Introduction

The beluga, or white whale, (*Delphinapterus leucas*), a medium-sized toothed whale with a circumpolar distribution, is of great importance to many Arctic communities (Fig. 1). Just 150 years ago, Brown (1868) noted that the beluga '…is, beyond all comparison, so far as its importance to the Greenlanders and the Eskimo is concerned, *the* Whale of Greenland.' Belugas have been hunted for centuries by Inuit families travelling the Arctic coastline, they were also subject to commercial hunting of variable intensity in Canada, Greenland, Svalbard and Russia, and they are still a very important species for Arctic subsistence hunters in Greenland, Canada and Alaska.

The historic and present importance of belugas is also reflected in the volume of scientific reports on the species – few other whales have been studied at such intensity and with such a variety of methods. This monograph joins a long tradition of monographs on belugas: Vladykov (1944, 1946) gave a detailed account of the belugas in the Saint Lawrence River in Quebec, Canada. Kleinenberg *et al*. (1964) thoroughly described belugas in the Russian Arctic. Smith *et al*. (1990) compiled the first monograph on belugas based on a series of papers dealing with belugas in Canada and Alaska in the Bulletin Series of the Journal of Fisheries and Aquatic Sciences in Canada. Born *et al*. (1994) compiled papers about belugas and narwhals (*Monodon monoceros*) in the North Atlantic in a special issue of Bioscience, Meddelelser om Grønland. In 2001 a special issue of Arctic, The Journal of the Arctic Institute of North America, dealt specifically with the latest results from satellite tracking of belugas and narwhals. In addition, descriptions of local stocks of belugas are available from the Saint Lawrence River (Prescott and Gauquelin 1990) and Cook Inlet, Alaska (Marine Fisheries Review 2000 vol 62, printed in May 2002)

The background for the compilation of the present monograph is the ongoing assessment of belugas in the North Atlantic, started by the North Atlantic Marine Mammal Commission in 1999 (NAMMCO 2000, 2001, 2002). Most of the information presented in this volume has been presented at scientific working group meetings within NAMMCO and the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga. The information from these meetings is both of general interest to scientists dealing with Arctic wildlife and of value for future scientific assessments of beluga stocks. As a consequence it

Fig. 1
Beluga meat, skin and blubber are important foods for people in Greenland and - Arctic Canada. (Photo: M.P. Heide-Jørgensen)

was decided that the information should be compiled as a volume in the series of Scientific Publications from NAMMCO.

Information on the two other Arctic cetaceans, the narwhal and the bowhead whale (*Balaena mysticetus*), often are by-products of studies specifically targeting belugas. This is especially true for aerial surveys of vast Arctic waters. Distribution and abundance information on Arctic whale species is generally scarce and the completion of Arctic sighting surveys is expensive and difficult. Therefore, information on narwhals and bowheads obtained from beluga surveys is included in this monograph.

Belugas are animals with predictable habits. They have strong site fidelity and return to the same areas around the same dates each year, despite being the subject of subsistence hunting at these localities. This was first noted by Degerbøl and Nielsen (1930) and has recently been substantiated through genetic studies (*e.g.* O'Corry-Growe 1997) and satellite tracking (*e.g.* Richard *et al.* 2001).

Beluga hunting in Canada and Greenland provides an important opportunity for collecting samples for studies of the biology of the species, including studies of the genetic identity of the exploited stocks. In this monograph, the genetic structure of belugas from different localities in Canada and Greenland has been examined by mtDNA and microsatellite analyses (de March *et al.* 2002). Based on genetic evidence, there appears to be more beluga stocks than previously identified based on simple evaluation of their distribution. It is particularly intriguing that belugas from Lancaster Sound seem genetically distinct from those in West Greenland, and that those from three localities along southeast Baffin Island, separated by only a few hundred kilometers, are also different. The authors stress, however, that the results obtained from genetic analyses are not always clear-cut. To make appropriate decision about stock management it is important to use patterns that persist over time.

The usefulness of genetic studies for stock discrimination is further questioned by Palsbøll *et al.* (2002) who find that samples from the same locality and season deviate between years. Thus, they question whether the samples are representative of actual stocks or if they represent different pods comprising family units. In their opinion it is, therefore, important to estimate the contribution of pod structure to overall heterogeneity before defining populations or management units.

Another novel approach to elucidate the stock structure of belugas is that of Innes *et al.* (2002a) who use the composition of organochlorine compounds in tissues to discriminate between stocks. In many respects this study confirms the results from de March *et al.* (2002). It shows both that several smaller stocks persist along southeast Baffin Island and in Eastern Hudson Bay, and that most belugas that have been sampled from the Canadian High Arctic are not the same as those sampled in West Greenland. Even within West Greenland some differences between belugas could be detected and the authors urge that the traditional definition of beluga stock structure, based on their use of estuaries in the summer, needs to be redefined in light of the new information.

There is a wealth of historical studies of belugas from Russia (*e.g.* Kleinenberg *et al.* 1964), concentrating mostly on populations in the Far Eastern Seas. Few studies have covered the western part of the Russian Arctic and knowledge on the distribution and local movements of belugas is generally lacking from these areas. The Russian aerial reconnaissance of sea ice (ARSI), conducted during 1958-1995, is a relatively consistent source for information on the distribution of cetaceans in the Russian Arctic. Belikov and Boltunov (2002) present a detailed report on the ARSI data series with emphasis on the effects of ice conditions on the distribution of the whales. Of the Arctic cetaceans in Russia, belugas are by far the most abundant, narwhals are rare, and bowhead whales and gray whales (*Eschrichtius robustus*) are primarily seen in the seas of east Siberia. In summer the belugas are mainly concentrated in the area of Frantz Josef Land, in the Kara Sea, the western Laptev Sea and the White Sea. Different summer aggregations in coastal areas have been identified based on observations. There are no reliable survey estimates of the stocks of belugas in these areas and the discreteness of the different summer aggregations is unknown.

The occurrence of belugas in the Canadian High Arctic has been studied for decades, however basic documentation of the phenology of the migrations, estuarine occupations, timing of births, and food habits was provided through a number of unpublished studies funded through the exploration for hydrocarbon resources. Based on observations from aerial surveys, Koski *et al*. (2002) showed that belugas follow the receding ice when entering Lancaster Sound in spring and occupy estuaries from mid-July through mid-August. After spending up to 3 weeks in estuaries, the whales move further west into Peel Sound and occupy deep offshore areas and estuaries. They may be feeding during the latter part of the summer when they are often seen in the vicinity of aggregations of polar cod (*Boreogadus saida*), an important food item in the Canadian High Arctic. The main exodus of belugas through Lancaster Sound in autumn takes place along the southern coast of Devon Island in less than one week in mid September. Judging from observations of neonates, calving seems to occur in July and early August and the proportions of neonates to the other age classes are consistent with a three year reproductive cycle. An uncorrected estimate of 10,250-12,500 belugas summering in the Canadian High Arctic is provided by the surveys in the late 1970's (Koski *et al*. 2002).

Reliable catch data extending as far back in time as possible is fundamental to most assessments of sustainable harvest levels of belugas. Preferably the catch data should include corrections for underreporting and killed-but-lost whales. This is notoriously difficult for any marine mammal species exploited by Inuit societies in Greenland and Canada. Catches in Greenland have been sporadically documented by various reporting schemes back to at least 1862. The reporting schemes include collections made by local authorities and compiled by the Ministry of Greenland or the Greenland Home Rule, but also by a number of scientists observing actual catches. Catch levels can even be inferred from the reported trade in the valuable beluga mattak (=skin) under assumptions of mattak yields per whale. Heide-Jørgensen and Rosing Asvid (2002) provide an attempt to reconstruct the history of beluga exploitation from 1862, with corrections for underreporting and killed-but-lost-whales for different areas and hunting situations. They conclude that if whales killed in ice entrapments are excluded from the catches, a correction factor of 1.28 must be used to estimate the number of whales killed from number of whales actually landed.

The frequent entrapments of belugas in pack ice are an intriguing phenomenon. Heide-Jørgensen *et al*. (2002a) document 3 recent occurrences of entrapments in Lancaster Sound and Jones Sound. In both cases involving belugas, the entrapped whales were heavily predated on by polar bears (*Ursus maritimus*). Another entrapment incident involved narwhals in Disko Bay, West Greenland, where the entrapped whales were utilised by local hunters. It is evident that the entrapped whales in many cases will succumb even when not discovered by hunters.

In the western Russian Arctic belugas have never had the same importance for humans as in Greenland and Canada. This is partly because belugas were and still are less abundant in this area and because the maritime hunting culture was less developed in this part of Russia. The history of beluga exploitation in Russia is reviewed by Boltunov and Belikov (2002) and although the exploitation goes back several centuries, few data on catches are available. During the period between 1954 and 1966, there was a substantial harvest with annual takes averaging 1,500 individuals with a maximum of 3,222 animals in 1960. Since the early 1990s, catches have been dwindling and present harvest levels in the Western Russian Arctic are insignificant. Despite these large catches, limited information on the biology of Russian belugas has been documented. The few studies seem to confirm results from the Western Atlantic.

Two aerial surveys of belugas in the Baffin Bay region are available from the latter part of the 1990s, one from the summering grounds in the Canadian High Arctic and one from the West Greenland wintering ground. Both use line transect methods and both correct for whales that are missed by the observers and are diving during the survey. These two surveys use different methods for correcting the observers; one uses a video camera to 'capture' whales on the trackline and the other uses double observers to estimate sight-resight probabilities.

Innes *et al*. (2002) conducted a survey of belugas and narwhals in the Canadian High Arctic using both sampling methods and total counts of animals in concentration areas. A correction for whales missed by the observers was developed analytically from a double observer experiment and a correction for whales that were diving below visibility during the survey was obtained from whales instrumented with satellite-linked dive recorders that recorded the proportion of time the whales spent near the surface. Photographic counts provided additional estimates of belugas in high density areas. The estimated number of belugas summering in the Canadian High Arctic in 1996 obtained from this survey was 21,213 (95% CI=10,985 to 32,619). For the same area a total and fully corrected number of 45,358 narwhals (95% CI = 23,397 to 87,932) was derived. Whereas this survey covered the entire summering stock of belugas, coverage was not complete for narwhals as narwhals have a much wider summer distribution in the Canadian High Arctic than belugas.

Based on a series of aerial surveys, it is believed that the West Greenland wintering stock of belugas underwent a severe decline from the early 1980s through the end of the century (Heide-Jørgensen and Reeves 1996). This is now confirmed by the recent surveys that include correction factors for diving whales and those missed by the observers (Heide-Jørgensen and Acquarone 2002). The stock size in 1998-1999 wintering off West Greenland was estimated as 7,941 (95% CI: 3,650 to 17,278) belugas. The size of the narwhal and bowhead stocks in the same areas was estimated to 2,861 (95% CI: 954 to 8,578) and 246 (95% CI: 62 to 978), respectively.

The HITTER-FITTER software package based on the Pella-Tomlinson population model (Pella and Tomlinson 1969) is widely used for population assessments of baleen whales by the International Whaling Commission, but has never before been used for belugas. Butterworth *et al*. (2002) used the catch history, population size figures and information on the biology of belugas to apply the HITTER-FITTER package to assess the population status of belugas in West Greenland. The rate of maximum sustainable yield is examined within a range from 1 to 4% which is in agreement with known values of reproduction and mortality of belugas. The present harvest level is evidently exceeding the sustainable level and a severe reduction in catches is needed to halt or reverse the decline. Innes and Stewart (2002) fit a similar population model using Bayesian techniques and using both the Canadian High Arctic (Innes *et al*. 2002b) and West Greenland population estimates (Heide-Jørgensen and Acquarone 2002) and catch statistics for both Canada and Greenland. By simultaneously solving for the population trajectory for both the shared Canada-Greenland stock that winters in West Greenland and the North Water stock, Innes and Stewart (2002) estimated that present sustainable harvest levels is 60 and 334 belugas per year for the West Greenland wintering stock and the North Water stock, respectively.

An isolated beluga population in the Saint Lawrence River experienced a severe decline due to a period of intense exploitation lasting until the late 1970s. The population has apparently recovered to some degree, however, it is suspected that the recovery is impeded by diseases caused by high levels of contaminants. Kingsley (2002) provides information on the current status and causes of mortalities of the belugas in this population. The numbers counted during surveys have increased since 1988 by about 3% per year and the observed mortality during this time has consisted mainly of old diseased whales. A model of the population structure indicates slightly elevated levels of mortality among older whales.

An important piece of information for the assessment of the St. Lawrence belugas, and any other beluga population, is the correction factor that corrects the photographic surveys for whales that were submerged when the photographs of the water surface were taken. Kingsley and Gauthier (2002) estimated this by combining the subsurface visibility of belugas and beluga models, and found that belugas were visible for 44.3% of the time.

A very important contribution to our knowledge of belugas is that collected and recorded over generations by Inuit hunters and other local people with frequent contact with the whales. Although no papers are included here that directly address this type of information, Inuit knowledge has contributed to the success of many of the studies presented in this volume and the local knowledge has positively influenced the scientific achievements. Some of the 'scientific knowledge' on belugas has however been questioned by experienced Inuit hunters in both Canada and Greenland and bridging this 'gap' in perception seems important for successful management. Hopefully, the present compilation of 'scientific knowledge' can provide a platform for the development of mutual understanding of the problems related to a sustained utilisation of beluga resources.

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