/90- III/93	VIIIc, IXa	*Eledone cirrhosa*		150.0		30-1,000	
Delphinus delphis (3)	XII/90- III/93	VIIIc, IXa	*Sepiola atlantica*		4.5			
	XII/90- III/93	VIIIc, IXa	*Loligo vulgaris*		83.4			
	XII/90- III/93	VIIIc, IXa	*Allotethis subulata*		4.7			
	XII/90- III/93	VIIIc, IXa	*Todarodes sagittatus*		164.0			
	XII/90- III/93	VIIIc, IXa	*Illex coindetii*		840.0			
	XII/90- III/93	VIIIc, IXa	*Gonatus steenstrupi*		197.7			
	XII/90- III/93	VIIIc, IXa	*Octopus vulgaris*		43.0		750-8,000	
	XII/90 III/93	VIIIc, IXa	*Eledone cirrhosa*		139.0		30-1,000	
D. delphis (5)	III/89- IV/89	6a	*Scomber scombrus*		275.5			18-34 (1985) 17-40 (1997)
D. delphis (8)	VI/86	5Ze	*Illex illecebrosus*					15-22
Grampus griseus (4)	XII/90- III/93	VIIIc, IXa	*Loligo vulgaris*		179.7			
	XII/90- III/93	VIIIc, IXa	*Todarodes sagittatus*		39.2			
	XII/90- III/93	VIIIc, IXa	*Octopus vulgaris*		1,603.7		750-8,000	
	XII/90- III/93	VIIIc, IXa	*Eledone cirrhosa*		148.6		30-1,000	
Globicephala melas (6)	III/73- IV/93	6 b-c	*Loligo pealei*	5-42 [2]				
	III/73- IV/93	6 b-c	*Squalus acanthias*	75	1,640	80-110		30-115
G. melas (5)	III/89- IV/89	6a	*Scomber scombrus*	36.3	414.9			18-34 (1985) 17-40 (1997)
	III/89- IV/89	6a	*Loligo pealei*	13.4	51.0			4-25 (1985)* 8-20 (1997)*
Phocoena phocoena (7)	1994- 1996	IVb	*Gadus morhua*	3-30				
	1994- 1996	IVb	*Merlangius merlangius*	3-25				
	1994- 1996	IVb	*Platichthis flexus*	5-13				
	1994- 1996	IVb	*Limanda limanda*	3-25				
	1994- 1996	IVb	*Solea solea*	5-35				
	1994- 1996	IVb	*Ammodytes* sp.	5-25				
	1994- 1996	IVb	*Osmerus operlanus*	5-15				
	1994- 1996	IIIc	*Gadus morhua*	3-50				

Cetacean species	Month/ year	ICES/ NAFO Area	Prey	Stomach size range/ average (cms)	Stomach average weight (grs)	Fishery size range (cms)	Fishery weight range (grs)	Survey size range (cms)
	1994-1996	IIIc	*Merlangius merlangius*	3-18				
	1994-1996	IIIc	*Clupea harengus*	5-25				
	1994-1996	IIIc	*Sprattus sprattus*	5-20				

[1]This presentation is useful to illustrate possible interactions between fisheries and diets of cetaceans. However the information on prey sizes in the stomachs of cetaceans is based on the analysis of a number of stomachs. The corresponding fisheries and survey data for the same species were obtained from fisheries data bases and unpublished reports. The years when the surveys were carried out are indicated. There is a very limited amount of information on the sizes of the prey species in the stomachs, and both in the fisheries and in the populations to complete a review of the degree of interaction between fisheries and cetacean diets at this stage.

[2] Mantle length (cm)

References:
(3) Santos *et al.*, 1997
(4) Gonzalez *et al.*, 1994
(5) Overholtz and Waring, 1991
(6) Gannon *et al.*, 1997
(7) Adelung *et al.*, 1997
(8) Major, 1986

Table 5. Available data on prey size in harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), and size range in survey data by ICES/NAFO areas.

14 PHOCA VITULINA

Month/ season/ year	ICES/ NAFO area	Prey spec.	Length range [cm]	Median/ mean length ±S.D. [cm]	Survey length range [cm]	Mean mass ± S.D. [g]	Caloric value [kj/g]	Source
VIII/94	IIa	*Pollachius virens*	14-35	24.5				1
Wi 90, 94, 95	IIa	*P. virens*	3-39	13.0-16.9				1
sum/88-92	4X	*Gadus morhua*	8-54	35.2±11.9		552±439		2
sum/88-92	4W	*G. morhua*	11-37	19±5.1		84±73		2
sum/88-92	4X	*P. virens*	8-34	20.5±7.0		127±128		2
sum/88-92	4W	*P. virens*	11-37	17.7±4.2		73±59		2
sum/88-92	4X	*Clupea harengus*	8-49	22.0±5.1		99±70		2
sum/88-92	4W	*C. harengus*	16-37	25.7±4.7		149±91		2
sum/88-92	4X	Squid	8-24	17.6±2.0		116±40		2
sum/88-92	4W	Squid	16-27	19.1±2.6		151±95		2
X/96-IX/98	IVb	*Limanda limanda*	3,3-24	9	3,5-24,5			3
X/96-IX/99	IVb	*Platichthys flesus*	4,5-35	8	8,5-25,5			3
X/96-IX/99	IVb	*Pleuronectes platessa*	4,5-22	8.5	4.5-24.5			3
X/96-IX/99	IVb	*G. morhua*	4.5-35	8	8.5-33.5			3
VI/92	IVa	*Merlangius merlangus*	10-26		8-22			4
I/92	IVa	*G. morhua*	16-42		6-22			4
I/91, 94	IVa	*Sprattus sprattus*	8-16		4-18			4
I/91, 92, 94	IVa	*C. harengus*	8-24		6-24			4
VI/92	IVa	*Ammodytes* spp.	10-14		8-16			4
1991-97	5Y	*Merluccius bilinearis*	5-50	21.9±6.4		92±81		5
1991-97	5Y	*Sebastes* spp.	6-26.1	16.2±4.2		42±26		5
1991-97	5Y	*Urophycis* spp.	4.2-38	19.4±6.7		68±65		5
1991-97	5Y	*G. morhua*	6-61	25.3±10.6		233±358		5
1991-97	5Y	*P. virens*	6-31	20.7±6.6		126±93		5
1991-97	5Y	*C. harengus*	15.3-35	25.3±4.6		134±69		5
1991-97	5Y	*Macrozoares americanus*	17.3-40	24.9±6.3		143±70		5
1991-97	5Y	*Illex illecbrosus*	11-23.8	19.6±3.2		84±82		5

Halichoerus grypus

Month/ season/ year	ICES/ NAFO area	Prey spec.	Length range [cm]	Median/ mean length ±S.D. [cm]	Survey length range [cm]	Mean mass ± S.D. [g]	Caloric value [kj/g]	Source
VI/91-III/93	4W	*Sebastes* spp.	8-27		11-34			6
VI/91-III/93	4W	*G. morhua*	3-37		8-39			6
VI/91-III/93	4W	*Hippoglossoides platessoides*	8-44		16-42			6
VI/91-III/93	4W	*M. bilinearis*	23-39		16-37			6
VI/91-III/93	4W	*L. ferruginea*	11-42		18-44			6
VI/91-III/93	4W	*Ammodytes* spp.	5-30					6
1988-90	4W	*G. morhua*	12-68	33.7		403±273	4.8	7
1988-90	4W, 4X	*P. virens*	7-38	19.2-20.2		133-141±154	5.0	7
1988-90	4W, 4X	*M. bilinearis*	12-48				6.0	7
1988-90	4W, 4X	Squid	12-28	17.3-19.4		114-150±51	4.2	7
1988-90	4W, 4X	*C. harengus*	17-43				7.9-10.6	7
1988-90	4W, 4X	*Ammodytes* spp.	7-28				5.8	7
1988-90	4W, 4X	*G. morhua*	12-68	24.1			4.8	7
sum/93-95	Vb1	*G. morhua*	4.3-67.2	31.4±14.7				8
sum/93-95	Vb1	*Melanogrammus aeglefinus*	2.7-48.1	23.5±10.1				8
sum/93-95	Vb1	*P. virens*	1.2-47.5	18.9±11.9				8
sum/93-95	Vb1	*Ammodytes* spp.	5.2-25	11.5±2.2				8
sum/93-95	Vb1	Pleuronectidae	3.5-32.3	20.3±8.7				8
sum/93-95	Vb1	*Anarhichas lupus*	16.9-85	59.5±14.5				8
VI-XII/83	4T	*C. harengus*		25.4±5.6		215.9±15.6	10.9	9
VI-XII/83	4T	*G. morhua*		17.3±11.4		142.3±336.4	4.1	9
VI-XII/83	4T	*H. platessoides*		34.4±5.2		393.3±190.9	4.2	9
VI-XII/83	4T	*L. ferruginea*		37.5		450	4.5	9
VI-XII/83	4T	*Mallotus villosus*		16.3±0.4		18.9±2.9	7.5	9
VI-XII/83	4T	*M. aeglefinus*		23.5		134.5	5.3	9

References: 1) Berg, Haug & Nilssen 1999
2) Bowen & Harrison 1996
3) Neudecker and Damm, pers. comm.; Krause 1999
4) Tollit et al. 1997; Krause 1999
5) Williams 1998
6) Bowen & Harrison 1994
7) Bowen, Lawson & Beck 1993
8) Mikkelsen & Haug 1999
9) Murie & Lavigne 1992