Introduction

The ringed seal (*Phoca hispida*) is one of the smallest of all living seal species. Its name refers to the light-coloured rings on the dorsal surface of an otherwise dark-grey pelt. Ringed seals are usually associated with icy waters and, together with their principle predator, the polar bear (*Ursus maritimus*), they venture further into the heavy Arctic pack ice than any other mammal.

For the Inuit who have lived and travelled for centuries along the northern Canadian coast and along the coasts of East and West Greenland, the ringed seal or "natseq" is of profound importance. Without constant supplies of ringed seal products, Inuit cultures would have had far greater difficulties inhabiting the Arctic. Bowhead whales (*Balaena mysticetus*) occasionally provided immense amounts of meat and blubber that could last for months in the sparsely inhabited Inuit hunting dwellings. Ringed seals, however, can be hunted year-round, even during the dark months, and they have therefore always been the most reliable source of daily necessities for the lives of northern peoples. Ringed seals have provided a stable supply of meat and blubber for food, heating and lightning, as well as skins for essential commodities such as "kamiks", skin clothing, tent coverings, bladder floats ("avataqs") and other equipment essential for the survival and success of Inuit hunting communities. Even the means of transportation to hunting grounds has been facilitated through the use of ringed seal products. Skins from ringed seals and bearded seals (*Erignathus barbatus*) is used to cover the fragile frames of the kayaks, and was also formerly used to cover the larger "umiaks" that were used for transportation of whole families, while seal meat is still the essential "fuel" for the dogs that pull the sleds. It could be argued that ringed seals have been as important for Inuit as cod (*Gadus morhua*) has been for other coastal peoples in the north. These two species have made it possible for human populations to extend their range northwards.

The harvesting of seals and other marine mammals is an integral part of the livelihoods and cultures of Inuit communities. In Greenland, dog sleds are widely used for travelling to hunting and fishing grounds. Ringed seals are used extensively for clothing for people who hunt or fish on the sea ice. Throughout the Arctic ringed seal meat is considered a delicacy and is a fundamental component of the human diet in hunting communities. Sealskins are traded and exported to international markets. Blubber lamps, skin covered tents and umiaks are no longer used, but skin covered kayaks, seal skin trousers, avataqs, anoraks and kamiks are still important equipment for hunters and fishermen in Greenland. The continued dependence of northern peoples on ringed seals is also illustrated by the vulnerability of Inuit communities to fluctuations in international markets for fur products. For decades, if not centuries, sealskins have been a major export commodity for Inuit in Canada and Greenland. Politically motivated import barriers on seal products in the US and the EU in recent decades have, however, resulted in a serious decline in international trade, with considerable economic consequences for Inuit communities.

In 1995, the North Atlantic Marine Mammal Commission (NAMMCO) asked its Scientific Committee for advice on ringed seals. Specifically the Committee was asked for "...advice on stock identity for management purposes and to assess abundance in each stock area, long-term effects on stocks by present removals in each stock area, effects of recent environmental changes (i.e. disturbance, pollution) and changes in the food supply, and interactions with other marine living resources". A Working Group was established to address these issues, which met in Tórshavn, the Faroe Islands, from 5 to 8 February 1996. The response was clear; despite high levels of exploitation in both Canada and Greenland, present hunting patterns and removal rates were unlikely to adversely affect ringed seal stocks. This conclusion is substantiated by removal levels that have remained high for centuries, by the wide distribution of ringed seals which apparently leaves a large proportion of the stock untouched, and by the observation that a substantial proportion of the harvest consists of males and young seals. However, it was also clear that, at present, far too little is known about this numerous, widely

dispersed and important marine mammal. In particular, the ringed seals that inhabit the pack-ice areas of both Baffin Bay and the Greenland Sea are poorly known in almost all respects. Whalers that penetrated the pack ice in search of bowhead whales noticed the ubiquitous ice-loving seal. It has been suggested that a special form of dwarf ringed seal inhabits the pack ice, which is distinctively smaller than members of the species living in fast-ice habitats. Recent work confirms that offshore pack-ice areas host a large number of ringed seals and that they likely contribute to the coastal harvesting. However, the population identity, production rates, dynamics and genetic relation to fast-ice ringed seals are unknown. Fortunately, several studies of ringed seal exploitation, feeding habits, movements, biology and population dynamics have been conducted. Much of this information has been presented in governmental reports, outside the primary scientific literature. In order to make these studies more widely available, and to identify gaps in knowledge, it was decided that a compilation of papers reflecting the present knowledge of ringed seals in the North Atlantic would be useful, resulting in the present volume.

In addition to the NAMMCO Scientific Committee's focus on the North Atlantic range of the species, relic populations of ringed seals in the Baltic and in the landlocked Ladoga and Saimaa Lakes were part of the ringed seal range in the North Atlantic 8-9,000 years ago. It was therefore decided that overviews of the population status and surveys for these areas should also be included in this volume.

The papers in this volume cover a wide array of topics. They begin with an extensive world-wide review of present knowledge about ringed seals, which is both a thorough introduction to the species and to the papers that follow (Reeves). This is followed by regional reviews of ringed seal biology in Svalbard (Lydersen), western Russia (Belikov and Boltunov) and the Karelian lakes (Sipilä and Hyvärinen), which summarise present knowledge about ringed seals for the respective areas and present the best available assessments of the local status of the species. Each of these three papers summarises for the first time literature that has until now been available only in Norwegian, Russian and Finnish, respectively.

In the North Atlantic, ringed seals are harvested most intensively in Canada and Greenland. Detailed catch and trade statistics based on the best available material for these areas, as well as western Russia, are presented in this volume (Belikov and Boltunov, Reeves *et al.*, Teilmann and Kapel). Although the statistics on catches are incomplete for each of the three areas, it is still possible to assess roughly the level of removals and patterns of exploitation. Clearly, ringed seal harvesting is a mainstay for Inuit in Canada and Greenland, whereas exploitation of this species in western Russia is dwindling. The combined harvest in Greenland and eastern Canada is roughly 100,000 ringed seals per year. Major biases occur in the catch statistics because of under-reporting of landed seals and no accounting for seals that are killed but lost.

Estimates of ringed seal densities have mainly been available from surveys in Canada, but an estimate for the fjord system around Scoresby Sound in East Greenland is presented in this volume (Born *et al.*). The number of ringed seals is around 2 seals per km^2 in the fjord fast-ice. This value is at the high end of the range of estimates reported from Alaska and Canada. In comparison, densities of ringed seals in the Baltic are around 0.5 per km^2 in the Gulf of Bothnia and values are even lower in the Gulfs of Finland and Riga (Härkönen *et al.*). The total number of ringed seals in the Baltic was 5,510 ± 42% in 1996. The density of ringed seals in the Gulf of Bothnia has been increasing since 1988, and, now protected, they are apparently recovering from excessive hunting earlier in the century. No data, however, exist for evaluating trends in the Gulfs of Finland and Riga (Härkönen *et al.*).

Another potentially useful method for estimating the size of a ringed seal population is in relation to polar bear densities. A crude estimate of the ringed seal population can be attained based on the size of the polar bear population, in conjunction with data on their rate of consumption of ringed seals. For Baffin Bay, estimates of polar bear stocks exist and their consumption of ringed seals can be modelled from

their caloric needs for growth, maintenance and activity (Kingsley). The standing population of ringed seals needed to sustain predation pressure from 4,025 polar bears, and a hunting yield of 100,000 seals, is estimated from the model to be roughly 1.2 million seals. An independent ringed seal estimate can be obtained by extrapolating seal densities from surveys of different ice types to the area covered by these ice types in Baffin Bay, and by correcting the surveys for detection and availability biases. Despite the incompleteness of the surveys involved in Kingsley's study, the extrapolated size of the ringed seal population was within the range of the estimate that was calculated to be required to sustain bear predation and human harvest combined. The model illustrates the major deficiencies in knowledge about the seal stocks and the density of seals in the pack ice.

Even though ringed seals are widely dispersed and apparently capable of surviving under very severe ice conditions, they are still vulnerable to sudden changes in ice coverage. Kingsley and Byers demonstrate how a local sub-population of ringed seals can undergo a collapse, probably induced by unusual ice conditions, and subsequently recover. Following a reduction in body condition, pup production was observed to be below normal. Five years later, normal reproduction was resumed after a renewal of the population and a concomitant recovery in body condition. This study provides insight into the response of ringed seal populations to small-scale changes in ice conditions, which may be useful knowledge in the event of large-scale changes in ice conditions in the North Atlantic.

Ringed seals have often been referred to as a stationary species that exhibit no obvious migratory patterns. Kapel *et al.*, however, recorded considerable movements through tagging of ringed seals in Greenland with conventional tags, especially among young males. Several recaptures in this study occurred more than 500 km from the release site. Tag recoveries were from local harvests, and high frequencies of tag returns were noted in areas with high catches.

There is no apparent competition between ringed seals and fisheries, with the possible exception of the populations in the Finnish and Russian lakes (Sipilä and Hyvärinen). This is probably because they feed primarily on small items such as crustaceans and polar cod (*Boreogadus saida*) that are not commercially valuable. Siegstad *et al.* provide a detailed account of the composition of the ringed seal diet in Greenland, where a large number of species are consumed and where the local availability of different species can be tracked in the stomach contents of the seals. The high Arctic Gadidae (i.e. polar cod and Arctic cod (*Arctogadus glacialis*)) constituted the bulk of the diet in northern areas and in East Greenland, but amphipods (i.e. *Parathemisto* sp.), euphausids and snailfish (*Liparis* spp.) did also occur in substantial amounts in the diet, especially during winter months. Species more common in the Atlantic, such as capelin (*Mallotus villosus*), redfish (*Sebastes* sp.) and squid (*Gonatus* sp.) were major prey from mid- to south-west Greenland.

Marine mammals are known to accumulate various trace elements and, despite their remote occurrence, ringed seals are no exception. Heavy metals such as mercury and cadmium are accumulated to levels that exceed what is recommended as maximum limits for human consumption. However, no pathological effects have been described for ringed seals or their consumers. Dietz *et al.* document the geographical and tissue variation of heavy metals and selenium in ringed seals from Greenland and Svalbard. Cadmium levels were high compared to seals from more temperate waters. This, and the increasing concentrations of cadmium in northern municipalities of West Greenland, seems to be related to high cadmium contents in the prey of ringed seals. A similar relationship could not, however, be demonstrated for mercury. Ringed seals in West Greenland had lower mercury concentrations than those reported for seals from temperate waters.

It is hoped that this first monograph on ringed seals will serve as a reference point from which more detailed studies of ringed seal biology and exploitation will emanate. Much more can be learned about the occurrence and dynamics of ringed seals in the vast pack-ice areas of the Greenland Sea, Baffin Bay and the Polar Basin.

In addition, further examination of the dependence of ringed seals on ice coverage and their susceptibility to variations in marine production would also enhance our understanding of the dynamics of sub-ice biota.

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