Fisken og havet, special edition 2–2010

Marine Mammals

INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

Fisken og havet, special edition 2-2010

Marine Mammals

Editors:
Arne Bjørge
Christian Lydersen
Mette Skern-Mauritzen
Øystein Wiig

Photo editors:
Kjell-Arne Fagerheim
Arne Bjørge

www.imr.no

INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

The photographs on the front page were taken by
Arne Bjørge and George McCallum

Photographs on first page of each chapter
Chapter 1: Kjartan Mæstad
Chapter 2: George McCallum
Chapter 3: Kjell-Arne Fagerheim
Chapter 4: George McCallum
Chapter 5: Aerial photographs: FotoNord
Chapter 6: Kjell-Arne Fagerheim
Chapter 7: Kjartan Mæstad
Chapter 8: George McCallum

The drawings of whales were done by Arne Bjørge

Siri Hartvedt and Nils Øien have created the maps in Chapter 5.4

ISSN 0802 0620

Editing completed in May 2011

Graphic design: Harald E. Tørresen, The Institute of Marine Research

Graphic production: John Ringstad, Ringstad Design

Printing: A2G Grafisk





Contents

Introduction

Marine Mammals deals with a subject in which there is both a great deal of interest and a great need for factual information. Some marine mammals are important renewable resources that can be harvested in a sustainable manner, others are important components of the ecosystems. There are also species that are extremely few in number and very threatened.

Marine mammals are charismatic animals and, in the international arena, they are important symbols of the fight for the environment and conservation. Marine mammals get people involved and we often see strong opinions in the news media, both for and against hunting and conservation. The Institute of Marine Research hopes that this report will contribute towards putting this debate within the framework of factual knowledge.

The report will show trends and provide the retrospective glances that are necessary in order to understand today's situation. The current management of marine mammals, both internationally and in Norway, will be presented in the form of brief outlines. In addition, the report contains seven articles about research topics of current interest. In Chapter 7, the new Marine Mammal Advisory Board, which will assist the Institute of Marine Research in providing advice to the authorities on research and the management of marine mammals in Norway, is introduced. Finally, a complete table of all the species of marine mammal in the world is provided, with scientific, English, and, where there is one, Norwegian names.

We believe that *Marine Mammals* will be useful not only in education but also for decision-makers in resource and environmental management. Hopefully, the report will also make interesting and enlightening reading for the community-oriented public.

The Institute of Marine Research is not alone in carrying out research on marine mammals. For this reason, we have invited experts from other specialist environments to contribute material and take part in the editing. All the articles in this special edition have been quality assured by being read and commented on by at least one peer. The editorial staff would like to thank Nils Øien and Tore Haug for assisting with this work.

The editorial staff for Marine Mammals has consisted of Arne Bjørge, Kjell-Arne Fagerheim, Christian Lydersen (the Norwegian Polar Institute), Mette Skern-Mauritzen and Øystein Wiig (University of Oslo). Bjørge, Lydersen, Skern-Mauritzen and Wiig have edited and quality assured the factual content. Fagerheim and Bjørge have picked and edited the photographic material. The proofreading has been done by Marie Hauge and Ingunn E. Bakketeig. John Ringstad and Hege I. Svensen has carried out the graphical production.

The report is also available on the Institute of Marine Research's webside *www.imr.no*.

Happy reading!

Tore Nepstad
Managing Director

This report should be cited as:
Bjørge, A., Fagerheim, K.-A., Lydersen, C., Skern-Mauritzen, M. & Wiig, Ø. (eds) 2010.
Sjøens pattedyr 2010 [Marine Mammals]. Fisken og havet, special edition 2-2010.

Chapter 1

What are marine mammals?

Somewhere between 35 and 60 million years ago, animals living on dry land left in favour of the sea. Since then marine mammals have adapted their bodies and bodily functions, to different degrees and in different ways, to a life in the wet element.

Arne Bjørge
arne.bjorge@imr.no

Marine mammals live in and obtain their food from the sea. But, just like other mammals, marine mammals are warm-blooded; they have lungs and they breathe air. The give birth to living young that are dependent on milk from their mother until they are sufficiently well developed to catch their own food. The structure of a marine mammal is generally the same as that of land mammals; the internal organs and main elements of the skeleton are the same.

A life in the sea has, however, led to a number of special adaptations. On land, mammals need a skeleton and four (or two) legs to keep themselves erect and move about. Submerged in water, the body gets support and buoyancy. The skeleton is primarily a foundation for the muscles that animals use to move around. Moving through water causes significantly more friction than through air and a streamlined shape thereby becomes much more important. Land animals have few restrictions on how often they can draw their breath. Marine mammals that mainly live under the surface of the sea need to return to the surface to breathe. The ability to absorb and store oxygen is, therefore, critical for how long at a time they can be submerged. Marine mammals live in water that is usually at a much lower temperature than the animals' body temperature. The ability to limit heat loss from the body to the water is, therefore, also important. Land mammals often use their sense of vision to find food. At great depths, there is little light and marine mammals need alternative ways of finding food.

1.1 WHICH GROUPS AND SPECIES ARE CONSIDERED MARINE MAMMALS?

Photo: A. Bjørge

There are considered to be three main groups of marine mammals: whales, seals and sea cows. Whales and sea cows are placed in their own orders: Cetacea and Sirenia[1]. The seals are called Pinnipedia. This is a sub group of the carnivore order (Carnivora), which also includes all land carnivores. In addition to whales, seals and sea cows, individual species that belong to the land mammals in terms of genus are also considered marine mammals in some contexts. This includes, for example, the Californian sea otter (Figure 1.1.1) and the polar bear. In the rest of the report, the emphasis will be on whale and seal species that are important for Norwegian waters.

Figure 1.1.1
Californian sea otter.

[1]Chapter 8 and species, groups and mutual relationships discussed in the following sections follow the classification described by D.W. Rice in 1998 (Marine Mammals of the World – Systematics and Distribution. Special publication no. 4. The Society for Marine Mammalogy) and English names for whales are in accordance with the list of names used by the IWC's Scientific Committee.

1.2 ADAPTATION TO A LIFE IN WATER

Whales have come furthest in their adaptation to a life in water, followed by sea cows and seals. Whales and sea cows spend their entire lives in water and also give birth to their young there. They have become specialised in swimming and have totally lost the ability to move around on land. Seals, on the other hand, give birth to their young on land or drift ice. This means that they still need to be able to move around on land.

In whales and sea cows, the rear limbs are totally rudimentary. Their front limbs have been converted into fins. They have developed a tail fluke in the same way as fish, but, unlike fish, which swim by moving their tail fin from side to side, whales and sea cows swim by moving the tail fluke up and down (Figure 1.2.1). The tail fins of whales and sea cows are shaped differently from species to species, but the general structure is similar. The spine ends in a fluke that has horizontal fins made of cartilaginous tissue on each side. The tail flukes of whales and sea cows do not, therefore, have an internal skeleton of bone.

There are two main ways in which seals swim. True seals (see Section 3.3) use their rear flippers as a "tail fluke", which they swing from side to side. Their front flippers are kept by their side but can be used to change the direction they are swimming in quickly. Sea lions and fur seals "fly" through the water using their front flippers as "wings". The rear flippers are used only as a tool for steering.

Seals also need to be able to move about on land. True seals hobble along, sometimes using their bellies and sometimes pulling themselves along using their front flippers. Their rear flippers always face backwards and are only used for swimming. Fur seals, sea lions and walruses still have a flexible hip joint and can swing their rear flippers under their body and walk on all four limbs (Figure 1.2.2).

Many marine mammals live in maritime zones where the water temperature drops down to close to freezing point (which is -1.8° C in sea water). Anyone who has fallen into cold water will have experience of how quickly you begin to suffer from hypothermia. This is a challenge that marine mammals have solved in an ingenious fashion. Under their skin, they have a thick layer of blubber that provides good insulation in addition to acting as an energy store and contributing to the animals' streamlined form. The fatty tissue in the blubber requires little oxygen so the blood circulation can be kept low and heat transport is reduced. The blubber is a good insulator between the skin and outer area of the blubber, which can maintain roughly the same temperature as the sea water. The inner part of the blubber and the muscles inside are the same temperature as the central parts of the body, that is to say about 37° C. The blubber also consists of a lot of unsaturated fatty acids that keep the blubber flexible even at low temperatures.

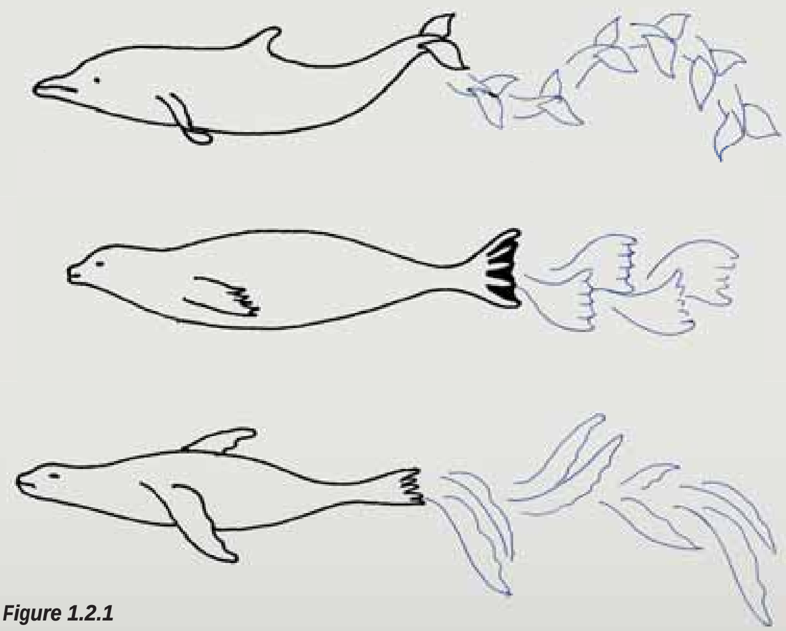


Figure 1.2.1
Whales and sea cows have developed a tail fluke that they move up and down to propel themselves forwards. True seals use their rear flippers to propel themselves forward in water by swinging them from side to side. Sea lions and fur seals use their front flippers to "fly" through the water.

Figure 1.2.2
In true seals, the rear flippers also face backwards when they are on land. Sea lions, fur seals and walruses can swing their rear flippers under their body and use them as rear legs when they need to move about on land.

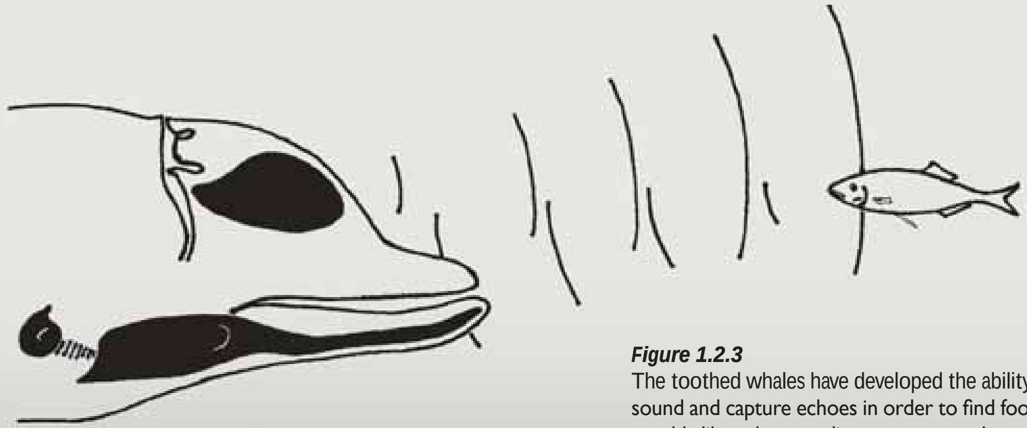


Figure 1.2.3
The toothed whales have developed the ability to produce sound and capture echoes in order to find food and navigate, roughly like echo sounding or sonars on board fishing vessels.

Flippers and tail flukes are not insulated with a thick layer of blubber. But marine mammals have solved this problem by developing an effective heat pump following the same principles as heat pumps in modern houses. The heat pump is constructed in such a way that warm arterial blood flowing out to the flippers is cooled by the cold venous blood flowing in from the flippers and the skin. In this way, heat from the blood flowing out is used to reheat up cold venous blood that is on its way back into the body. This is possible because arteries and veins lie against each other in such a way that heat is conducted from one blood vessel to the next.

The ability to undertake long dives varies from species to species. Porpoises, dolphins and some smaller seals like to come up to the surface to breathe every a few minutes. Baleen whales appear to prefer dive times of less than 20–30 minutes. Elephant seals, sperm whales and some beaked whales can remain submerged for more than an hour: perhaps as long as 90 minutes. Marine mammals have a greater volume of blood in relation to their body size than land mammals and the blood of marine mammals has a high concentration of haemoglobin. Haemoglobin is found in the red blood cells. This substance can bind oxygen and direct it from the lungs and round the body to where it is to be used. In addition, marine mammals have a similar substance in their muscles, called myoglobin. This myoglobin means that their muscles can also store large quantities of oxygen. It is this myoglobin that causes the meat of marine mammals to look very dark, compared with meat from land mammals.

Whales and seals have the ability to control their blood flow while diving in such a way that their brain and other vital organs are continually provided with a supply of fresh blood containing oxygen. Over the course of a dive, the muscles must basically get by with the oxygen they have bound to their own myoglobin. During extremely long dives, the muscles work anaerobically (i.e. without oxygen) and build up lactic acid. Once the animals reach the surface again, the muscles must get rid of the lactic acid and absorb new oxygen before the next long dive.

Whales and seals generally have well-developed vision, both above and under water but, compared with land mammals, their eyes have become specialised for better vision under water. Vision is based on light being refracted into a focused image on the retina of the eye. In land mammals, most light refraction takes place between the air and the cornea; the lens simply adjusts the focus. In water, there is little light refraction over the cornea and almost all refraction must take place in the lens. For this reason, land mammals have a rather flat eye lens, while whales and seals have a spherical lens.

Whales and seals searching for food at great depths where little light penetrates also have other adaptations. Toothed whales use "echo sounding" both for finding food and navigating. They can direct air across some structures in their windpipe straight under their blowhole and create clicking and whistling sounds. Many toothed whales have a wax-filled organ (melon) in front of their blowhole that acts as a physical lens for focusing the sound ahead. In this way, the animals can direct the sound in the direction they wish to swim in or towards somewhere they assume there is food. Echoes from fish, squid or other animals are received and interpreted in the brain in the same way as we receive light-induced pulses through the eye and form a picture of what we see (Figure 1.2.3).

The ears of land mammals are specially adapted to capture sound signals in the air. The sound signals, vibrations in the air, are captured by the eardrum and transferred to the liquid-filled cochlea by means of three small bones in the middle ear: the hammer, the anvil and the stirrup. In the cochlea, there are a large number of sensitive cells that convert the vibrations into nerve impulses that are sent to the brain to be interpreted. This ear construction is not very suitable for transferring sound signals in water. In whales in particular, the ear has been greatly adapted. The outer ear is vestigial and has lost its functionality. The toothed whales capture sound from water using their lower mandibles. Fatty structures in the mandible conduct the sound signals to the middle ear, which transfers them to the cochlea, which has the same function as in land mammals.

The inner parts of the ears of baleen whales appear to act in the same way as in toothed whales, but it is unclear how baleen whales capture sound waves from the water. They actually lack the fat channels for conducting sound waves from the mandible to the middle ear that the toothed whales have. For this reason, it is likely that bones in the middle ear, combined with air-filled structures around, them have the function of capturing sound waves directly from the water.

Seals live an amphibian existence and need to be able to hear both in and out of water. Out of water, sound signals are captured by the eardrum and transferred via the middle ear to the cochlea, as with land mammals. It is assumed that, in water, seals capture the sound waves directly by means of the bones in the middle ear.

Many seal are nocturnal and some dive deep where there is a minimum of light. It is still uncertain whether seals have a form of echolocation equivalent to that in the toothed whales, but it is definitely the case that several species of seal produce sound under water. In addition, their whiskers are well developed for capturing vibrations in water. The whiskers are rooted in a "bag" with a large number of sensitive nerve cells that register bending of the whiskers. The walrus and bearded seal have particularly well-developed whiskers. It has been demonstrated in experiments that the harbour seal can register the movement of fish even if they are blindfolded.

Chapter 2

The evolution of whales and their relationship to each other

All living whales are descended from the ungulate mammals. There were a great number of species of primordial whales, but 30 to 35 million years ago, the development of the modern whales that constitute today's two main groups – baleen whales and toothed whales – began.

Arne Bjørge
arne.bjorge@imr.no

All living whales have the same family tree and have evolved from ungulate land mammals. This happened roughly 60 million years ago when the great supercontinent, Pangea, had split and formed the inland sea, Tethys Ocean. This happened roughly where the Mediterranean is situated today and further east, between Asia and the Indian subcontinent. The climate was warm with lots of precipitation and this created great wetlands where the rivers flowed out into the sea. On land, mammals had evolved rapidly. They had become specialised into ruminants, insectivores and carnivores once they were free of the burden of the dinosaurs, which had become extinct about 65 million years ago. Without knowing for sure what driving forces led to the evolution of whales, it is easy to imagine that there was competition on land for food and a risk of being eaten by carnivorous mammals. The ruminant ungulates that later became whales found more food and had fewer enemies as they continually found their way further out into the wetlands.

The fossils of the oldest species of whale are about 50 million years old. The fossils were discovered near the shore zone of the old Tethys Ocean and show some of the cranium characteristics typical of whales, such as the typical ear bones. The first primordial whales (Archaeoceti) became abundant and evolved into several species. But the diversity of species nevertheless decreased 35–40 million years ago. During this period, the Neoceti group, which is the predecessor of modern whales (Cetacea), came into existence. As early as 33–35 million years ago, we find signs of two evolutionary paths that end up with the baleen whales and toothed whales, the two main groups of whales we have to this day. Both groups are descended from ungulates and have a multi-chambered stomach in common with today's ungulates on land.

The evolutionary line in the the skeleton from land mammals to whales show that the forelimbs become pectoral fins, while they still retain the skeletal structure with five "fingers". All species have developed a tail fluke and some species have also developed a dorsal fin. These fins do not, however, have a skeleton of bone. The rear limbs are rudimentary and have disappeared completely, mobility in the vertebrae of the neck is reduced and the nose opening (blowhole) has moved backwards to the top of the cranium. From the external changes, we can clearly see the evolution of an extremely streamlined form and the disappearance of hair growth.

2.1 BALEEN WHALES

The baleen whales are generally large animals. The blue whale, with its length of 30 metres and weighing more than 170 tonnes, is the biggest species to have ever lived on our planet. The smallest baleen whale is the pigmy right whale, which has a maximum length of 6.5 metres. The baleen whales form their own suborder (Mysticeti), with a total of 14 species divided into four families. What all baleen whales have in common is that they have no teeth, unlike toothed whales. Instead they have baleen, banks of corneous plates hanging down from the gum in the upper mandible. On the inside of these corneous plates, there are brushes, much like a piassava broom. These brushes act as a filter, straining the food from the seawater. The design of the upper mandible and the baleen and the way in which the whales use the baleen differs from family to family. All baleen whales have a blowhole split into two parts, which is parallel to the nostrils of land mammals. All species are listed in Chapter 8; here, we will only discuss the main groups.

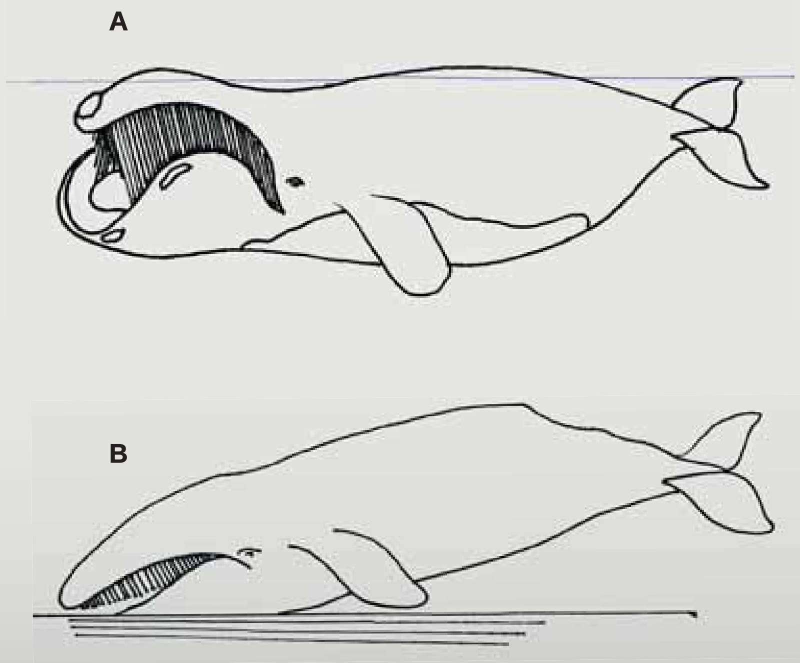


Figure 2.1.1
Three different ways in which the three main groups of baleen whale catch food.

A: Right whales swim with their mouths open and water flows into their mouth from the front and out through the baleen at the side while zooplankton and other food is filtered out.

B: Grey whales put their snout down at an angle into the mud at the bottom to separate the food from the mud by means of their baleen.

C: The fin whale group expand their oral cavities by means of their flexible ventral grooves. In this way, they can take in large quantities of water, which they filter over their baleen when their ventral grooves contract.

2.1.1 RIGHT WHALE AND PYGMY RIGHT WHALE – THE BALAENIDAE AND NEOBALAENIDAE FAMILIES

The right whale group consists of only four species, including the bowhead whale and the North Atlantic right whale. All of them have a chunky body shape, they lack dorsal fins and their pectoral fins are short and wide. Their head is a third or more of their total length. The upper mandible has a strong curve, with baleen up to four metres long. The extremely long baleen mean that they can swim with their mouths open and let the water stream in from the front and out through the baleen at the side. The brushes on the inside of the long baleen filter out small organisms like copepods and limacina from the sea water. This method of catching food is referred to as "skimming" (Figure 2.1.1). The spout (visible water vapour from the blowhole) is V-shaped.

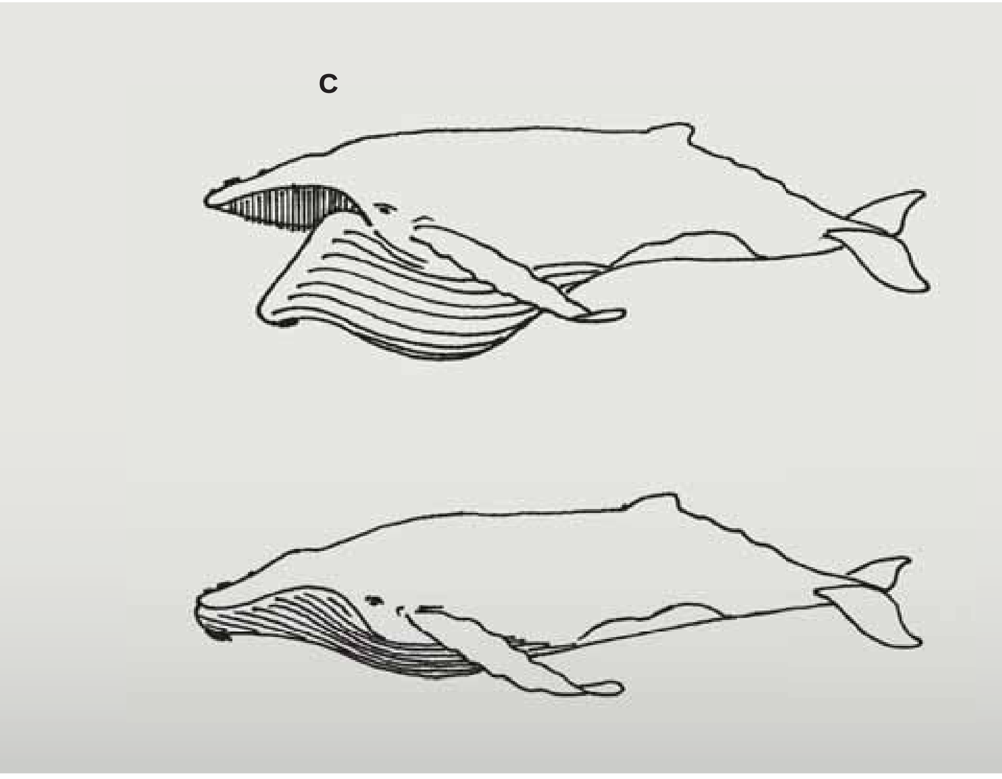
The name, right whale, comes from these being the right whales to catch. Right whales swim slowly, they have a very thick layer of blubber and they float after they are killed. So, it was possible to kill them using primitive tools. The Basques began hunting the North Atlantic right whale as early as in the 13th century and the Dutch also hunted the bowhead whale at Svalbard from the 17th century (see Chapter 6.1).

The pigmy right whale family, Neobalaenidae, only includes the pygmy right whale species, which reaches a maximum length of 6.5 metres. They share characteristics in common with all the three other families of baleen whale and their relationship to other groups has not been clarified. The species only exists in the southern hemisphere in temperate and subantarctic waters.

2.1.2 GREY WHALE – THE ESCHRICTIIDAE FAMILY

This family also includes just one species, the grey whale, which now only exists in the northern Pacific where there are two separate populations – a western one and an eastern one. Five hundred years ago, the grey whale was also widespread in the northern Atlantic but it was probably wiped out by whaling over the course of the 17th century.

In the Pacific, commercial hunting for grey whales increased in the 1840s, and over a period of barely a hundred years, the populations were hunted down to a minimum. After the Second World War, the eastern population became protected from commercial whaling, but some indigenous groups have been allowed to take a small number of animals for their own consumption. Hunting of the western population continued into the 1960s and did not stop until the population was practically wiped out. In 2007, the western population was estimated at only 121 individuals and is now considered one of the world's most threatened baleen whale populations. The small population is feeding in a small area outside Sakhalin in Russia. The area is rich in oil and gas, and petroleum-related activity is regarded as a threat to the population's continued existence. Their calving areas and migration routes are not known, but during the period 2005–2007, four grey whales drowned in fishing equipment off the coast of Japan. Since then, the Japanese authorities have tightened their regulations in order to reduce the risk of catching grey whales. If grey whales are caught up in fishing equipment, everything possible must be done to set the whales free alive.



The development of the population in the eastern Pacific is in stark contrast to the western population. Since becoming protected, the population has grown and, in 1998, it consisted of almost 30,000 grey whales. This is equivalent to the level before the increase in commercial whaling. The grey whales in the eastern Pacific migrate though the waters of four nations (Mexico, the USA, Canada and Russia) and the rebuilding of this population is one of the success stories in international conservation. Over the last few years, the population has declined a bit for unknown reasons. It is assumed that a scarcity of food could be one of the reasons. Indigenous groups in eastern Siberia, who have a small quota for their own consumption, are complaining that some whales are extremely emaciated while others may be very foul-smelling. It is in one area in particular that the whales are foul-smelling, but it is unclear whether this is due to disease, their food or a lack of food. Fish, seals and seabirds in the same area also have this unpleasant body odour.

Grey whales have a very special and complex way of catching food. Their diet includes everything from zooplankton filtered from the upper water layers to bottom animals living in the mud on the ocean bottom. A common way for grey whales to find food is by sticking their heads at an angle into the muddy bottom and filling their oral cavities with mud. Then they strain the small animals from the mud using their baleen (Figure 2.1.1). The most important feeding areas for the population in the eastern Pacific are shallow areas in the Bering Sea between Alaska and Siberia.

Grey whales undertake very long seasonal migrations. Each winter they migrate south from Arctic waters to shallow lagoons on the west coast of Mexico. Here, their calves are born, which, after a few weeks on strengthening milk from their mothers, set off on their first migration to the Arctic.

2.1.3 FIN WHALES – THE BALAENOPTERIDAE FAMILY

With its eight species, the fin whales are the biggest family of baleen whales. The family includes the biggest of them all, the blue whale, which is more than 30 metres in length, and the common minke whale, which does not grow to any more than about ten metres. The humpback whale also belongs to this family. In contrast to the right whales, the fin whales are fast swimmers. They have dorsal fins and their pectoral fins are longer and narrower. The head is considerably shorter than a third of their body length. Other characteristics are their ventral grooves, which look like furrows, from the lower mandible back to the front part of the abdomen. Their ventral grooves make it possible to expand the oral cavity to a very large volume. The fin whales swim into a shoal of prey and fill their oral cavity with water and prey and then the ventral grooves contract and the water is forced out over the baleen. The tongue is used like a piston to force out the last remnants of water so as to "smack" their prey free from their baleen. Fin whales that catch food in this way are called "gulpers" (Figure 2.1.1). Their spout is a high and relatively lofty column.

Fin whales sink once they are killed. That is to say, they were difficult to catch until the invention of the whale gun, which could fire a harpoon with a hook that stuck into the whale's body. The harpoon was attached to a line that meant that the whale could be winched in to the whaling boat after being killed. This development marked the beginning of modern whaling, which will be discussed in Chapter 6.

2.2 TOOTHED WHALES

The toothed whales are an abundant group with a whole 72 species divided into nine families. The most abundant is the dolphin family, Delphinidae, with 36 species and the beaked whale family, Ziphiidae, with 21 species. A complete table of all the species can be found in Chapter 8. Here, we will only discuss the largest groups and those that are important in Norwegian waters.

What all the toothed whales have in common is their asymmetrical cranium and having only one opening in their blowhole. This asymmetry is manifested by the right-hand side of the cranium always being bigger than the left-hand side. This asymmetry with only one blowhole in toothed whales, unlike the symmetrical cranium and the paired blowhole in baleen whales, suggests that this shifting of the blowhole from the front of the cranium back to the top of the cranium has taken place as two parallel and independent evolutionary processes.

Photo: G. McCallum

Figure 2.2.1
Sperm whale with a visible spout. Note that the spout is pointing at an angle to the left from the left-hand side of the head, the result of an asymmetrical cranium.
In the 19th century, sperm whales were subjected to extensive whaling, which began in the North Atlantic but that later spread to all the oceans (see Chapter 6).

2.2.1 SPERM WHALES – THE PHYSETERIDAE AND KOGIIDAE FAMILIES

Sperm whales are divided into two families, the Physeteridae family, which includes the great sperm whale and the Kogiidae family, which includes the pygmy sperm whale and the dwarf sperm whale. The sperm whale is the biggest of all toothed whales, but there is a great difference between the males, which grow to more than 16 metres (in extreme cases up to 20 metres) in length and the females, which only reach about 11 metres. The dwarf sperm whale only reaches 2.7 metres. The typical characteristic of this family is the large fore head above the mandible and the narrow lower mandible. The teeth in the upper mandible are vestigial and the lower mandible is, therefore, more of a trapping and gripping tool than a chewing tool.

The sperm whale is widespread in all the oceans of the world. While throngs of sexually mature females with calves spend their year in warm temperate waters between about 40° north and south of the equator, males may migrate to higher latitudes. The sperm whale is a typical deep-sea species and often lives in areas with a water depth of more than 1,000 metres. The sperm whale's spout is often very visible, particularly the first spout after a deep dive. The spout then points to the front and at an angle to the left of the animal's longitudinal direction.

2.2.2 BEAKED WHALES – THE ZIPHIIDAE FAMILY

The beaked whales are a species-rich family and include 21 medium-sized to large toothed whales from 4.5 to 13 metres in length. All these species have a clear beak and they also have a protruding lower mandible, that is to say, the lower mandible sticks out further than the upper mandible. The beaked whales are considered typical squid catchers. Many of the species dive very deep and their haunt is above very deep seas. Generally, there has not been a great deal of research done on them and not very much is known about their range, migrations and numbers.

Figure 2.2.2.1
The bizarre oversized teeth of the male strap-toothed whale prevents the mouth opening fully.

Over the last few years, researchers throughout the world have become aware of an unusually high number of mass strandings of beaked whales. These beachings have occurred in the aftermath of naval exercises in which military sonars using middle and low frequencies have been used. These mass strandings have occurred in, among other place, the Mediterranean, the Canary Islands, the Bahamas, Madagascar and North America. Researchers see a clear connection between the use of military sonars and these strandings but do not know which mechanisms are involved at the moment. Beaked whales hunt in very deep water and use echolocation to find their prey. For this reason, they have extremely sensitive hearing and it is likely that damage to the hearing organ could be a contributory factor. Signs of the "the bends", that is gas bubbles in the blood, have been found in whales beached after military exercises. It is speculated that the sonar signals may be causing "the bends": either through the sonar signals directly causing gas bubbles in the blood or affecting the animals' behaviour in such a way that gas bubbles arise.

One species, the northern bottlenose whale has been heavily hunted in the North Atlantic for more than a hundred years. It was not given protection until 1978, several years after it was wiped out "commercially", that is to say, there were so few of them left that commercial whaling was no longer possible.

One of the most peculiar whales belongs to this group, the strap-toothed whale, which only occurs in the southern hemisphere. The male gets a couple of odd teeth in its lower mandible, which grow and curl around the upper mandible so that the mouth cannot be fully opened. This does not seem to have any impact on the whales' ability to catch food but looks undeniably strange (Figure 2.2.2.1).

2.2.3 RIVER DOLPHINS – THE PLATANISTIDAE, PONTOPORIIDAE AND INIIDAE FAMILIES

River dolphins are not a homogenous group with a strong relationship to each other. They consist of four species, divided into three families. In addition to these four species, there are two species from the Delphinidae family that have purely freshwater populations (the Irrawaddy dolphin in Burma, Cambodia, Laos and Vietnam and the Tucuxi dolphin in the Amazon) and a species of porpoise that occurs in rivers (finless porpoises that live in rivers in Southeast Asia, including in the Yangtze River in China).

What all freshwater toothed whale populations have in common is that their range is very limited and often exposed to fragmentation and destruction of habitat due to watercourse regulations, flood prevention and pollution. One species, the baiji in the Yangtze River, probably became extinct around the turn of the last millennium due to habitat destruction. The baiji had become specially evolved to cope in murky water. Its eyes were small and sat high on its head and were probably only used to distinguish larger objects close to the surface. Well-developed echolocation ability and a long and sensitive "beak" were probably the most important tools for navigating and finding food. But about one third of China's population and, therefore, about 10 percent of the entire world's population live in the Yangtze Valley. Rapid industrialisation in China at the end of the 20th century, often at the expense of environmental protection, changed and made the Yangtze River worse to an extent and at a speed that meant that the species was not able to adapt. The baiji is, therefore, the first species of cetacean to be wiped out due to human activity. The baiji was not closely related to any other species and probably represented a separate evolutionary line entirely from when it migrated up into the Yangtze River from the sea 10–15 million years ago. One of the unique evolutionary features of the baiji was that it lacked a pre-stomach and the main stomach was divided into three chambers. This evolutionary line, which it took 10–15 million years to develop, is now gone.

2.2.4 HIGH-ARCTIC TOOTHED WHALES – THE MONODONTIDAE FAMILY

The Monodontidae family contains two very characteristic species, the narwhal and the white whale, which spend their entire lives in high Arctic waters. These whales are medium-sized toothed whales that reach just under five metres in length. Both these species lack dorsal fins, something that could be an adaptation to life under drift ice. What they also have in common is that their neck vertebrae are flexible so that they can swing in relation to the body's longitudinal direction. In the narwhal, the males have a tusk that is twisted like a spiral and that grows out from the left-hand side of the upper mandible and forwards through the upper lip. In rare cases, some males may get two tusks and females have also been observed with tusks. These grey-speckled animals reach up to five metres in length. In addition, the tusk can be three metres long. Narwhals are found along the edge of the drift ice from Arctic Canada and eastwards to Greenland, Svalbard and Franz Josef Land. They are not, therefore, regularly found in the northern Pacific and Bering Sea, although some individuals have been observed there.

The white whale, on the other hand, has a circumpolar range along the Arctic coasts. It reaches slightly less than five metres in length. The adults animals are milky white, while the calves are dark grey at birth. In the summer, they often make their way into shallow bays and up into estuaries. Sometimes large herds from the White Sea migrate west along the Kola Peninsula to Finnmark.

Photo: G. McCallum

Figure 2.2.4.1
Two white whales with their characteristic colour and body shape.

2.2.5 DOLPHINS – THE DELPHINIDAE FAMILY

With its 36 species, the dolphin family is the most species-rich group of marine mammals. It includes all the classic dolphins: the bottlenose dolphin we recognise from the Flipper films and other fast-swimming and jumping dolphins that appear in dolphinariums. The white-beaked dolphin and Atlantic white-sided dolphin are very abundant in Norwegian waters. The killer whale is the largest of the dolphins and reaches about ten metres in length.

Two species of pilot whale also belong to this group. One species, the long-finned pilot whale occurs in our waters and it is this species that is hunted in the Faroe Islands. Pilot whales travel in groups and can often occur in fjords or bays. It is this behaviour that is the basis for the pilot whale hunt in the Faroe Islands. Once a group is observed near the coast, the hunters make their way out in small boats, frighten the whales in towards land and steer them into bays where the whales finally run aground on shore. These pilot whale hunts in the Faroe Islands are based on traditions going back hundreds of years with a well-developed system for how the meat is shared between whalers, land owners and the rest of the population.

Photo: G. McCallum

Figure 2.2.5.1
A killer whale takes a look at the situation.

2.2.6 PORPOISES – THE PHOCOENIDAE FAMILY

There are six species in the porpoise family. They are all small with a total length of less than two metres. Five species have a distinct dorsal fin, but one species living in southeastern Asia lacks a dorsal fin. With the exception of one species in the Pacific, Dall's porpoise, porpoises are very confined to the coasts. For this reason, they are affected by human activity and environmental changes in the coastal zone.

Our common porpoise is very abundant and has a very wide range. It is found in temperate to subarctic coastal areas in the northern hemisphere with three geographically distinct populations in the northern Pacific, the northern Atlantic Ocean and the Black Sea. There are probably several genetically different populations in both the Pacific and Atlantic oceans. Porpoises have been given their Norwegian name of "nise" from an Old Norse verb for to sneeze, due to the sound they make when they come to the surface to breathe. Porpoises are very vulnerable to becoming bycatches in fishing equipment and, despite the fact that the species is abundant, bycatches are considered a serious threat to the populations in several areas.

This family also includes the vaquita: a species of porpoise that is very rare and distributed only in the very upper section of the Gulf of California in Mexico. The vaquita is considered one of the world's most threatened species and the threat is from bycatches in fisheries. There are only a few hundred individuals left, and yet perhaps as many as ten or so die each year in fishing equipment. Some of this fishing equipment is also set out to catch protected species of fish. The upper Gulf of California is an area with little shipping traffic, hardly any industrialisation and little pollution. Given that this is a threatened species with a range concentrated to a small and easily monitored area, and the fact that we are aware of the threat, it should be possible to take action to ensure the future survival of this species. The vaquita is often seen as an important symbol and a test of what society will choose when the conservation of a species is in conflict with economic interests.

Dall's porpoise is a species that lives in the open ocean in the northern Pacific. The species is abundant but vulnerable to bycatches in Japanese and Korean drift net fishing in particular. After the introduction of restrictions in commercial whaling, Japanese spearfishing developed. Almost a quarter of a million porpoises were harpooned between 1981 and 1994. For a while, this fishing was far in excess of a sustainable level but has, over the last few years, come under control and is now probably sustainable.

Photo: A. Bjørge

Figure 2.2.6.1
Porpoises in the Geiranger Fjord.

Chapter 3

The evolution of seals and their relationship to each other

Two theories exist with regard to the origin of seals. One of these suggests two sets of forefathers: a bear-like ancestor that evolved into the eared seals, and walrus and an otter-like ancestor that developed into true seals. The second theory suggests a common origin for the three seal families.

Arne Bjørge
arne.bjorge@imr.no

There are two main hypotheses for the evolution of the seals of the sub order, Pinnipedia, which means fin-footed. As regards the beginning of their evolution, which began about 35 million years ago, the two hypotheses differ. One hypothesis indicates two different evolutionary lines (so-called diphyletic evolution). One evolutionary line went from bear-like ancestors to what are now eared seals (sea lions and fur seals) and walruses. This evolution took place in the northern Pacific along the west coast of North America. The second evolutionary line went from otter-like ancestors to what are now true seals. This evolution took place in the northern Atlantic, probably along the European coasts. The alternative hypothesis indicates a common origin for all seals (monophyletic evolution). This evolution took place in the northern Pacific. But at an early stage, there was a parting of the ways of the two main groups; the true seals followed one evolutionary line and the eared seal and walrus the other. The distinction between the eared seal and walrus also happened at an early stage in the development of the seals.

3.1 EARED SEALS – THE OTARIIDAE FAMILY

As the name suggests, the eared seals have a visible external ear and they have flexible "hips", which means they can use their rear flippers to walk on land. The eared seals are divided into two main groups: nine species of fur seal and seven species of sea lion. Fur seals have a fine undercoat and shiny overhair. The coat is valued as an excellent raw product for different fur products and has been the basis of sealing. Sea lions are generally a bit bigger than fur seals. What both groups have in common is that the male is considerably bigger than the female. During the mating season, large colonies are formed in which the large males have a harem of several females. None of the eared seals give birth to their young on drift ice and their breeding colonies are found on both islands and the mainland.

Fur seals occur around the Pacific and around the southern hemisphere. One species, the northern fur seal lives along the Aleutian Islands between Alaska and Siberia and feeds in the North Pacific as far south as California and Japan. Another species has its range on islands in a belt around the Antarctic. The others live along temperate coasts in Australia and New Zealand, southwestern Africa, South America and smaller islands.

Sea lions are widespread around the Pacific from the Bering Sea in the north to the south coast of Australia, New Zealand and South America. The South American sea lion can also be found along the coast of Argentina and as far north as Brazil. It is the only species that occurs in the Atlantic.

Photo: A. Bjørge

Figure 3.1.1
Sea lion photographed in the Galapagos Islands.

3.2 WALRUS – THE ODOBENIDAE FAMILY

The walruses only consist of one species, but this is divided into two sub species. One of these lives in Arctic regions of the Pacific and the other in Arctic regions of the Atlantic. There are also walruses in the Laptev Sea, north of Siberia. They have similarities to both the Pacific and Atlantic walruses, and there is still some discussion on whether the Laptev walruses should be separated as a sub species in their own right.

Like the eared seals, walruses can use their rear flippers when they walk on land. On the other hand, they do not have a visible external ear like the eared seals. Walruses are big animals. The males reach more than three metres in length from their snout to their tail piece and can weigh more than 1,200 kg. The females reach about 2.5 metres in length and weigh 800 kg. The Pacific walruses are a bit bigger than the Atlantic walruses. A characteristic feature of the walruses is their long tusks, which can reach more than half a metre in length.

Walruses live in shallow waters and areas with drift ice. But this has, perhaps, not always been the case. One theory suggests that, a few million years ago, the walrus lived in the shallow water areas between North and South America. The land uplift led to the continents becoming joined together by a narrow land bridge (Central America), which separated the Atlantic walruses from the Pacific walruses. In the Pacific, the walruses died out, while in the Atlantic they evolved further and colonised the Arctic. It is less than a million years ago that walruses again colonised the Pacific, and then via the Arctic. More recent genetic studies challenge this theory. It is asserted that it is equally likely that the evolution of the walrus was taking place in the Pacific the entire time and that the walrus has colonised the Atlantic via the Arctic over the last million years.

Photo: K. A. Fagerheim

Figure 3.2.1
Walruses photographed at Moffen in Svalbard.

3.3 TRUE SEALS – THE PHOCIDAE FAMILY

With their 19 species, the true seals are the biggest family in the Pinnipedia group. The true seals lack visible external ears and their rear flippers point backwards and cannot be bent in under the body to walk on land. Their rear flippers are, therefore, only instruments for swimming.

There are big differences in size between the species. The ringed seal grows to 115 cm in length and weighs around 50 kg. The males of the large elephant seals can reach more than five metres in length and weigh up to four tonnes. A general characteristic of true seals is that the males are a bit bigger than the females. In the elephant seal, where the dominant males may keep large harems during the mating season, the females may only reach about half the size of the males.

Most species are associated with cold and, preferably, ice-filled waters in both the Arctic and Antarctic. As a group, the true seals have a very wide range in the Atlantic, Pacific, Mediterranean, Baltic, Caspian Sea, Lake Baikal, Lake Ladoga and a few smaller inland lakes in Finland and Canada.

The northern seals consist of ten species. Three of these only occur in the Atlantic (the harp seal, hooded seal and grey seal), two only occur in the Pacific and three species occur in both the Atlantic and Pacific (the harbour seal, ringed seal and bearded seal). In addition, there are two species that are very closely related to the ringed seal. They live in the Caspian Sea and Lake Baikal. There are also subspecies of the ringed seal in the Sea of Okhotst, the Baltic and the inland lakes, Saima, in Finland and Ladoga in Russia. The explanation for this is probably that the ringed seal, which is basically an Arctic species and very confined to the coast, was living in the freshwater lakes that became dammed at the southern edge of the large ice caps during the ice age. It is possible that water levels increased in such a way that the great Russian rivers now running northwards have changed direction and used to flow southwards and the ringed seals were carried along to the Caspian Sea. The land uplift after the ice age has led to the inland lakes, Ladoga and Saima, being closed off from the sea to the north and from the Baltic. These strains of ringed seals have, therefore, been isolated for possibly 10,000 years and now form their own subspecies.

Photo: A. Bjørge

Figure 3.3.1
The Norwegian name for the harbour seal, "steinkobbe" (stone seal) is an appropriate name.

Figure 3.3.2
Elephant seal on the coast of California.

The same process of land uplift after the ice age has led to a separate subspecies of harbour seal, which now lives in some inland lakes east of the Hudson Bay in Canada.

One family, the monk seals, are found in subtropical or tropical waters. Previously, there were three species: in the Mediterranean, the Caribbean and off Hawaii. The Caribbean monk seal became extinct as recently as in 1952 when the last confirmed observations were made. The Mediterranean monk seal is seriously threatened with extinction, with probably fewer than five hundred individuals left. Its range is now also split between the Northeast Mediterranean and the Atlantic coast of Northwest Africa. Some seals are still being shot by fishermen who believe that the seals are spoiling their fishing. The Hawaiian monk seal is also seriously threatened with extinction. There are only about 1,200 individuals left, but there are now better prospects for the recovery of this population since both the species and its most important habitats are now protected.

Elephant seals consist of two closely related species. A southern species that gives birth to its young on the sub-Antarctic islands and the Valdes Peninsula in Argentina. The northern elephant seal gives birth to its young on the west coast of North America, from Mexican California to British Columbia in Canada and on islands off the coast. Outside the breeding season, both species live pelagically over large areas of the sea, dive very deep and can remain submerged for up to 90 minutes. Both species were decimated by sealing during the time that animal oil was a valuable resource.

The Antarctic seals consist of four species. These are the Ross seal, Weddel seal, crabeater seal and leopard seal. They are divided into four families. The crabeater seal is probably a specialist in catching krill, while the leopard seal is a carnivore that eats penguins and other species of seal.

Chapter 4

Important species in Norwegian waters

The marine mammals in Norwegian waters range from the blue whale, which can be around 30 metres long, to the harbour seal, which rarely exceeds one and a half metre.

Nils Øien and Arne Bjørge
nils.oien@imr.no
arne.bjorge@imr.no

4.1 Blue whale

Balaenoptera musculus

Photo: G. McCallum

Figure 4.1.1
The variation between lighter and darker greytone patches and the relatively small, but pointed, dorsal fin at the very rear of the body is typical of the blue whale.

The blue whale is the world's biggest animal, even if we count the enormous dinosaurs that died out more than 60 million years ago. The largest blue whales caught in the Antarctic were up to 32.6 metres long and could weigh up to 190 tonnes. In the North Atlantic, they are usually less than 30 metres long and weigh between 50 and 150 tonnes. Blue whales have patches with gradual transitions between several shades of grey. In good light, they look bluish in clear water. The dorsal fin, which is located at the far end of the body, is relatively small compared with the size of the body in general. The upper mandible has between 270 and 395 black baleen on each side. The longest baleen may be a metre in length.

When blue whales come to the surface to breathe, they emit a column of steam (spout) that can be 10–12 metres high and be visible for more than a minute. After the spout, their back continues to stick out of the water for several seconds until the small dorsal fin and the powerful tailfin become visible and the whale begins a new dive.

Blue whales become sexually mature at around 8–10 years old. By then, the females are 21–24 metres long: a bit bigger in the southern hemisphere than in the northern hemisphere. The males are 20–22 metres long when they become sexually mature. Mating takes place in the autumn and winter, and the females have a gestation period of between 10 and 12 months before giving birth to a 6–7 metre long calf, weighing from 2 to 3 tonnes. The suckling period is 6–8 months. The calf will have become about 16 metres long by the time it is weaned and must start to catch its own food. The females have a calf about every three years.

It is difficult to determine the age of baleen whales, but we assume that blue whales become at least 80–90 years old. Animals that have been recognised due to their pattern of patches have reached more than 40 years of age.

Although blue whale populations were greatly reduced by whaling, they can still be found in the North Atlantic, the North Pacific and circumpolar in the southern hemisphere. They graze in cold waters, preferably right at the edge of the ice in the summer and migrate to warm areas in the winter. Krill is their most important prey. During their migration between their breeding and grazing areas, blue whales swim at a speed of 5–30 km/h. When they are eating, they often swim at between 3 and 6 km/h. Their dive times are 8–15 minutes, but dive times of up to 36 minutes have been recorded.

Photo: G. McCallum

Figure 4.1.2
A blue whale ready for another dive. Note the contrast between the powerful tailfin and the small dorsal fin.

Nils Øien and Arne Bjørge
nils.oien@imr.no
arne.bjorge@imr.no

4.2 Fin whale

Balaenoptera physalus

Photo: G. McCallum

Figure 4.2.1
The fin whale's characteristic asymmetrical colour pattern with its dark lower mandible on the left-hand side and light colour on the right-hand side.

In the southern hemisphere, fin whales reach about 26 metres (females) and 25 metres (males). They are somewhat shorter in the northern hemisphere and weigh from 60–80 tonnes in the south and 40–50 tonnes in the north. The upper mandible has between 350 and 400 baleen on each side and the longest baleen can reach about 70 cm in length. Fin whales have dark grey backs and somewhat lighter grey bellies. Their skin has asymmetrical colour patterns. Their upper mandible is dark on both sides, while the lower mandible is dark on the left-hand side and light on the right-hand side. The baleen on the right and left-hand sides follow this colour pattern.

Fin whales reach sexual maturity at around 6–8 years of age. By then, the females are 18.5–20 metres long, a bit bigger in the southern hemisphere than in the northern hemisphere. The males are between 17.5 and 19 metres long when they reach sexually maturity. Mating takes place in the autumn and winter. The females have a gestation period of 11 months before giving birth to a 6-metre long calf weighing 1–1.5 tonnes. The suckling period lasts for 6–7 months and the calf is between 11 and 13 metres long by the time it is weaned. The females can have a calf every two years at the most, but some take a "gap year" and have a calf every three years. Twins have been observed in fin whales, but this is considered very rare. Hybrids between blue whales and fin whales have been confirmed.

Fin whales are found in all the oceans of the world and local populations are even found in the Mediterranean. They have a versatile diet and this varies from copepod (zooplankton) and krill to fish such as herring, mackerel and codfish. Fin whales are quick animals and can maintain speeds of 15 km/h when they are migrating. Short spurts of almost 30 km/h have been observed. Dive times are 3–10 minutes. Fin whales migrate between cold waters, where they graze in the summer, and warmer waters in the winter. Their calves are born in the winter. Observations suggest that not all fin whales leave their grazing areas in the winter, but their pattern of migration is not very well documented.

Photo: G. McCallum

Figure 4.2.2
Fin whales can certainly move. This close-up shows the blowhole with the typical carina in front of the snout and the light lower mandible on the right-hand side.

Nils Øien and Arne Bjørge
nils.oien@imr.no
arne.bjorge@imr.no

4.3 Common minke whale

Balaenoptera acutorostrata acutorostrata

Photo: G. McCallum

Figure 4.3.1
The minke whale's characteristic colour scheme with white bands across the pectoral fins.

Common minke whales reach up to 10 metres in length. The females are slightly longer than the males. The common minke whales in the northern hemisphere have dark backs with a lighter, almost whitish abdomen. The pectoral fin has a clear white band. They have whitish baleen.

Until recently, all the minke whales of the world were considered one species, but genetical and morphological studies are underway to clarify the more complicated reality. The dominant form in the southern hemisphere is a little bigger than "our" minke whale and lacks the distinct white band on the front flippers. Their baleen also have a colour pattern that resembles that of the fin whale, that is to say, some of the baleen on the right-hand side are light coloured while others are dark. This form has now been classed as a distinct and separate species (*Balaenoptera bonaerensis*) and can be called the Antarctic minke whale. In the southern hemisphere, there is also a "dwarf form" that has a colour scheme resembling that of the northern minke whale. In addition, the minke whale in the North Atlantic has been made a separate distinct subspecies in contrast to the minke whales living in the North Pacific.

Minke whales reach sexually maturity at around six years in the case of females and seven for males. Mating takes place in the autumn and winter, and the females have a gestation period of ten months before giving birth to a calf 2.4–2.7 metres in length. The suckling period is almost six months. Minke whales have an annual reproduction cycle and, apparently, about 90 percent of sexually mature females are pregnant each year.

Minke whales have a migration pattern similar to that of the blue whale. The diet is very varied for a baleen whale and varies from copepod (zooplankton) and krill to fish such as capelin, herring, mackerel and sometimes large codfish. Minke whales are very fast animals that can achieve great speeds over short distances, and they do not normally have a visible spout. They are extremely streamlined and visible on the surface for a short while each time they breath. The most common movement pattern is a series of 3–5 rather fast spouts before making a long dive that may last up to about 5 minutes. On average, the minke whale comes up to breath about 50 times over the course of an hour.

The minke whale is the only species of whale that it is permissible to catch in Norway (see Chapter 6.3). The meat is used for consumption and is popular in fish restaurants. Catches are regulated by quotas and monitored carefully. DNA tests of all minke whales caught are analysed and form part of a national DNA register. In this way, it is possible to trace all whale meat sold back to the individual whale. This is an effective way of exercising control over legal whaling.


Photo: G. McCallum

Figure 4.3.2
A minke whale has just been up for a blow.
Notice the extremely streamlined form.

Nils Øien and Arne Bjørge
nils.oien@imr.no
arne.bjorge@imr.no

4.4 Humpback whale

Megaptera novaeangliae

Photo: K.A. Fagerheim

Figure 4.4.1
The underside of the humpback whale's tail fin has individual colour designs that are used in "mark/recapture" studies.

With its extremely long pectoral fins (a third of its body length), hump on its back and wart-like growths on its upper and lower mandibles, the humpback whale is distinct from the other whales in the fin whale family. The generic name *Megaptera* is of Greek origin and means "large-winged" (mega = large; ptera = wing). This obviously refers to the long pectoral fins. Humpback whales have a dark back and light, almost white, abdomen from the lower mandible back to the anus. The long pectoral fins and underside of the tail have individual degrees of white. Humpback whales very often lift their tail before a new dive, and their colour pattern on the underside of the tail fin is used to identify individuals in behavioural studies and "mark/recapture" experiments.

Humpback whales reach 15–17 metres in length. The females are 1–1.5 metres longer than the males. The age of reaching sexual maturity varies from area to area but is often between five and ten years of age. The gestation period is 11.5 months and the calves are 4–4.5 metres long at birth. They will have grown to between 8 and 10 metres by the time they are weaned. Some calves may suckle for up to a year, but they gradually begin to move on to other food after about six months. Sexually mature females have a calf every two or three years.

Humpback whales migrate from cold waters near the edge of the ice, where they graze in the summer, to subtropical waters where they give birth and mate in the winter. The calves follow their mothers for at least a year, and this means that a connection to specific grazing areas is formed through their mothers. The known calving areas for the humpback whale are shallow waters in subtropical areas. North of the Dominican Republic in the Caribbean, there are several known shallow banks where we find humpback whales that have grazing areas along the coasts of the USA and Canada, off Western Greenland, Iceland and the Barents Sea. Although they have a common calving area, there is little interchange between the different grazing areas.

In the winter, the sexually mature males "sing". The song is long and varied. All the male whales from the same population have songs built up along the same basic theme, but with small individual variations. This basic theme can gradually change and these changes appear to be coordinated within the same population. Their song has been interpreted as a method for attracting females, but newer studies suggest that the primary function is communication between the males, perhaps to establish a hierarchy between them.

Humpback whales appear to be playful; they jump out of the water and strike the surface of the water with their long pectoral fins or their tail fin. The biological significance of this apparently playful behaviour is not known.

Photo: K.A. Fagerheim

Humpback whales have a diet that ranges from krill to small fish in shoals such as capelin and herring. They have developed a special hunting technique: One whale swims in gradually decreasing circles releasing bubbles of air that rise to the surface. In this way, they concentrate their prey inside a "bubble curtain" before coming up to the surface open-mouthed at the centre of the bubbles.

Figure 4.4.2
Feeding humpback whales concentrate their prey using air bubbles before capturing them in their enormous jaws.

Arne Bjørge
arne.bjorge@imr.no

4.5 Killer whale

Orcinus orca

Photo: G. McCallum

Figure 4.5.1
The killer whale is characterised by its high dorsal fin and black and white colour pattern.

The killer whale is the largest species in the dolphin family (Delphinidae). With its high dorsal fin and its clear pattern with its white abdomen, a white spot behind the eye and a grey saddle patch on an otherwise black body, the killer whale is easily recognisable.

The males reach about nine metres in length and the females up to eight metres. The weight of adult individuals varies from 4.5 to almost 7 tonnes. Calves are about two metres long at birth and weigh up to 200 kg. The age at which they reach sexual maturity varies from area to area, but females are usually between ten and twelve when they rear their first calf. The gestation period is around 16 months and the suckling period lasts for more than a year. Their young are weaned gradually while they learn to catch their own food. Sexually mature females give birth about every five years and they can have young until they are a good 30 years of age. Then they have a non-productive period of 10–20 years. Both males and females appear to be able to live to about 50.

Killer whales occur in all the oceans, but they are, nevertheless, rare in tropical waters. They are also very sociable with a well-organised group and social structure. A group will remain stable over a long time and be organised around one mother (maternal organisation), with her daughters and sons and second-generation daughters. Interdependence between several groups is called clans and the clans are organised into communities. Off British Columbia in Canada, it has been shown that several communities can exist in the same area. A community of fish-eating killer whales is sedentary (resident) all year round, but groups from another community that mainly eats meat comes into the area for periods (transient).

It would appear, therefore, that killer whales are organised into communities by hunting strategy. Today, all killer whales are considered one species but it is possible that the species will soon be divided into several closely related species.

Some killer whales have a well-organised form of hunting. Killer whales off the Norwegian coast herd shoals of herring into tight "herring knots" just under the surface. Several killer whales swim in a "carousel" and scare the herring together using powerful blows of the tail and air bubbles. Then they take turns entering the carousel and helping themselves to this herring platter. Even more spectacular is the hunting strategy of meat-eating killer whales off the Valdes Peninsula in Argentina. Here, killer whales almost go ashore to catch sea lion calves standing at the shore edge. Other whales may also form part of the killer whale's menu. They have been known to take grey whale calves on their migration northwards along California.

Although killer whales' prey may range from small fish in shoals, such as herring, to great whales, individuals or groups may have a specialised hunting strategy and a narrow choice of food.

Photo: G. McCallum

Figure 4.5.2
Killer whales strike the water with their tail fin with a bang. A technique they also use to paralyse fish.

Arne Bjørge
arne.bjorge@imr.no

4.6

Porpoise

Phocoena phocoena

Photo: F. Graner

Figure 4.6.1
Backlit porpoise.

Together with five other species, the porpoise forms the Phocoenidae family. They are all small toothed whales about one and a half metres long. In Norway, the porpoise takes its name, "nise", from an Old Norse word for to sneeze. This refers to the sound of the spout when the porpoise comes to the surface to breathe. It has a dark grey back and somewhat lighter abdomen with a dark stripe from the corner of the mouth to the pectoral fin.

The female is a little bigger than the male and reaches 160 cm and 60 kg while the male typically reaches 150 cm and 50 kg. At birth, the calves are about 70 cm long and weigh no more than five kg. Porpoises reach sexual maturity when they are about 140 cm in length (three to five years old). Sexually mature females give birth to a calf every year and most births are in the early summer. The suckling period is relatively long but does not last an entire year. Their maximum life expectancy appears to be about 24 years of age, but only about 5 percent of the animals live for more than 12 years.

Porpoises are probably the most abundant cetacean species in Norwegian waters. In the North Sea, there are about 350,000 individuals. They occur in considerable numbers further north along the Norwegian coast and in the Barents Sea north to the polar front. In these areas, we do not presently have reliable figures regarding the size of the population.

Porpoises are very vulnerable to getting stuck in fishing nets and drowning. Each year, a few thousand drown in Norwegian fisheries. The EU has introduced measures for reducing this mortality rate, but it is unclear how effective the measures are.

A great range of fish species are on the porpoise's menu. But it appears as though they do not dive much deeper than to 200 metres to find food. A study of the porpoise's choice of food showed that their diet varied along the Norwegian coast from North to South. Along the Finnmark coast, they ate a lot of pelagic fish, particularly capelin. Along the Sørland coast, they had eaten some herring and sprats and, in the Kattegat, a lot of bottom fish. Along the west coast, their diet was a mixture of pelagic fish and bottom fish with a great element of mesopelagic fish, such as the lantern fish. During the day, the lantern fish is probably so deep that it is inaccessible to porpoises. They have, therefore, probably been eaten at night when they migrate to the surface.

Photo: F. Graner

Figure 4.6.2
The porpoise is the smallest, but most abundant cetacean, species in Norwegian waters.

Tore Haug and Arne Bjørge
tore.haug@imr.no
arne.bjorge@imr.no

4.7 Harp seal

Pagophilus groenlandicus

Photo: M. Poltermann

Figure 4.7.1
Harp seal with whitecoat.

The harp seal belongs to the true seal family (Phocidae). Their pups have white fur at birth (whitecoats), which they lose after two or three weeks. While moulting, they are called "lurv" (mops) in Norwegian and, once they have acquired their new, dark, short-haired fur, they are called "svartunger" (blackcoats) in Norwegian and greycoats in English. For the rest of their lives, they replace their coat every year and gradually acquire a lighter colour with dark, irregular patches. During this period they are called "brown seals" in Norwegian, a term that covers both immature and sexually mature animals. At about the age of ten, they acquire black heads and a light, almost white body with a saddle mark on their backs. Once they have acquired this characteristic colour pattern, they are called saddleback seals or "old dogs" in Norwegian. Harp seals live to about 30 years of age.

Adult harp seals reach up to 1.9 metres in length measured in a straight line from the snout to the tip of the tail and can weigh up to 200 kg. Both sexes are roughly the same size. At birth, their pups are about 1 metre long and weight about 12 kg. During the two-week long suckling period they are quickly fattened up to more than 30 kg when they are weaned. Once they have replaced their coat after three weeks, they will have lost 5–10 kg before they leave the ice to find food on their own.

The harp seal is only found in the North Atlantic. In late winter every year, they gather in three main areas to give birth to their pups on the drift ice. These are on the east coast of Canada (outside both Newfoundland and in the Gulf of St. Lawrence), in the Western Ice north of Jan Mayen and in the Eastern Ice in the White Sea. Mating takes place at the end of the suckling period and the adult seals search briefly for food before gathering again on the drift ice, this time to moult. Young animals and males first and then sexually mature females.

Outside the breeding and moulting seasons, harp seals search for food along the edge of the ice and in open waters across large areas of the North Atlantic. Typically, harp seals occur in large flocks in their feeding areas. Their diet varies from area to area and depending on the time of the year. In the Barents Sea, the harp seal is very abundant and its consumption has an effect on other resources. Capelin is an important prey in the Barents Sea and the harp seal's choice of food is probably influenced by how much capelin is available. One estimate based on 2.2 million seals showed that their total consumption in the Barents Sea was about 3.37 million tonnes in years with a big capelin population. Capelin consisted of a quarter of this, but Arctic cod and krill, which are the second most important prey, together made up 36 percent of their consumption. In years where there is little capelin, consumption was estimated at 3.49 million tonnes. This was due to the fact that the harp seal was then forced to eat a somewhat poorer diet, in which the proportion of Arctic cod increased.

Photo: M. Poltermann

Figure 4.7.2
Harp seal whitecoat.

Tore Haug and Arne Bjørge
tore.haug@imr.no
arne.bjorge@imr.no

4.8 Hooded seal

Cystophora cristata

Photo: B. Bergflødt

Figure 4.8.1
Male hooded seal, also called "hettakall" in Norwegian because it can blow up the skin of its nose to a "cap" – a "hette", and the septum between the nostrils into a red balloon.

The hooded seal belongs to the true seal family (Phocidae). When its young are born, they are called bluebacks because of their colour. They will actually have moulted their birth fur before being born and are born with a short-haired coat that is steel-grey on the back and cream white on the abdomen. Then when they are one year old and until they reach sexually maturity, they are called "boars" in Norwegian. When the hooded seal is sexually mature, the males are called "hettakall" and the females "mus" in Norwegian. They can live to more than 30 years of age. The adult animals have a dark grey coat with black, irregular blotches. While they are "boars", their coat gradually becomes more like the adult coat. A characteristic of the sexually mature males is that they can blow up their nose so that it stands out like a big balloon on the top of their snout. In addition, they can also blow up up the septum between the nostrils so it becomes a red bladder. It is particularly during the mating period that they demonstrate their masculinity in this way.

There is a big difference in size between adult males and females. The males can grow to as much as 2.7 metres measured in a straight line from the snout to the tip of the tail and then weigh about 400 kg. The females reach 2.2 metres in length and weigh about 300 kg. At birth, the pups are a good metre long and weigh about 25–30 kg. Their suckling period lasts only four days, the shortest suckling period known in any mammal. During this period, the pups drink 10 litres of milk with a fat content of 60 percent. They store about 75 percent of the amount of energy they eat and put on seven kilograms a day so that they weigh about 50–60 kg by the time they are weaned.

The pups are born in March. During the four days that the suckling period lasts, the female will be together with the blueback. At the end of the suckling period, the female will be ready to mate again. A male will team up with the mother and cub during this period and these "families" spread around thick floating sheets of ice with a distance of about 50 metres between them. In between them are "bachelors" who tag along if there is a spare female. Mating takes place in the water as soon as the female has left the blueback. After mating, the male may start competing for new females.

Moulting takes place on the drift ice between June and early August and not necessarily in the same place as the pups are born. Outside the breeding and moulting seasons, the hooded seal feeds across large parts of the North Atlantic in both deep, oceanic water and along the slope of the continental shelf. Squid and deep-sea fish, such as blue halibut and redfish are considered their most important prey, but they also eat codfish and Arctic cod. Satellite tracking of tagged hooded seals in the Western Ice shows that they migrate repeatedly to the slopes of the continental shelf all the way from Svalbard to west of the British Isles in their search for food. These trips may last for several weeks. Between trips they return and rest on the drift ice.

Photo: K.A. Fagerheim

Figure 4.8.2
Female hooded seal with pup. The pups are called bluebacks due to the greyish-blue colour on their back.

Kjell Tormod Nilssen and Arne Bjørge
kjell.tormod.nilssen@imr.no
arne.bjorge@imr.no

4.9 Grey seal

Halichoerus grypus

Photo: K.A. Fagerheim

Figure 4.9.1
The grey seal is common from Trøndelag and further north along the Norwegian coast, but also includes a small colony in Rogaland.

The grey seal belongs to the true seal family (Phocidae). When born, the pups have a white (greyish), long-haired coat. They moult their white coat after two to three weeks and then acquire a dark, spotted and short-haired coat. Adult animals have a grey and sometimes brown colour with darker patches.

At birth, the pups are about 1 metre in length and weigh 12–15 kg. During a two-week long suckling period they increase their body mass to more than 40 kg. Adult male grey seals can be up to 2.3 m in length and weigh more than 300 kg. The females are smaller, up to 1.9 m in lengh and below 200 kg. At birth, the young are a good metre in length and weigh about 12–15 kg. The age at sexual maturity is 5–7 years and grey seals can reach an age of 35 years.

Grey seals are only found in the North Atlantic. The highest concentrations are around the British Isles where the overall population estimate was 180,000 grey seals in 2008, and in the Nova Scotia-Gulf of St Lawrence area in Canada where the total population estimate was 330,000–410,000 grey seals in 2010. A population of about 23,000 grey seals inhabit the Baltic. In comparison, the population along the Norwegian coast was modelled to be about 8,000 grey seals (pups included) in 2010.

It is, however, mainly over the past 10–15 years that the grey seal has become so numerous. In the British Isles, 5,000 pups were born annually in the early 1960s. After that, pup production increased rapidly to about 46,000 pups in 2008. Since 2004, the annual growth has levelled out. The largest colony in Canada is at Sable Island offshore of Nova Scotia where a few hundred pups were born annually in the early 1960s. During the mid 1990s, the population began to grow, and since then, pup production has increased by more than 12 percent annually. In 2010, it was estimated that more than 60,000 pups were born on the Sable Island. In the last years, the annual growth rate has levelled out.

What caused grey seal populations to increase so dramatically? The enormous cod population in the Newfoundland area collapsed over the 1960s. Also distinct cod populations in the Gulf of St Lawrence–Nova Scotia area decreased by about 80% due to overfishing during the 1980s and early 1990s. Cod is an effective predatory fish that eats smaller fish. The collaps of the cod populations and other large bottom living fish spesies, resulted in dramatic changes in the ecosystem over the past several decades. Groundfish resources, such as cod, have been replaced by small-bodied fishes, such as sand eel. Studies suggest that the sand eel is one of the grey seal's favourite prey species. An increased amount of energy-rich prey, possible improvements in breeding conditions related to changes in ice conditions, and reduced hunting of grey seals, resulted in a rapid increase in the Canadian grey seal population.

No corresponding studies have been carried out in the North Sea, but the story there shows the same main trends: Overfishing of cod since the Second World War, sand eels becoming the most important prey for the grey seal and the grey seal populations beginning to increase before appearing to stabilise at a higher level after 2000.


Photo: K.A. Fagerheim

Along the Norwegian coast, the grey seal population has increased slightly in the Northern areas and remained stable in Central Norway. The authorities use controlled hunting to regulate growth and they want to stabilise the grey seal population to avoid conflicts with the fishing industry. While the sand eel appears to be important grey seal prey off Canada and in the North Sea, wolffish, cod, saithe and haddock appear to be the most common prey along the Norwegian coast.

In the Northeast Atlantic, grey seal pupping occurs on land in the autumn. In Canada and the Baltic, pupping occurs both on land and on ice in the winter. In the Baltic, the pups are, preferably, born on ice, when sea ice is abailable. Pups born on land appear to have a higher mortality rate than those born on ice in this area.

Figure 4.9.2
Grey seal whitecoat. It is these that are counted to find out the size of the population.

Kjell Tormod Nilssen and Arne Bjørge
kjell.tormod.nilssen@imr.no
arne.bjorge@imr.no

4.10 Harbour seal

Phoca vitulina

Photo: A Bjørge

Figure 4.10.1
Harbour seals on a rock in the tidal zone. Harbour seals are common along the entire Norwegian coast.

The harbour seal belongs to the true seal family (Phocidae). The pups have already lost their birth-coat by the time they are born, and have a coat with irregular patches in several shades of grayish and brown. Their belly is usually a bit lighter than their back. There are great variations in colour between individuals within the same colony and, during the moulting period, they look more light brown than after moulting.

The males can be about 1.5 m in length and weigh more than 100 kg. The females are somewhat smaller and can weigh about 80 kg. When born, pups are about 80 cm and weigh 8–10 kg. Pupping occurs in areas exposed by the tide, and the pups may follow their mother into water at the first high tide. Pups have a poorly developed ability to swim and dive during the first days and are vulnerable to disturbance. Harbour seals reach sexual maturity after about four years, and their maximum life span is in excess of 30 years.

The harbour seal can be found from temperate to sub Arctic waters along the east and west coasts of both the North Atlantic and North Pacific. The major oceans act as geographical borders between the coastal harbour seals that have developed into four subspecies along the coasts of the North American and Eurasian continents. In addition, there are a few hundred individuals living in freshwater in the Ungava Peninsula in Canada. These are considered a fifth subspecies.

Harbour seals are pupping in June–July and the suckling period lasts 3–4 weeks. Towards the end of the suckling period, the females become receptive to mating again. Just before and during the mating period, the males exhibit a typical behaviour that includes territorial defence and vocalizing under water. The vocalizing is repeated three or four times per dive and the males can keep up this type of behaviour for several hours. Within the same geographical area, all males have the same basic theme in their vocalizing, but with slight individual variations. There appear to be "dialectal variations" in harbour seals vocalizing between different areas.

Harbour seal moulting occurs in August, when they spend more time on land, and they are therefore more available for countings. Counting moulting animals is a common method for monitoring populations. Harbour seals are stationary, social animals, and they gather in groups that regularly lie ashore in tidal zones. During feeding trips at sea, they usually appear individually and they feed close to their haul-out areas. Feeding trips of several tens of kilometres lasting several days are, nevertheless, not uncommon outside the breeding and moulting periods. Their main prey is saithe, Norway pout and herring in Norwegian areas.

Photo: A Bjørge

Figure 4.10.2
There are great individual differences in colour between harbour seals, from light grey to almost black.

Chapter 5

Current research topics

There are many key problems – biological, environment-related and in terms of regulation – associated with research into and the management of marine mammals. The research environment works in fields ranging from scientific advice on setting quotas via climatic threats to Arctic species to the interaction between great whales, fish and plankton in the Barents Sea.

Kjell Tormod Nilssen
kjell.tormod.nilssen@imr.no

5.1 COASTAL SEALS – A THREAT TO THE FISHING INDUSTRY?

The harbour seal and grey seal are coastal seals that live all year round in colonies along the Norwegian coast. Harbour seals are relatively sedentary and live in small groups ranging from tens of animals to larger colonies consisting of a few hundred individuals. Harbour seals are widespread along the entire Norwegian coast from the Swedish border to Finnmark with the greatest concentration along the coast of Sør-Trøndelag and Nordland. Tagging experiments have shown individual ranges of about 70–80 km in the case of harbour seals. This could indicate that there are many local, sedentary populations along the coast, something also supported by preliminary results from genetic research. In addition, the world's most northerly population of harbour seals occurs at Prins Karls Forland in Svalbard. This isolated population is protected and the Norwegian Polar Institute estimates that it numbers more than 1,000 individuals.

The grey seal occurs in the most outer and weather-beaten islets and rocks from Rogaland to Finnmark, with the greatest concentration in Trøndelag and Nordland. Grey seals are gregarious animals that form colonies at permanent locations, particularly in connection with giving birth, mating and moulting. The hunting of both species is subject to quotas.

How big are the populations?
It is often asserted in quarters within the fishing industry that the populations of harbour and grey seals are far greater than recorded in the Institute of Marine Research's counts. It is also argued that seals are being observed in areas other than those counted by researchers. Population counts of the harbour and grey seals are, however, carried out during the periods of the year when we are safe in the knowledge that the animals will gather together, when giving birth and moulting. In these seal colonies, it is possible to estimate the number of animals in practice. There is, however, reliable information that both harbour and grey seals can be found in other areas at other times of the year.

Photo: K. A. Fagerheim

Figure 5.1.1
Harbour seal pup.

Management then and now

Rock carvings on Rødøy in Nordland show that seals were hunted more than 4,000 years age, but coastal seals have probably been hunted heavily since the first ancient hunters migrated after the Ice Age. Finds at Skipshellaren in Nord-Hordland show that the harbour seal was the most important marine mammal in the diet of the people who lived there. Gradually, as agricultural cultivation and more permanent settlements developed, sealing became more associated with hunters with exclusive rights to hunt on behalf of the land owner. Regulations on seal hunting existed as early as in Frostating's Law (12th–14th century) and Magnus Lagabøte's Law (1276). The first modern law that dealt with sealing came into force in 1876 and regulated the duration of the hunting season for the harp and hooded seals in the West Ice. It was revised several times before it was replaced by the Sealing Act in 1951.

After local initiatives and by the authority of the Sealing Act, the grey seal became a protected species in Sør-Trøndelag in 1953 and the harbour seal in Tjøtta, Nordland, in 1962. From 1966, both species were given protected status in the summer in Orskjæra and Ravnane, Møre and Romsdal. In 1973, all seals became protected all year round from Østfold to Sogn and Fjordane. From Møre and Romsdal to Finnmark, coastal seals were protected during the period May–November. In the hunting season, hunting was unrestricted. Today, coastal seals are managed in accordance with the Saltwater Fishing Act of 3 June 1983 and the Participation Act of 26 March 1999. From 1997, quota regulations were introduced for coastal seals along the entire coast. The hunters had to register, perform shooting tests and report seals taken.

High hunting pressure led to local coastal populations being almost wiped out during the course of the 1950s. Hunting restrictions of both species resulted in increased populations. This has led to the fishing industry again wanting to reduce the number of seals. The authorities want to subdue the conflicts between coastal seals and fisheries by providing incentives for more hunting that is regulated by quotas. At the same time, the authorities have expressed a target of maintaining sustainable populations within the seals' natural ranges. Norway has also committed itself to this internationally, including through the Convention on Biological Diversity (CBD). Today, management is based on the carrying out of nationwide censuses of the populations every five years. The results form the basis for the hunting quotas. Harbour seals are managed by county while grey seals are managed within the Lista–Stad, Stad–Lofoten and Vesterålen–Varanger regions. Genetic studies on grey seals show clear differences between these three areas.

Harbour seal

The harbour seal population is monitored using aerial photography and visual counts (from small boats and from land) during the moulting period (August) when the animals rest together and in great numbers on land. This is an internationally accepted method for counting harbour seals and is done this way in most countries that monitor their populations regularly (e.g. Sweden, Denmark, Scotland and Canada). All known locations are surveyed, and the counts are carried out during the day at low tide and preferably in good weather conditions when most animals are ashore. The counts provide minimum figures for the size of the population. Since there will always be seals in the sea, the animals' behaviour during the moulting period is studied to calculate the conversion factor between the recorded numbers and the total population size. These behaviour-dependent conversion factors may vary from location to location.

The first nationwide count of harbour seals was carried out by the Institute of Marine Research in 1996–1999 and resulted in approximately 7,500 harbour seals. After making a correction for seals in the sea, based on observation data from Norwegian colonies and conversion factors from Swedish surveys, the total harbour seal population in Norway was estimated at about 10,000 individuals in 1999. These corrections are not safe enough to be used to provide advice on the management of the species, and until we have better knowledge of conversion factors for Norwegian harbour seals, the number of animals recorded will be used as a minimum estimate in order to assess the status of the population.

In 2003–2006, a new nationwide count was carried out, resulting in about 6,700 animals. This survey indicates an annual reduction in the total population of 1–2 percent since 1999. In a few areas, the populations of harbour seals were half what they had been. This decline led to the harbour seal being listed as "vulnerable" in the Norwegian Red List in 2006. The category vulnerable indicates that there is a 10 percent probability of the species disappearing from Norwegian territory within 100 years if current trends continue.

Grey seal

Annual pup production counts as a basis for modelling total populations provides reliable estimates for grey seals. Pups are counted using boats and/or aerial photography. In boat-based surveys, the pups are counted and classified by age (in days) based on morphological development over a three weeks period when they moult their whitecoat. To avoid double counts during several visits to the colonies, the pups are tagged. New nationwide population estimates are procured every five years. The long Norwegian coast dictate that population counts must be done in parts of the coast every year which cover the entire coast line, during a 2–3 year period.


Photo: K. A. Fagerheim

Figure 5.1.2
Moulting grey seal pup.

Between 1996 and 1999, the Institute of Marine Research studied grey seal pup production using aerial photography in the area between Froan and Lofoten, while the number of moulting grey seals was recorded in Troms and Finnmark. These studies resulted in an estimate of about 4,400 grey seals along the Norwegian coast from Trøndelag northwards. Rogaland was not studied. In 2001–2003, a new boat-based study of grey seal pup production was carried out along the entire coast from Finnmark to Rogaland, where it was found that about 1,200 pups were born annually. This corresponded to an estimated total population of about 4,600–5,500 grey seals aged one year or more (1+), based on conversion factors of 4.0–4.7 between the number of pups born and the number of grey seals (1+). These results are higher than in the period 1996–1999, but the methods for estimating the populations in the two periods was somewhat different and therefore not fully comparable.

The last nationwide count of grey seal pups in Norway was carried out in 2006–2008. At that time, the population estimate for the grey seal was 5,100–6,000 (1+). These results show an increase in the grey seal population in the area from Lofoten to Finnmark, while a reduction in the number of pups born was recorded in Froan. In the Lista–Stad area, only breeding at Kjør islands in Rogaland was recorded. This local population of about 200 animals is increasing slightly. The total number of grey seals along the entire Norwegian coast has increased by around 2.5 percent annually during the period from 1998 to 2007.

Hunting quotas

Given the lack of time series for population sizes and thereby a basis for useful population models, the Institute of Marine Research has recommended that hunting quotas for both harbour and grey seals are restricted to only 5 percent of the population estimates. It is estimated that this will be close to a sustainable level and takes into account the fact that the population estimates for the harbour seal are probably a bit less than the actual population size. In addition, account has been taken of the fact that there are considerable unrecorded losses from the populations through bycatches in the fisheries. Preliminary studies indicate that 300–500 harbour seals and 100–200 grey seals drown each year in fishing nets along the coast. In areas of conflict between seals and fisheries, the Institute of Marine Research has recommended an increase of up to 30 percent on the recommended quota.

The recommended quotas from the Institute of Marine Research have not, however, been taken into account by the Marine Mammal Council (Sjøpattedyrrådet) and the administrative authorities. From 2003, they recommended hunting quotas of up to 13 percent of the harbour seal population and 25 percent of the grey seal population. The Marine Mammal Council has also proposed financial incentives for hunting coastal seals. Since 2003, the Ministry of Fisheries has set quotas for grey and harbour seals in accordance with the Marine Mammal Council's advice, including payment of compensation upon handing in the jaws of seals shot. This has led to a great increase in hunting for harbour seals, while there has been less impact on the grey seal. The counts during the period 2003–2006 indicate that hunting has led to a decline in numbers of harbour seals. The Institute of Marine Research has expressed its concern regarding the effects of large quotas combined with payment for seals shot. This particularly applies to the harbour seal, which is far more accessible to hunters than the grey seal. There could be a danger of local and genetically isolated harbour seals being wiped out if incentives continue to be provided for hunting (in addition to the authorities' compensation scheme, bounties have also been introduced on coastal seals in some Finnmark municipalities). Because the harbour seal is managed by county, genetically isolated populations could be wiped out if the entire quota is taken in areas with small populations.

Conflicts – do coastal seals damage fisheries?

The increase in the hunting of coastal seals over the past few years is a direct result of the fishing industry's desire to greatly reduce populations. The main argument has been that seals cause great damage to the fishing industry due to their consumption of fish, destroying fishing gear and spreading of parasites (seal worms). The authorities' desicion to reduce the numbers of coastal seals has not been based on studies of potential seal–fish interactions.

The Institute of Marine Research has carried out estimates of the harbour and grey seals total food consumption along the Norwegian coast based on information on diet from several areas along the coast and bio-energetic models of the seals' food requirements. The harbour seal's diet is dominated by small individuals of saithe, herring, Norway pout and cod. The grey seal's diet is dominated of wolffish, cod, saithe and haddock, and in some areas, also herring and flounders. Total annual consumption was estimated to be 13,000 and 15,000 tonnes for harbour and grey seals respectively. The average annual consumption of cod was estimated to be 300 tonnes for harbour seals and 5,500 tonnes for grey seals. The harbour seal's consumption of cod mostly involves coastal cod as it feed close to the coast, while the grey seal probably consumes both coastal cod and spawning Northeast Arctic cod.

Who is catching the coastal cod?

By comparison, tourist and leisure fishing for cod along the Norwegian coast has been estimated at 10,000–12,000 tonnes, assuming that the majority is coastal cod. Between 22,000 and 40,000 tonnes have been taken each year in commercial fishery for coastal cod during the past ten years. The coastal seals' total consumption of saithe and haddock is small in relation to the stock sizes of saithe and haddock, and also in relation to the fisheries' takes of these two species. The number of coastal seals along the Norwegian coasts appears to be too small to have any significant impact on commercial fish stocks, including coastal cod. This is supported by an evaluation of removals of coastal cod south of 62°N, in which it was estimated that catches of cod by tourist and leisure fishing is more than 20 times greater than the total consumption by harbour and grey seals. We cannot, however, ignore the fact that relatively large populations of harbour and grey seals in some areas could have an effect on local fish stocks.

In areas where it is claimed that seals cause damage to fisheries, increased hunting of seals should be based on exploration of the impact of seals on fish catches, gear and fish farms. At present, the knowledge based on systematic studies is poor.

The coastal seal and the ecosystem

The coastal seals' role in the ecological system is still insufficiently mapped along the Norwegian coast. Similarly, knowledge of parasitic worms in commercial fish species is limited. This applies to variations in quantities of parasitic worms from different areas at different times, as well as financial consequences for the fishing industry. Little information is available from Norwegian waters regarding where the coastal and particularly grey seals have their most important feeding areas, whether these are locally in fjords, close to the coast or further out on the edge of the continental shelf. Information from satellite tagged grey seals in Scotland showed that they fed far out in the North Sea. It is important to obtain such information on grey seals in Norwegian waters in order to evaluate the species' ecological importance and possible local impact on fish stocks.

In addition, such studies should include mapping of the most important fish resources and catches from fisheries (professional, leisure and tourist fishing). One such ecological study is now carried out by the Institute of Marine Research in the Porsangerfjord (Epigraph).

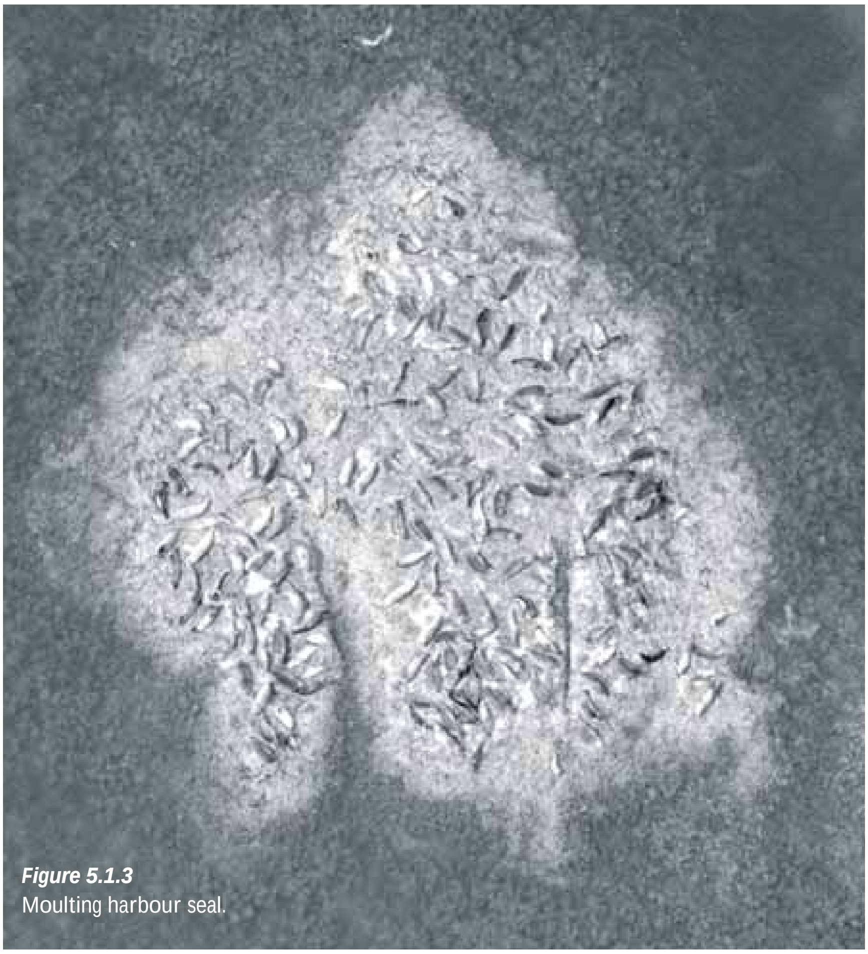


Photo: FotoNord

Figure 5.1.3
Moulting harbour seal.

Tore Haug
tore.haug@imr.no

5.2 HARP AND HOODED SEALS ON THIN ICE?

In a warmer Arctic, the living conditions for sea mammals would change. Increased water and air temperatures could: 1) lead to there being less drift ice; 2) have consequences for their diet as a result of the composition and availability of prey changing; 3) lead to increased competition, possibly also pressure from being predated on, from other marine mammals that have traditionally lived further south; 4) increase the risk of the outbreak of disease and exposure to pollution and human activity (for example, shipping traffic).

"Ice-loving" species of seals

The reduction in the ice sheet in Arctic Ocean areas could have particularly noticeable consequences for the so-called pagophilic ("ice-loving") species. These are species that are particularly dependent on sea ice for parts of their entire life cycle. The drift ice seals, the harp and hooded seals, are both pagophilic species. During both the breeding and moulting periods, they need to come out of the water, and both species use floating floes of ice in the Arctic as a basis for these objectives.

In our waters, there are two breeding and moulting areas for the harp seal: the Greenland Sea between Jan Mayen and Greenland, often called the West Ice, and the White Sea and the southeastern Barents Sea, also called the East Ice. The hooded seal only breeds and moults in the West Ice. Outside of the breeding and moulting periods, both the harp and hooded seal sare out on long migrations after food: the harp seal primarily in the vicinity of drift ice in the Barents Sea, while hooded seals migrate to more temperate areas in the Norwegian Sea. During this period, they regularly return to the drift ice, which is then used as a place of rest.

On thin ice?

Both the harp and hooded seals gather in large concentrations within relatively predictable, limited areas on the drift ice during the breeding period each spring (March–April). For this reason, both species have been important for commercial sealing. Management of these species is based on advice from the ICES. Both species are monitored through the size of their population and ability to reproduce being measured at regular intervals (about every five years). This has provided an important insight into both the status of the population and its development. Some observations have been made that could signal climate change and the reduction in ice has literally meant the future of these two species of seal being on thin ice.

Different population developments

In the first two decades after the Second World War, the hunting of the harp seal in the East and West Ice and the hooded seal in the West Ice was far too severe. These populations therefore reduced in size right until the end of the 1960s when regulations were introduced with regard to sealing activities. Combined with the reduction in sealing effort through the 1970s, this has had a positive effect on both the harp seal populations, which immediately began to increase. The hooded seal population in the West Ice continued, however, to reduce in size right up to about 1980. After this, it appears to have stabilised at a low level (around 80,000 animals), which is presumably no more than 10–15 percent of the level more than 60 years ago. The population was therefore given protected status in 2007.

The harp seal population in the West Ice appears to be steadily increasing and now amounts to more than 800,000 individuals. At the turn of the century, the harp seal population in the East Ice amounted to more than 2 million individuals. Russian aerial counts in the years after 2003 indicate, however, a considerable reduction in the population, which was no more than about 1 million individuals in 2009, that is to say, the population has apparently halved over a six-year period. The recommended quotas for the East Ice population were, therefore, dramatically reduced in 2009. We cannot ignore the possibility that the problems with the harp and hooded seals in the East and West Ices respectively could be connected to the reduction in the ice sheet.

Increased pup mortality?

The ice sheet in the West Ice is now considerably smaller than it was 20–30 years ago – the edge of the ice in March/April is now almost 150–200 nautical miles west of Jan Mayen, whereas, only a couple of decades ago, it extended all the way to the island. The ice sheet in the White Sea now freezes considerably later in the winter than only 5–10 years ago, and the ice is generally much thinner than before. The combination of less accessible drift ice, which is more open (a greater distance between the floes) and is considerably thinner, undoubtedly represents a deterioration in the vital breeding habitat for the harp and hooded seals. In Canada, mass mortality among harp seal pups has been observed in individual years when difficult ice conditions have been observed. Similar conditions have been observed for the harp seal in the White Sea, where the combination of poor ice and difficult conditions due to currents succeeded in wiping out large parts of the brood of pups in some years. The reduction in the ice sheet could also make seal pups more vulnerable to predation from, for example, the polar bear (because the ice sheet will become smaller and the breeding areas will be forced closer to land) and killer whales (because there will be more open water between the ice floes).

Photo: K.A. Fagerheim

Figure 5.2.1
Female harp seal with pup in the Western Ice.

Figure 5.2.2
Hooded seal with pup in the Western Ice. Is climate change in the process of destroying the ice conditions necessary for the hooded seal to reproduce successfully?

New addresses?
The odd year where few pups survive and with low recruitment to their populations is probably something that both the harp and hooded seals are in a position to cope with. With the more permanent reduction in ice caused by climate change, this lack of new recruits could become the rule rather than the exception. Will these seals continue to visit the same areas or will they look for ice of the quality they require in other areas? In 2007, a completely new breeding area for the harp seal was discovered at the southern tip of Greenland, far south of the traditional, well-known areas in the West Ice where both breeding and sealing has gone on for more than 200 years. Is it possible that some of the hooded seal populations in the West Ice have established themselves in new areas? The great and rather sudden reduction in harp seal pup production in the White Sea over the last few years has raised the question of whether some of this population may have established itself in new breeding grounds. This could, for example, be north in the Barents Sea where the animals traditionally feed in summer and autumn, and possibly in the southeastern areas of the Barents Sea or perhaps even as far east as the Kara Sea.

Wrong food?
Due to great seasonal variations in the availability of food, both the harp and hooded seals store energy reserves in the form of an increased layer of blubber in the late summer and autumn. This is their main source of engergy during winter and spring when their food intake is reduced. For adult females, the layer of blubber also forms the actual basis for milk production during the intensive suckling period. From the seals at the top, via their prey (large crustaceans living on plankton, capelin and polar cod) and down to the smallest crustaceans living on plankton in the Arctic food chain, it is vital that all species have a well-developed ability to absorb and store energy reserves in the form of fat during the the productive, light time of the year. With increasing sea temperatures, these species will come into competition with other species from more temperate areas further south where this strategy for energy storage is not really required or well-developed. For the seals, this could mean a transition from high-fat to low-fat food. Initially, this could affect their ability to deposit the necessary fat resources in their blubber and, in the next stage, could affect their ability to produce viable offspring. This would presumably be more of a problem for the harp seal, which feeds to a greater extent on Arctic species associated with areas on the edge of the ice sheet than the hooded seal.

Increased traffic and disease
Less ice in the Arctic could lead to an increase in human activity, for example increased shipping traffic. Increased stress caused by pollution could be another negative effect, particularly if this occurs in association with exposure to contagious, epidemic diseases. In the Skagerrak and North Sea, it is well-known that epidemic outbreaks of an influenza virus (PDV) wiped out large sections of the harbour seal population in both 1988 and 2002. Could something similar happen to hooded and harp seal populations, which are already under pressure due to to the reduction in the ice sheet and a possible lack of adequate food?

There are signs that several of the seal populations in the North Atlantic may already be having problems related to climate change. Both the hooded seal in the West Ice and harp seal in the East Ice are showing signs of fewer recruitments. Possible reasons for this are, however, still difficult to clarify and pose major challenges for the scientific circles that presently carry out monitoring and research into both these and other species for management purposes. The mapping of possible new breeding areas, clarification of the seals' general condition and their reproductive ability, state of health and possible stress as a result of pollution are, therefore, obvious urgent tasks. The seals are at the top of the marine food chain – the observations noted may be signals that something is wrong in the ecosystems the animals are living in.

Tore Haug and Tor Arne Øigård
tore.haug@imr.no
tor.arne.oeigaard@imr.no

5.3 ARCTIC SEALS – FROM PUP PRODUCTION TO SEALING QUOTAS

Since their ranges are primarily associated with areas containing drift ice, the harp and hooded seals are often called drift ice seals. In the spring, both species gather in specific drift ice areas in the North Atlantic to give birth to their pups; this has made hunting these polar resources possible. Over the last few years, the traditional Norwegian hunt for drift ice seals has been conducted in two fields in the Northeast Atlantic: In the West Ice (the drift ice in the Greenland Sea off Jan Mayen), both harp and hooded seals are hunted, but, in the East Ice (drift ice areas in the south-eastern part of the Barents Sea) only harp seals are hunted. There are also large populations of hooded and harp seals in the Northwest Atlantic. These populations are hunted today by Canada and Greenland while Norway pulled out after the 1982 season. The sealing season has always been concentrated to spring in the breeding areas.

Sealing

In the West Ice, the hunt for harp seals has been conducted since the 18th century. Norwegian sealers did not join this activity until the middle of the 19th century. The pressure from sealing was greatest in the 1870s and 1880s, something that contributed to the population probably being at a historic low at the turn of the century. Regulatory measures were introduced as early as in 1876, but quotas were not introduced until 1971. By that time, hunting yields had been reducing from 35,000–40,000 animals around 1950 to fewer than 20,000 animals in 1970. In the last 30 years, pressure from sealing has been very low with an average level of between 5,000 and 10,000 animals, primarily yearlings.

Since the 1860s, Russian and Norwegian sealers have hunted harp seal on drift ice in the White Sea and East Ice. There was much pressure from sealing on the East Ice population from the beginning of the 20th century up until the middle of the 1960s. Catches reduced, however, from around 170,000 just after the Second World War to around 80,000 at the beginning of the 1960s. In the middle of the 1960s, strict regulatory measures were introduced, including total quotas. Since

Photo: Michael Poltermann

Figure 5.3.1
When establishing the sizes of the seal populations by counting pups it is necessary to do this on the seals' breeding grounds. Then an ice-enforced vessel is required.

then, these quotas have varied between 35,000 and 80,000 animals, but, over the past 15–20 years, activity has been very low with 35,000–40,000 animals killed. Since 2005, there have been several years without any sealing. Norwegian vessels, for example, have not participated since 2007. As a result of pressure from animal protection activists, Russian authorities imposed a ban on hunting for seals younger than a year (i.e. yearlings) in the White Sea in the 2009 season. As Russian catches traditionally only contain yearlings, the hunt was cancelled.

In the West Ice, hunting for hooded seals has been conducted since the 18th century. Norwegian sealing operations did not begin, however, until the latter half of the 19th century. There is a lack of statistics regarding sealing prior to the Second World War as catches at this time were usually presented as the total catches of hooded and harp seals. It was actually not until after 1920 that hooded seal hunting in the West Ice began to be of an extent that was really significant. With the exception of a general halt to sealing during the Second World War, intensive hunting of the species was conducted right up to the 1960s. In addition to the breeding areas in the West Ice, Norwegian sealers were involved in hunting hooded seals in their moulting areas in the Denmark Strait from 1904, with increased activity after the Second World War. Soviet/Russian whaling ships took part in the West Ice during the period, 1955–1994.

At the end of the 1950s, the total average level of annual catches (the West Ice and Denmark Strait together) was almost 70,000 hooded seals. This level of hunting was too high and regulatory measures were necessary. For this reason, quotas were introduced on hunting in the Denmark Strait (where it was now clear that the majority of the animals came from the breeding grounds in the Northwest Atlantic) in 1958. These sealing operations were cancelled after the 1960 season. In 1958, agreements were reached between Norway and the Soviet Union on time and activity restrictions on sealing in the West Ice, but it was not until 1971 that quotas were introduced. By that time, the volume of catches has been reducing from the middle of the 1960s, partly as a result of a reduction in activity. The volume of catches continued to decrease: While this was at an annual average of about 47,000 hooded seals in the first half of the 1960s, it had reduced to around 6,000 animals by the beginning of the 1980s. Average catches over the past 25 years have been 5,000 animals, primarily yearlings ("bluebacks"). As a result of falling recruitment to the population, the hooded seal was given protected status in the West Ice from the 2007 season.

The management system

The Ministry of Fisheries and Coastal Affairs and the Directorate of Fisheries are responsible for the management of the drift ice seal populations. The scientifically based advice is provided through international institutions such as ICES – the International Council for the Exploration of the Sea and NAMMCO – the North Atlantic Marine Mammal Commission. The basis for recommendations on hunting quotas for Arctic seals are laid down by a working group for harp seals and hooded seals (WGHARP – Joint ICES/NAFO Working Group on Harp and Hooded Seals) consisting of researchers from Canada, Denmark, the Faroe Islands, Greenland, Iceland, Norway, Russia and the USA.

On the basis of advice provided by WGHARP through ICES, the actual regulatory provisions for sealing (quotas, date and area restrictions, instrument provisions etc.) will be laid down by Norway for hooded and harp seals in the West Ice and by Russia for harp seals in the East Ice. Questions on ICES' quota recommendations are discussed in a joint working group set up within the framework of the Joint Norwegian–Russian Fisheries Commission. The working group's mandate has included mutual reporting of catches and research over the past year, assessing seal populations, drawing up proposals on sealing quotas (dividing the quota between the two nations) and other regulatory provisions for the coming season and also mutual information on agreements on research work for the following year.

Estimation of population size

Assessing population sizes for drift ice seals is based on estimates of the annual pup production. Harp and hooded seals concentrate together in the drift ice during the breeding season. The pups are born there and live on the ice during the entire suckling period. In the case of hooded seals, the suckling period may be 4–5 days and 10–12 days for the harp seal. Pup numbers are estimated either through experiments using the mark-recapture method or by means of the strip transect method, performed by means of aerial photography or visual counts from helicopters. Breeding takes place over a relatively short period of time. Using the strip transect method, information must, therefore, be gathered on the progress of breeding in order to be able to make a correction in respect of pups born after the count. In the case of the hooded seal, which has a short suckling periods, pups that have left the area must also be estimated. Pup production is used in population models, where sealing and biological data are included in order to estimate both the total population and sustainable hunting levels.

In 2007, the Institute of Marine Research carried out an expedition to perform population estimates for the harp and hooded seals in the West Ice. During the field work, planes were also used (stationed on Iceland, Greenland and Jan Mayen) and helicopters (stationed on board). The plane and, to some extent, the helicopter were initially used for reconnaissance flights in order to locate the breeding areas. In the areas between Greenland and Jan Mayen and between about 71°N and 73°N, a total of three different breeding grounds were located. In each breeding patch, the progress of breeding was monitored by estimating the distribution of births over the pupping season. This was done by assessing the proportion of pups in each of five distinct age-dependent stages (based on pelage color and condition) from helicopter at regular intervals over the entire patch.. During their first weeks of life, the pups undergo a number of changes in colour, hair cover, condition and behaviour. This makes it possible to classify them into age stages. This determination of stages showed that most of the breeding in 2007 took place during the period 23 to 29 March in the case of the hooded seal and 15 to 21 March for the harp seal. This breeding peak may vary somewhat in time from one year to the next.

The extent of pup production was estimated using strip transect counts. The transect lines were straight, parallel lines that were moved in an east-west direction over the breeding areas. The distance between the lines varied from 2 to 5 nautical miles, depending on the size of the breeding area. Along the transect lines, the pups were photographed from the plane, which flew backwards and forwards at a constant distance between the transect lines. This method for estimating pup production is based on knowing the length and breadth of the strip being counted visually or photographed. The average density of pups can thereby be estimated for each line and this can, in turn, be used to estimate the total pup production during breeding. For the harp seal, the estimated pup production from the counts in the Western Ice in 2007 was almost 110,500 pups, with a margin of uncertainty of 25 percent. For the hooded seals, pup production is estimated to be 16,000 pups with an uncertainty margin of 13 percent.

Population sizes and advice on quotas

The advice from ICES requires up-to-date information on the status of the populations. In order for the populations to be regarded as what is described as data-rich, several independent population estimates much be available (preferably no fewer than three within a period of 10–15 years, with the time between each estimate being 2–5 years). The estimates must have an acceptable degree of precision and the latest population estimate must be no more than 5 years old. In addition, roughly similar up-to-date information on the population's productivity and mortality must also be available. Unless this information is available, the population will be classified as data-poor and the management strategy will have to be based on a more cautious level.

WGHARP met in both 2008 and 2009 to assess the status of the populations of harp seals in the East Ice and West Ice and the hooded seal in the West Ice.

Based on the working group report from the WGHARP meeting in 2008, ICES formulated new assessments of the statuses and guidelines for managing these seal populations. The results of the latest WGHARP meeting have not, however, been discussed by ICES' advisory committee (ACOM) yet, as there was no fresh request from the Norwegian administrative authorities in 2009. In its assessments regarding seal management for 2010, the Joint Norwegian–Russian Fisheries Commission therefore used the advice from ICES in 2008 and the latest results from WGHARP's meeting in 2009 as its basis.

The harp seal population in the West Ice is estimated at around 810,000 animals in 2009. The level for sustainable catches for 2010 and the years to come was calculated at 30,865 one-year old and older animals or an equivalent number of pups (where two pups balance an older seal). In addition to the harp seal population in the West Ice now being classed as data-rich, ICES has also said that the current population estimate is the largest observed for this population. At the request of the Norwegian administrative authorities, ICES has, in principle paved the way for a management strategy in which the long-term objective could be to bring this population down to around 70 percent of today's level. This would mean catches above a sustainable level for a limited period of time (10 years). Model estimates show that a catch level for 2010 and the years to come of 42,000 one-year and older animals or an equivalent number of pups (where two pups are equivalent to an older seal) will meet this condition. Once the population comes down towards 70 percent of today's level, there will be a return, according to ICES' framework for self-management, to a catch level that coincides with the estimated sustainable level. ICES emphasises that implementing a hunting strategy like this will require the populations to be monitored carefully so that the impact can be documented with new data.

Photo: K.A. Fagerheim

Figure 5.3.2

When counting seals, a plane is used that flies in transects over the breeding grounds. The density of pups and the range of the breeding area are recorded photographically. Pup production is estimated by multiplying the number of pups per area unit by the entire area of the breeding grounds.

Russian aerial pup counts in 1998–2003 indicated a total harp seal population in the East Ice of a good 2 million animals. Later counts, carried out by the Russians between 2004 and 2009, indicate, however, a significant reduction in pup production, from around 330,000 in 2003 to 160,000 in 2009. So far, there is no satisfactory explanation for this, but it cannot be ruled out that difficult ice conditions in the White Sea after 2003 may have contributed. It is possible that some of the population may have migrated to new, as yet unknown breeding locations outside the White Sea – this should be investigated.

With this dramatic decline in pup production, the usual population model was not able to estimate the population's status and catch potential in a useful manner. The model was, therefore, only used to develop a conversion factor between observed pup production and the total population. This gave an estimated total population of about 1.1 million animals in 2009.

Due to the problems involved in using the usual population model, but also because the East Ice population is now apparently between 30 and 50 percent of previously observed levels, ICES has used the conservative PBR (Potential Biological Removal) method for estimating a sustainable catch level. The PBR method was originally developed in the USA and is used to estimate whether unintentional bycatches of, among other things, seals is sustainable in relation to the size of the populations. Using the PBR method, ICES concluded that a cull of around 30,000 harp seals for 2010 and the following years would, in all likelihood, lead to a slight growth in the population.

The West Ice population of hooded seals was estimated at around 82,000 animals in 2008. The model considerations forming the basis for these estimates indicate that this population has declined considerably in size during the period from the end of the 1940s on to around 1980. After this, the population appears to have stabilised at a low level, which is presumably no more than 10–15 percent of the level more than 60 years ago. ICES has, therefore, recommended that there is no cull of hooded seals in the West Ice from the 2007 season and sealing has now ended. The exception to this ban is a limited catch for research purposes. Research activities have been commenced to clarify the conditions involved in the hooded seal's weak population status in the West Ice.

Nils Øien
nils.oien@imr.no

5.4 WHALE COUNTS AND POPULATION ESTIMATES

Figure 5.4.1
Two whale counters vigilantly scanning the sea from the crow's nest.

Once Norway resumed commercial minke whaling in 1993, this was on the condition that this would be managed on a sustainable basis and based on the so-called *RMP* (Revised Management Procedure). By then the RMP had been developed in the International Whaling Commission's Scientific Committee (*IWC/SC*) for several years and had been chosen as the best procedure in the sense that it provides the best results in simulations of underlying conditions and management targets.

Visual counting expeditions and other methods

The RMP is intended to be a generic procedure for baleen whales. It can be implemented for individual species and populations and the population's characteristics in relation to genetic structure, behaviour and biological parameters can be incorporated. Once implementation and parametrization have been carried out, only two types of data need to be added: catch histories and abundance estimates with associated uncertainties. The population estimates must be gathered at not too great intervals as there is a scaling-down rule in the RMP that takes the quotas down to zero if a new population estimate for an area is not approved within six years. Trends in the population estimates and the associated uncertainty are of great importance for the quotas. At present, it is only population estimates based on visual counting expeditions that have been approved for use in the management procedure but, in principal, there is nothing to prevent the estimates being based on some other method. The population estimates are prepared and discussed at the Scientific Committee. The Commission has adopted "Guidelines for conducting surveys and analysing data within the Revised Management Scheme". These are a set of guidelines that form the basis for dealing with the entire process from the planning, implementation and analysis of counting expeditions to the final approved estimate.

New management procedures

Before the RMP was developed, the management of the minke whale was based on analysis of whaling data. The commercial use of the minke whale began around

1920 and, from 1938, a licensing scheme for small-scale hunting of the four species, the minke whale, the northern bottlenose whale, pilot whale and killer whale, was introduced. Since that time, we have information on all whales that have been caught. Whaling data was used to estimate catches per unit of effort – indices that were expected to reflect population trends and thereby form a basis for quota regulation. At the beginning of the 1980s, however, major question marks were raised regarding whether these indices painted a true picture of the population status and how they should be interpreted. The result was moving away from these indices as a basis for management. The International Whaling Commission brought a halt to whaling and the Scientific Committee worked on developing new management procedures.

In recognition of the need for a new method, we began experimental counting expeditions on a small scale in 1984 and 1985. We based this on the so-called line transect method, which involves working through an area using planned transects and recording all whales observed and where these whales are seen in relation to the boat. On the basis of this, we can estimate the number of whales that were in the area we studied using statistical modelling. Because the transect is regarded as representative of the total area, we can scale the result up to a total abundance. The results of these first trials were disappointing, however, as it became quite obvious that rather a lot of observer resources are required in order to obtain sufficient data for modelling.

Important assumptions for the line transect method

The traditional line transect method (also referred to as "distance sampling") has become the preferred method for whale counts. The method provides the best and most effective sampling at relatively low population densities. Although the method is quite robust, it is based on some assumptions that can create problems. All whales on the transect line must be detected (”g(0)” = 1), the whale must be stationary in relation to the movement of the boat and the measurement of the relative position of the whale in relation to the boat (distance, angle) must be exact. For large whales, such as the fin whale, violations of the assumptions are not so great that the method does not provide acceptable estimates for most purposes. For minke whales, however, the situation is completely different. Firstly, the minke whale is only available for observation above the surface about 5% of the time. When it is available, it is also very difficult to see. Usually only a dorsal fin and a bit of its back are visible; we rarely see a spout from the minke whale in our waters. As this is the target species for our whale counts, we have, therefore, further developed the fundamental method in order to come to grips with these special problems. On each individual boat, we have two independent observation platforms in a symmetrical design so that, when we compare the observations made from the two platforms, important correction values can be calculated.

Observations from symmetrical platforms

For the minke whale, we have also introduced "tracking", a special technique where, in the event of observing a minke whale, the observer tries to follow the whale for as long as he can. This could, however, be interpreted as a trial to see how good the second platform is at seeing the same whale. Because the platforms are independent, each series of observations from a platform can be seen as a test for the second platform. The platforms are symmetrical and this provides effective use of the data. In the analysis, there is a module where the minke whale's diving pattern is simulated on the basis of real dive data. The data is collected in separate experiments by means of radio tagging. This is a complicated, but important, element of the analysis method. Since these counting expeditions are carried out under many different wind and weather conditions, this

Photo: K. A. Fagerheim

Figure 5.4.2
Not just observers, but also those ensuring that the data is correctly stored for later analysis, must perform an accurate job if the counting results are to be exact enough to be used for setting quotas.

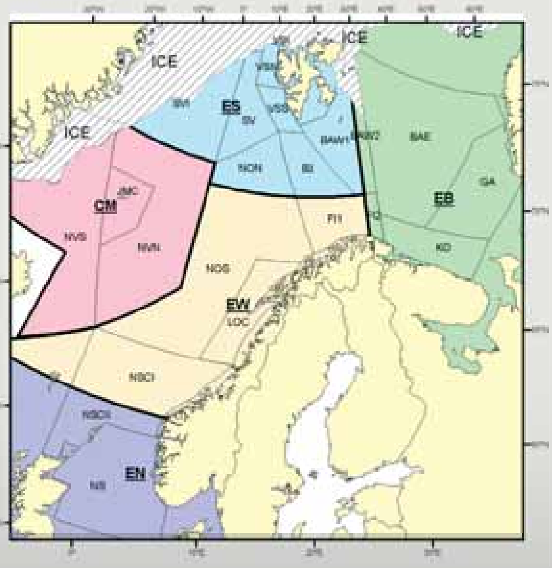


Figure 5.4.3
Overview of the geographical area that forms the basis for Norwegian minke whaling. Since the last revision in 2003, the area includes two "regions": C and E. Each of these is again divided into smaller management areas, where the Jan Mayen area, CM, belongs to region C and the rest (EB, ES, EW and EN) belong to region E. For the practical execution of the counts, the areas are divided into blocks (strata) to take account of differences in whale density and to achieve a uniform level of cover within the block.

information is also gathered in tandem and used in covariant analyses. Because the observers cannot always estimate distances and angles for their observations without error, in addition, our own calibration experiments are carried out to estimate errors and uncertainties in the estimates. The analytical method also uses aggregation of minke whales at several levels. This is done because the minke whale clearly demonstrates such behaviour and thereby departs from a fundamental assumption of an even distribution in its range.

The great 1995 whale count

The total area forming the basis for Norwegian minke whaling is a good 3 million km² (see figure 5.4.3), but will vary somewhat, depending on the extent of the ice coverage in the north in the Barents Sea and west of Spitsbergen and Jan Mayen. In 1988 and 1989, we had good coverage of central areas for Norwegian minke whaling. So, in 1995, we carried out an expedition involving 11 boats, which covered the entire Northeast Atlantic with the exception of an area between Iceland and Jan Mayen, and a basic estimate was established for the minke whale population in the North east Atlantic. The great benefit of this expedition was that it covered the entire area in question at the same time ("synoptic"). But it was of the utmost importance that a plan was now established that could produce regular population estimates for the minke whale in the Norwegian whaling area. After the great whale count in 1995, the basic method was established, but it was clear that it would be extremely difficult to obtain the necessary resources within a year to perform a synoptic counting expedition across the entire population area equivalent to the 1995 expedition.

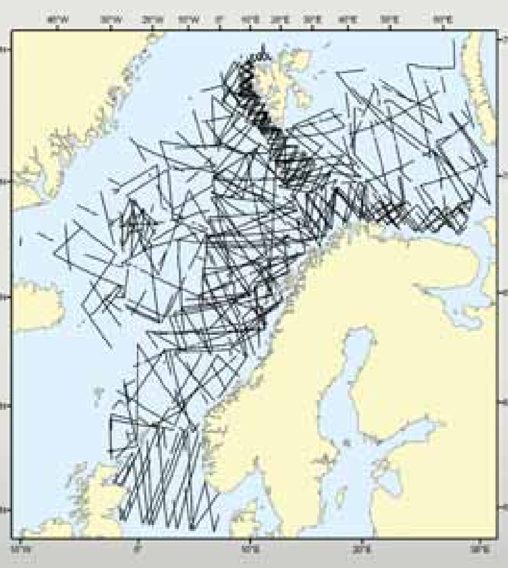


Figure 5.4.4
Overview of transects that have been covered by primary search activities in whale surveys during the years 1984–2008.

Whales are changing their distribution

This was also another problem with the 1995 expedition; the data gathered were extremely heterogeneous. This was probably due to great variation in the abilities of the whale observers, different degrees of follow-up and execution in line with the expedition protocol on the part of the expedition leaders and also great variations in observation platforms and boats. It was decided that whale surveys should be carried out for the entire area over a six-year period with the same resources each year. This has led to a new problem in the analyses, that is to say, the introduction of a model that calculates the extra uncertainty we get in our data because whales are expected to move from year to year as a result of changes in biotic and abiotic factors. This is a well-known phenomenon that whaling statistics for the minke whale since 1938 illustrate. There are quite obviously periods when the minke whale has a dominant western or eastern distribution.

Using this plan, a population estimate for the total area can be presented every six years and thereby satisfy the RMP's requirement for regular monitoring of the population and, in so doing, avoid a reduction in the quotas.

Since the 1995 expedition, we have completed two counting cycles: 1996–2001 and 2002–2007. Figure 5.4.4 shows the transects used in primary search operations during the years 1984–2008.

Four estimates for the Northeast Atlantic population

The most important minke whale population hunted by Norwegian whalers is the Northeast Atlantic population that is found in the North Sea, along the Norwegian coast, in the Barents Sea and at Svalbard.

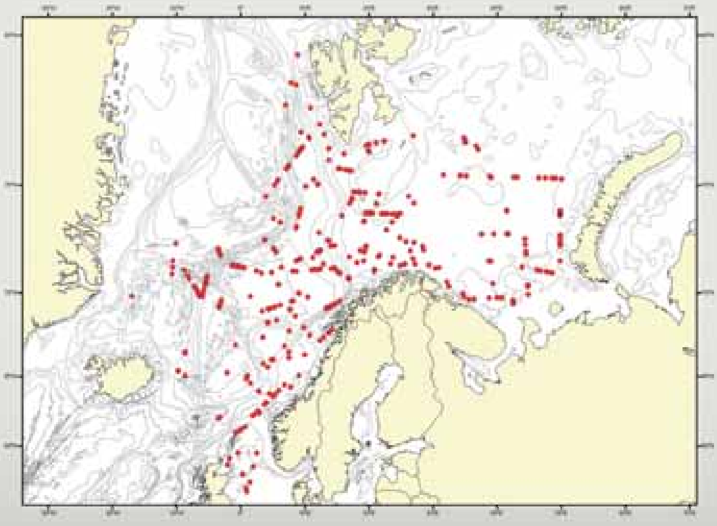


Figure 5.4.5
Primary observations of minke whales in the last counting period, 2002–2007.

We have four estimates so far for this population: 65,000 (1989), 112,000 (1995), 80,500 (reference year 1999, based on counting expeditions during the period, 1996–2001) minke whale, and the newest estimate so far of 81,400 (reference year 2005, based on counting expeditions during the period, 2002–2007). That is to say, the population counts have varied a bit with a clear peak in 1995, but, in the period since 1995, the population figures have remained stable.

Norwegian whalers also carry out limited hunting of the population in the economic zone around Jan Mayen. Here, the basic population has been estimated at 26,700 (cv 0.14) for the minke whale based on a count carried out in 1997 and the same figure for the count carried out in 2005 was 26,700 (cv 0.39). For the Northeast Atlantic Ocean, in the areas east and north of Cape Farewell, the total population of minke whales has been estimated at 184,000 animals, based on counts carried out in 1995.

Compared with 1995, the minke whale had a more western distribution in the northeastern Atlantic in the period between 1996 and 2001. By the end of the six-year cycle from 2002–2007, we have covered the Norwegian Sea (2002), Svalbard (2003), the North Sea (2004), the Jan Mayen area (2005), the Norwegian coast, including Lofoten/Vesterålen (2006) and the eastern Barents Sea (2007). It appears that the tendency from the previous cycle towards a more westerly distribution in summer has continued. In Figure 5.4.5 a distribution map is shown for observations of minke whales in the last complete counting period, 2002–2007.

Whale counting expeditions have also provided valuable information about the abundance, distribution and trends of other whale species, particularly great whale species. In Norwegian waters, there are around 6,400 fin whales, 1,450 humpback whales and 6,200 sperm whales. While the fin whale and humpback whale at times migrate to the Barents Sea in the late summer and autumn, the sperm whale remains on the edge of the deep Norwegian Sea.

Useful in ecosystem models

Population estimates for marine mammals are primarily used for management, either in specially developed procedures, such as the RMP, or in population models. Now and then, we have several population estimates available and can analyse trends. But they can also be used in ecosystem models or in other contexts. Generally, we primarily want accurate estimates, that is to say, we have made corrections in respect of factors that we believe skew matters. Our next priority is having as little uncertainty as possible in the estimate. This uncertainty usually has a clear connection to the effort we put in, but it is usually possible to find a sensible level for our resources on the basis of a cost/value assessment.

When used in multi-population and ecosystem models, uncertainty in estimates will probably be overshadowed by model uncertainty. We will usually require at least five surveys over a specific period of time in order to be able to say anything useful about trends in the population.

Mette Skern-Mauritzen
mette.mauritzen@imr.no

5.5 GRAZING BALEEN WHALES IN THE BARENTS SEA: MOSTLY KRILL OR A BIT OF EVERYTHING?

The Baleen whales – important predators in the Barents Sea
The minke, humpback and fin whales are the most abundant baleen whales in the Barents Sea. Around 60,000 minke whales and 1,800 fin whales graze in the Barents Sea in the summer, but it is uncertain how many of the roughly 6,400 humpback whales in the Northeast Atlantic that migrate to the Barents Sea. Because it is both numerous and relatively big (about 10 tonnes), the minke whale is one of the most important predators in the Barents Sea, measured by consumption.

The minke whale's diet early in the summer has been carefully studied through studies of the stomach content of whales caught. These minke whales preferred to graze on capelin, but also foraged on herring and krill. Since the 1980s, the quantity of capelin in the Barents Sea has fluctuated greatly, from around 0.1 million tonnes to almost 8 million tonnes. These fluctuations were very important for the minke whale's diet, because their diet reflected what was available: The consumption of herring and krill increased when there was no capelin.

Figure 5.5.1, A
Grazing humpback whale in the Barents Sea. Note the extended ventral grooves.

Photo: K. A. Fagerheim

Figure 5.5.1, B
In addition to being an instrument for swimming, humpback whales' tail fins also have individual colour patterns that mean that we can recognise individuals and thereby chart migrations to, for example, their calving areas in the Caribbean Sea, or we can study individual behaviour while at their grazing area, as here in the Barents Sea.

Photo: K. A. Fagerheim

Figure 5.5.1, C
Humpback whales are very charismatic animals. They seem to like to play, often jumping and falling back in a cloud of ocean spray. Humpback whales also have a complex song and use "bubble nets" to concentrate their prey. This behaviour and their long and very mobile black and white fins contribute to the charisma of the species.

Photo: K. A. Fagerheim

Figure 5.5.1, D
A humpback whale has just come to the surface in the middle of a ring of "bubble nets" that we can see the remnants of as lighter-coloured water around the whales. It had its mouth open when it surfaced and filled its oral cavity with large quantities of water and prey so that the ventral grooves were greatly extended. See also Figure 2.1.1.

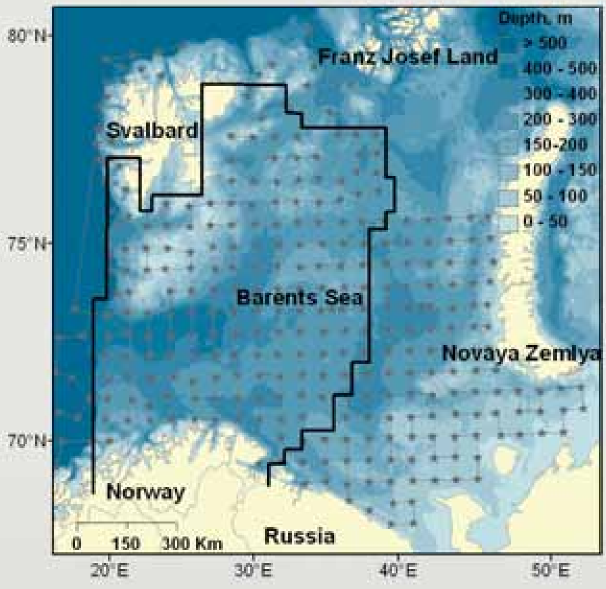


Figure 5.5.2
Maps that show the extent of the Norwegian-Russian ecosystem expedition in 2005 and the limited area (thick black line) included in this study. Dotted grey lines show the transects the vessels have covered, while grey stars show the position of the trawl stations. The blue colour in the background indicates depth.

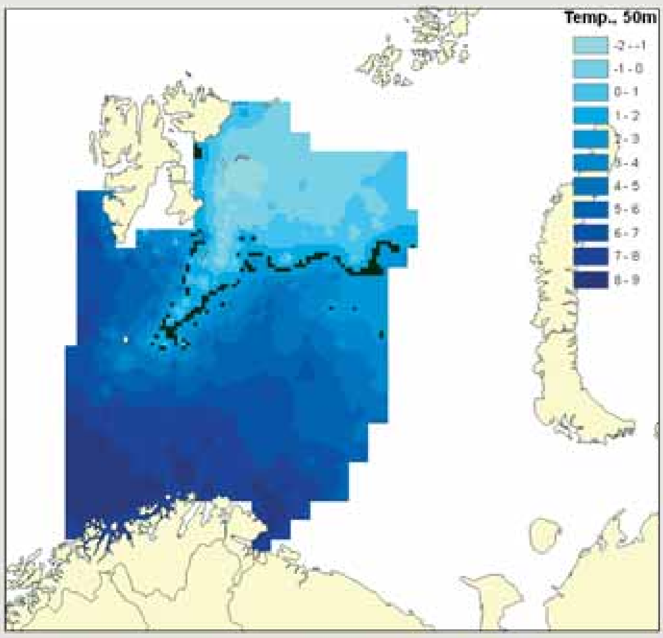


Figure 5.5.3
Temperature (°C) at a depth of 50 metres. Black fields show the position of the polar front where the temperature is around 2°C. The areas north of the polar front are characterised by cold Arctic water masses (<2°C) and the areas south of the polar front by warm Atlantic water masses (> 2°C).

During the years, 2003–2007, marine mammal observers took part in the Norwegian-Russian ecosystem surveys in August–September. While the ecosystem survey covers the entire Barents Sea (Figure 5.5.2), the whale observers only took part in the western area in the first few years and it is this area that forms the basis for this study. On the ecosystem surveys, pelagic trawl catches provide information on the distribution of zooplankton, such as krill and amphipods. Acoustic measurements along the transects between stations provide data on the distribution of pelagic fish such as blue whiting, herring, capelin and Arctic cod. In addition, the temperature and salt content of the water masses are measured and we thereby also obtain information about the physical habitat. The Barents Sea is characterised by warm Atlantic water masses in the south and cold Arctic water masses in the north, which meet along the productive polar front (Figure 5.5.3). The distribution of these water masses is of great importance for the distribution of species in this ecosystem.

According to ecological theory, there should be a positive relationship between the distributions of predators and prey. Where there is much prey, we expect to find more predators than where there is little prey (Text box 1). We can, therefore, use the spatial association between the species to identify which prey predators feed on. The years 2003–2007 were characterised by a particularly warm climate and low capelin abundance because the capelin population collapsed in 2003. On the other hand, herring was abundant in the Barents Sea. In line with the previous studies of the minke whale's diet, we expected, therefore, that the minke whale would feed on herring and krill and that the minke whale's distribution would reflect this. We do not have corresponding information on the diets of fin whales and humpback whales. But fin and humpback whales often feed in the same areas as the minke whale, which suggests they have a relatively similar diet. For this reason, we also expected these whales to feed on herring and krill.

Spatial distribution of whales and potential prey

In order to get an idea of the general distribution of zooplankton, pelagic fish and baleen whales, we first modelled their average distribution over all years. In order to do this, we used general additive models (GAM) based on the distribution of physical habitats (depth, salinity and temperature). The average distributions are shown in Figure 5.5.5. Here, we can see that the quantity of krill and amphipods increases to the north towards the cold, Arctic water masses. The pelagic fish share the Barents Sea between them; blue whiting in the south-west, herring in the south, capelin along the polar front and Arctic cod in the

Figure 5.5.4
A fin whale grazing on the surface of the Barents Sea.

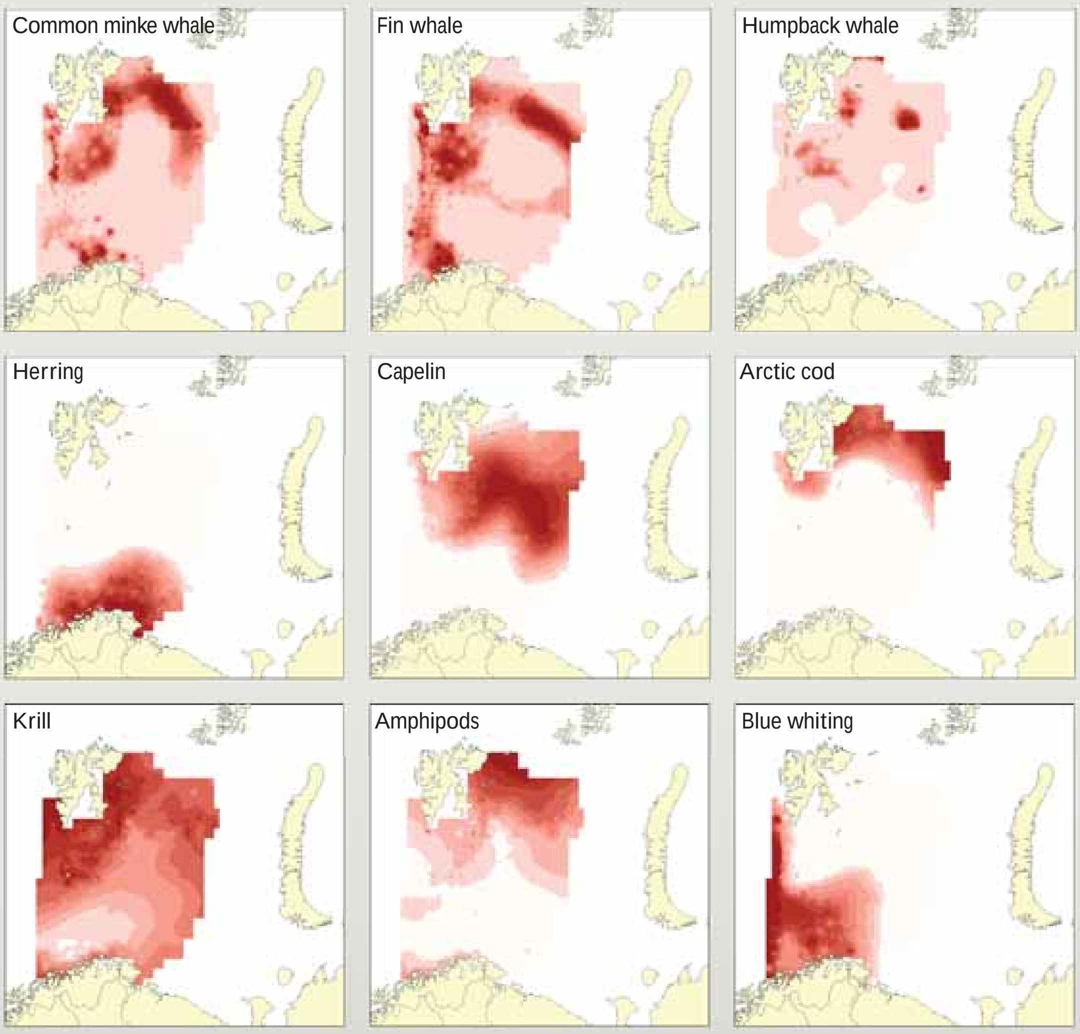
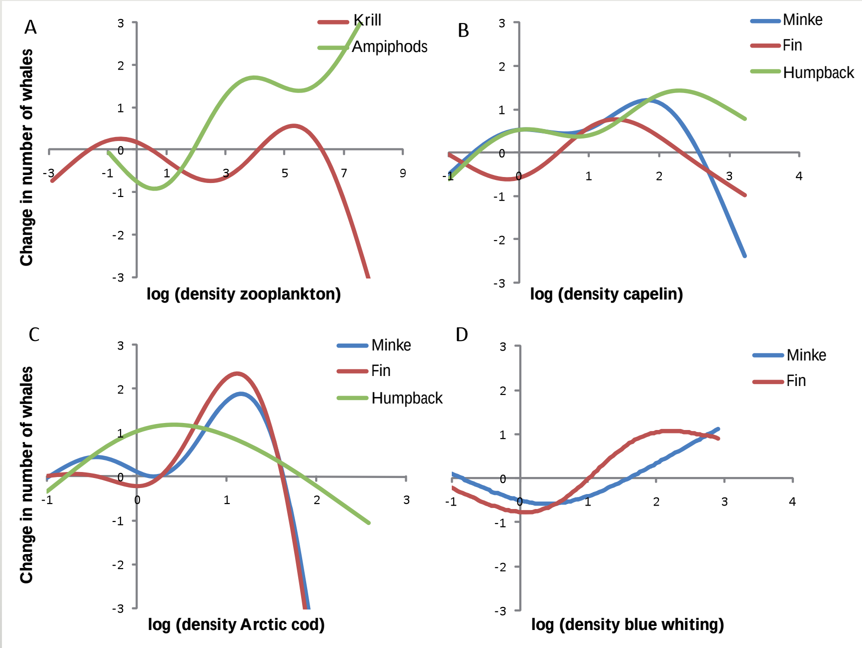


Figure 5.5.5
The average distribution of zooplankton, pelagic fish and baleen whales for the years 2003–2007. Darker colours indicate greater densities, and these densities range from 0 to 0.03, 0.06 and 0.18 individuals per km for minke, fin and humpback whales, from 0 to 1.13, 1.04, 0.79 and 2.20 for Arctic cod, capelin, herring and blue whiting (on a logarithmic scale, acoustic quantity per nautical mile), and from 0 to 6.07 and 6.30 for krill and amphipods (on a logarithmic scale, kg per nautical mile).

Figure 5.5.6
Changes in the density of baleen whales with a density of prey A: krill and amphipods, B: capelin, C: Arctic cod and D: blue whiting. In the case of krill and amphipods, we have looked at the density of baleen whales in total for the three species due to few observations of whales in grid cells with trawl stations.



northern, cold water masses. The baleen whales had relatively similar distributions. The majority of minke, fin and humpback whales stayed within a narrow zone along and north of the polar front. This zone corresponded to areas with a high density of krill but lay north of the areas with a high density of capelin and south of the areas with a high density of Arctic cod and amphipods. A smaller proportion of minke whales and fin whales also stayed along the shelf break in the west and the southwest Barents Sea.

Are baleen whales krill specialists in the late summer?

The overlap between baleen whales and krill in the north may suggest that these whales primarily graze on krill and that krill is, therefore, an important alternative prey when there are few capelin in the sea. The increased density of krill towards the north is probably due to grazing throughout the summer; the southern and central areas have been ice-free and accessible to predators longer than the northern areas. This depletion of zooplankton causes capelin to migrate north as the ice gradually retreats and new areas with high production are opened up. The baleen whales also undertake a similar migration. Baleen whales are large and warm-blooded. A baleen whale weighing about 40 tonnes, such as a small fin whale, must eat 600–1,600 kg of zooplankton a day to cover its energy requirements. Baleen whales are, therefore, dependent on being in areas with a very high density of prey in order to graze effectively. Capelin are also an important krill predator and, where there are many of them, they can almost empty areas of krill in just a few days. But capelin are also small and cold-blooded and a few individual krill are a good meal. It is, therefore, likely that capelin can cater for their food requirements at lower densities of krill than baleen whales. In this case, baleen whales and pelagic fish and other krill predators may be involved in asymmetrical competition for krill. Capelin may reduce the krill to densities below critical levels for baleen whales, but it is not certain that baleen whales can do the same to capelin.

Are baleen whales generalists in the late summer?

We also carried out a more detailed analysis of the spatial relationships between whales and their prey. We divided the study area into 50 km grid cells (so that we got about one trawl station of zooplankton in each cell). We calculated the density of whales and prey in these cells for each year. In order to reflect the results based on the average distributions, we expected the baleen whales to show a positive association with krill (Text box 1): in cells with a lot of krill, there should also be a lot of baleen whales and, correspondingly, there should be few baleen whales in cells with few krill. The expected connection between baleen whales and prey did not materialise. The baleen whales did not demonstrate a positive match to krill, but to amphipods. The humpback whale was also positively associated with capelin. In addition, the minke whale and fin whale were positively associated with one of the southern pelagic fish, the blue whiting (Figure 5.5.6). There may be several reasons for the spatial relationships between whales and prey changing from the average distributions to distributions in 50 km grid cells. This could be related to the quality of the data – it is likely that a trawl haul will not really provide an exact picture of the quantity of krill in a 50 km grid cell. High densities of krill were also observed in the central Barents Sea in areas without whales and in areas where there were few krill on average. A lack of a match between krill and whales in the grid cells could, therefore, also tell us something about what is important for the whale; it could prove more rewarding in the long run for them to spend time in areas where, on average, there is a high krill density, than in areas with a locally high krill density but where, on average, there is a lower krill density.

Another possible explanation is that baleen whales are generalists in these northern areas and graze on several species. In this case, they are there because there is a high total biomass of prey; a lot of krill and a little of the other prey combined can provide a lot of food. In fact, the areas in the north continually hold a lot of food, despite the great variation in the quantities of the different species. In years where there are little capelin, there are high densities of zooplankton, as was observed in the period 2003–2007. In years with much capelin, capelin typically migrate further north, probably due to increased depletion of zooplankton. In years with much capelin, the quantity of zooplankton in the north may, therefore, by reduced by increased grazing of capelin but, in return, be replaced by an increased immigration of capelin into the area. Our results suggest that krill, capelin and amphipods may be relevant prey in these northern areas. In order to look more closely at this explanatory model, we must calculate the biomass of prey and then see if there is a correlation between whales and the total biomass of prey. While the biomass of pelagic fish is routinely calculated following ecosystem surveys, the lack of information on the trawl's effectiveness in catching krill and amphipods is an obstacle to calculating biomasses of zooplankton.

In addition to harbouring a lot of prey, there may be good topographical conditions in the north. These areas are relatively shallow (Figure 5.5.2) and baleen whales can, therefore, graze over the entire water column.

What happens when capelin return?

These two explanatory models, whales as krill-eaters and whales as generalists, provide different expectations to the whales' response to an increased quantity of capelin. If the whales prefer to graze on krill, the whales will continue to avoid areas where krill is depleted by capelin and other predators. An increased quantity of capelin in the north is then expected to lead to a corresponding northern movement by baleen whales. If the whales are, on the other hand, generalists and prefer to graze in an area with their preferred topography, the whales distribution is expected to remain relatively stable. The increased migration of capelin will increase the spatial overlap between whale and capelin and increase predation on capelin. A third alternative is also a possibility: that whales may move from, for example, krill to capelin only when there is enough capelin to graze on. In this case, we would expect the whales to move south and have a more compact distribution similar to that of the capelin, rather than the narrow, oblong distribution observed in 2003–2007 (Figure 5.5.5). The capelin population began to increase again in 2006. In 2007 there were 1.88 million tonnes of capelin and, in 2008, 4.43 million tonnes. Nevertheless, the majority of baleen whales were observed within the same narrow, oblong zone in the north in both 2007 and 2008. This stability in the distribution of the whales, despite great changes in the capelin population therefore clashes with the generalist model. Due to a lack of observations from 2009, we must wait until after the 2010 survey before we have enough observations for detailed analyses of the whales' response to the return of the capelin.

Whales and southern fish populations

Because there were few capelin in the Barents Sea, we expected that herring would be an important prey. We can determine with a great deal of certainty that this was not the case at this time of the year. Their distributions hardly overlapped, and only a limited number of fin and minke whales stayed in the southern Barents Sea (Figure 5.6.5). These two whale species were, however, spatially associated with blue whiting (Figure 5.6.6). The blue whiting is a Norwegian Sea species that increased in the Barents Sea at the beginning of the 21st century. Normally, this species, which often keeps to deep water, is a more important prey for deep-diving toothed whales than for baleen whales. But, when the blue whiting comes in over the continental shelf, it also comes up to depths that can be reached by the baleen whales and they can then form part of the baleen whales' diet. Regardless of this, it is a small proportion of the whale populations that overlap with the blue whiting (Figure 5.5.5), so, despite the spatial correlation, there will be relatively little pressure from grazing.

There may be several reasons for baleen whales deciding to migrate north to graze on prey other than herring even when there are a lot of herring in the system. Herring exhibit an extremely dynamic shoal behaviour and grazing on them is demanding. Such shoal behaviour is less dynamic among the northern prey, such as krill and capelin. If the whales are generalists in the north, they also have more species to graze on in the north than in the south. This can provide access to both a greater total biomass and a more predictable supply of food.

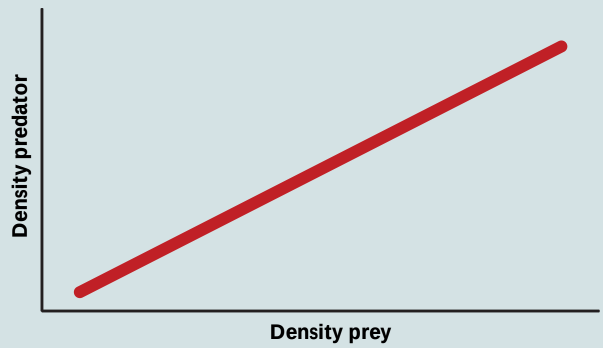
Different prey in the preferred habitat

The Norwegian–Russian ecosystem surveys have given us a new insight into the ecology of baleen whales in the Barents Sea. In the late summer, they mainly graze within a narrow zone along and north of the polar front, although the quantity of the different prey varies. This stable distribution suggests that baleen whales graze on different prey in a preferred habitat and that the degree of predation on different prey depends on the overlap within these areas. Southern prey are hardly grazed on, despite the abundant southern pelagic fish populations. It is important to emphasise that this study was carried out in years with a very warm marine climate and years with low capelin abundance. In colder climatic conditions, the ice may stretch towards the areas that are now open and available to the whales and possibly reduce the production of zooplankton. A colder climate could, therefore, change both the distribution of the whales and the overlap with prey.

Text box 1

Spatial relationships between predators and prey

An overlap between predators and prey is a necessity in order for the predators to be able to feed on prey. In addition, we also expect there to be positive, spatial associations between predators and prey: Where there is a lot of prey, there are more predators than where there is little prey (Figure). This expectation is associated with two ecological processes. One process is an *area restricted search*. The search pattern of the predators is conditional on the density of prey. Where there is little or no prey, predators move quickly and in a specific direction to leave the area quickly. If the density of prey increases, their speed decreases and their search pattern becomes more intricate. Predators thereby spend more time in areas with more prey, which gradually leads to an inflated number of predators in areas with a lot of prey. The second process is the principle of *ideal free* distribution. This principle dictates that the predators will distribute themselves in such a way that the density of predators relative to the density of prey will be constant so that there will be an equal amount of food for everyone. An area with a lot of prey can nourish more predators than an area with little prey. The principle of ideal free distribution in particular is associated with several unrealistic assumptions. Nevertheless spatial associations between species are an important and useful method for identifying predator-prey relationships.



Expected connection between density of prey and predator.

Christian Lydersen and Kit M. Kovacs
christian.lydersen@npolar.no
kit.kovacs@npolar.no

5.6 SVALBARD'S RESIDENT MARINE MAMMALS AND THE CLIMATE THREAT

Photo: Kit M. Kovacs/Christian Lydersen

Figure 5.6.1
The ringed seal is the most common seal species in the Svalbard area and also the seal species that is most dependent on sea ice.

We have eight species of marine mammals that spend their entire life cycles in the Svalbard area. There are four seal species (ringed seals, bearded seals, harbour seals and walruses), three species of whales (bowhead whales, white whales and narwhals) and also the polar bear. All of these species are affected to a greater or lesser degree by how sea ice varies in time and space.

Today, there are numerous models that attempt to predict how the Arctic will be affected by the climate of the future. There is, of course, a great degree of uncertainty in these models, but, by and large, they all agree that there will be a dramatic reduction in sea ice extent and thickness, and that this will happen rapidly. This is in fact already taking place; there has been a considerable reduction in both the extent of the ice and its thickness over the last few decades. In addition, many models indicate that the Arctic will be totally ice-free in the summer as early as a decade from now and that large parts of the Barents Sea and Greenland Sea will also be ice-free in the winter. Such major physical changes would have extensive consequences for life in these regions.

Competition from the south

We have no experience regarding the effects of climate change occurring as rapidly as we assume will be the case in the Arctic in the coming years. For this reason, the assessments that follow are more "educated guesses" than data-based predictions. However, it is certain that if even some of the expected physical changes that are predicted to take place do indeed take place, this will lead to significant biological community changes. Many of the species living in the Arctic have developed as a response to the general global cooling that has been going on for the last 5 million years. But, the warming predicted will occur too quickly to accomodate via adaptation (evolutionary change through natural selection). Animals will simply shift geographically where possible to stay within their biological comfort zones, or they display however much flexibility they have in terms of behavioural or physiological "scope" in dealing with the changing environment. Some temperate species (that like warmer conditions) have already extended their ranges northward into Arctic areas and, it is expected that some of the Arctic species will experience range reductions or even extinction. In addition to direct competition from more southerly species Svalbard's marine mammals will also be exposed to changes in prey populations, with more temperate low-energy species replacing their lipid-rich Arctic prey.

Marine mammals at Svalbard will likely be exposed to more pollution due to increasing discharges from rivers in industrialised areas to the south under warmer climatic conditions. Additionally, they will be exposed to new diseases and parasites and they will also be more exposed to human disturbance from increased shipping traffic, oil and gas activities, mining operations and tourism.

The ringed seal

Many seal species depend on sea ice for their survival. They need the ice as a birthing and moulting platform and as a resting platform and many are also dependent on sympagic (ice-associated) prey. The ringed seal is the most common species of seal on Svalbard and is the most vulnerable to changes in the extent of the ice, as so many aspects of their lives are linked to the ice. They have quite specific requirements for ice availability as well as the need to have a good snow cover on sea ice by the early spring so that they can build snow caves on top of the ice in which to give birth to their pups, in addition to stable ice that will remain long enough for their normal suckling

Photo: Kit M. Kovacs/Christian Lydersen

period. Ringed seals hardly ever go ashore and starting to do so would be a major change in the species' behavioural repertoire. Giving birth on land would lead to a tremendous increase in mortality for the pups, mainly due to increased predation.

The bearded seal and walrus

The bearded seal's range and breeding success are dependent on suitable ice conditions (small pieces of free floating packice) over relatively shallow areas. There needs to be a good supply of bottom-living animals that make up most of the diet of this seal species (fish, crabs, shrimps etc.). Similarly, the walrus, which also feeds itself on bottom organisms, mainly clams, has very specific requirements when it comes to ice. They spend the winter in areas with pack ice. The ice must be thin enough for them to keep breathing holes open and, at the same time, thick enough to be able to withstand their weight when they climb up and rest on it. When the sea ice extent in the Arctic retreats to the point where it only exists in areas where the water is deep, walruses and bearded seals will both face challenges; they will have to travel much longer distances between their resting places and their food. Both these species do use land as a resting platform in some areas of their range, so it is possible that both the bearded seal and the walrus could adapt their breeding strategy; changing to giving birth on land.

They could then adjust their ranges to places where there is a rich supply of benthic food in the vicinity of their resting places during the ice-free period. This would however, in a best case scenario, result in overall range reduction and hence likely also abundance reduction. Apart from when breeding, the Atlantic walrus already relies on land as a resting platform much of the summer throughout much of its range.

Another problem with the ice retreating is that this could lead to a general reduction in benthic production, which bottom-feeding pinnipeds depend on for food. This is because most of the sympagic production currently sinks to the bottom when ice melts in spring and summer, raining food to the different benthic organisms. Without sea ice, most of the production associated with sea ice would be retained in the pelagic ecosystem and not reach the bottom and its benthic residents.This would result in less food being available for the bearded seal and walrus.

Figure 5.6.2
Bearded seals prefer shallow water areas close to the coast where they find their prey, which is mainly caught close to or at the bottom.

Figure 5.6.3
Walruses use both land and ice as resting platforms. However, if there are ice floes in the vicinity of their foraging areas this is definately their preferred habitat.

Photo: Kit M. Kovacs/Christian Lydersen

Photo: Kit M. Kovacs/Christian Lydersen

Figure 5.6.4.
The harbour seal population at Svalbard is by far the most northerly population of this species in the world and a warmer climate would probably be a positive thing for this small population.

The harbour seal

For the small, genetically isolated, population of harbour seals on Svalbard, climate change will probably be a positive thing. This largely temperate species has a range that spreads down the European coast and it is actually restricted by the extent of the ice. When Arctic sea ice retreats northward, this species is likely to expand its range northward.

The bowhead whale

How this purely Arctic baleen whale species will tackle climate change is more uncertain than our assumptions for the sympagic seal species and polar bear. Each of the three Arctic whale species prefers slightly different conditions as regards ice cover, depth and the structure of the bottom of the sea.

The bowhead whale is considered the best adapted of all whale species to ice. They have the thickest skin and blubber of all the whales and can surface through up to 60 cm thick ice to breathe. They are dependent on small crustaceans (calanoid copopods and krill) for food and changes in the ice conditions are likely to have considerable consequences for the food supply of this whale species. Today, Svalbard bowheads are critically endangered. Despite having been protected for a long time this species is finding it difficult to make a comeback, though there have been some very positive signs in recent years. It is difficult to say whether this species will be able to survive in an Arctic without ice in summer.

Figure 5.6.5.
The white whale is the most abundant species of whales at Svalbard. This species can be found within the pack-ice, along the edge of the ice-covered areas and in ice-free waters.

Photo: Kit M. Kovacs/Christian Lydersen

The white whale and narwhal

The white whale and narwhal also spend a lot of time in ice-filled waters and are often seen along the edges of the ice and in open channels far inside the ice. But both species also spend a significant amount of time in the summer months far south of the ice edge. At Svalbard, it appears that the white whales find a lot of their food in front of the many glaciers throughout the archipelago. Narwhals can be found near the coast in the summer, but, in winter, they migrate out to deeper water where bottom conditions are more complex. These are often areas that are totally covered by ice but, since this is drift ice, there are always some small cracks and openings where they can surface to breathe. They eat a lot of squid and Greenland halibut and climate change would probably affect these whales as a result of changes in their prey abundance and distribution. The greatest threat to these three species of whales would probably be competition from other whale species that would move north once the ice was gone. In addition, it is assumed that the ice provides these three species with protection from predation by killer whales. If this protection was gone, this could pose a threat, particularly for the slow swimming bowhead whales.

Figure 5.6.6

The polar bear finds most of its food out on the sea ice and is, therefore, very vulnerable to changes in the ice conditions.

The polar bear

The polar bear is closely associated with sea ice and any changes in sea ice extent will have impacts on polar bear populations. The polar bear hunts its food on the ice, primarily ringed seals, but also other species of ice-associated seals. The ice is also important when the polar bear moves from one area to another. Pregnant females dig out holes in the snow, often in steeply sloping areas near the sea, where they give birth to their cubs. In some areas they even den on sea ice. But in any case all bears are dependent on good ice conditions with a supply of seals once they come out of their lair in the early spring after many months without feeding. We have already been able to see the effects of climate change on the polar bears that live in the southern parts of their range. In areas in both Canada and Alaska, the bears traditionally live on land in the summer. They eat little if at all while waiting for the ice to form. Now, the prolongation of the ice-free period (and thus the period of fasting) is leading to the females generally being in poorer condition and having fewer and smaller cubs with less chance of survival than before. Mortality in older bears has also increased due to their poorer body condition.

Land-based polar bears?

If the sea ice breaks up earlier in the spring, this could lead to separation of their wintering and spring-hunting areas. Adult animals are very good swimmers but young cubs are not and they lose heat quickly in cold water. A total lack of sea ice in the summer means that the only chance of survival for the polar bear would be to become a land-bear like the brown bears they are descended from. But the polar bear cannot survive on plant food alone, unlike the brown bear. They depend on prey that is high in energy (fat-rich food). In Arctic areas other than Svalbard, brown bears and polar bears could soon have overlapping ranges, with associated competition, and increased chances for hybridisation. Increased conflict with humans is also probable if polar bears spend more time on land in summer and there are more human activities in the Arctic. Polar bear experts have asserted that the polar bear is unlikely to survive as a species if the sea ice disappears as quickly as some of today's climate models indicate. These models suggest that the sea ice between the Northeastern part of the the Canadian Archipelago and West Greenland is likely to last the longest into the future, so this area might be a last strong-hold for polar bears in the decades to come.

The scenarios regarding what might happen to Svalbard's marine mammals described here mostly focus on negative consequences because Svalbard's marine mammals of the present are mostly Arctic specialists. But it should be pointed out that the expected changes will bring with them new opportunities for other species. A warmer Arctic with a longer growing season would probably be a more productive system than today. In addition, we should not forget the often surprising abilities that many species show in the face of adversity and not ignore the possibility that at least some of these Arctic marine mammals would be able to survive in some places in the Arctic of the future.

Øystein Wiig, Kit M. Kovacs and Christian Lydersen
oystein.wiig@nhm.uio.no
kit.kovacs@npolar.no
christian.lydersen@npolar.no

5.7 THE BOWHEAD WHALE – OUR MOST THREATENED WHALE POPULATION

Photo: Ø. Wiig

Figure 5.7.1
A rare sight – tagging and sampling a bowhead whale in the Fram Strait in the spring of 2010.

The bowhead whale is the animal species that was of greatest importance for the early development of human activity at Svalbard (and in other Arctic areas). When Svalbard was first discovered, in 1596, the bowhead whale was one of the most abundant animals in the area. Estimates suggest that the population numbered in excess of 100,000 individuals before whaling began. The fjords were full of them and they were a major resource. Bowheads swim slowly and float after they are killed (due to their thick layer of blubber). It was therefore easy for the early whalers to catch and was given the name "right whale" – the right whale to catch. Whaling began in 1611 and, over the course of a few hundred years, the species was almost extirpated at Svalbard. The same thing happened in other areas of the Arctic. Old whaling reports show that more than 100,000 bowhead whales were caught in the Svalbard area over the centuries that whaling went on.

What is a bowhead whale?

The bowhead whale can weigh up to 100 tonnes and is one of the largest creatures ever to have lived on our planet. Adult males are between 14 and 17 meters long, while females are a little bigger, up to 20 meters. The fluke (tail) measures 6 meters across in adults.

The bowhead whale is well adapted to ice-filled waters and it can dive under the ice for more than an hour. The large, powerful head makes up a third of its body length. The whale uses its head to break through up to 60 cm thick ice in order to breathe through its raised nostrils, which sit on the top of its head. In order to retain heat, the bowhead whale is packed into a thick layer of up to 50 cm of blubber lying under the 2–3 cm thick skin. The bowhead whale is a baleen whale that lives on tiny crustaceans that are only millimeters long which it filters out of the sea using its baleen.

Bowhead whales are large, round, dark animals. They lack a dorsal fin and have white lower jaws and cheeks. Their neck is curved so, when swimming on the surface, there is water between the head and back. They may also have white patterns on their fluke. The white patterns on their head and tail distinguish the bowhead whale from their closest relative, the North Atlantic right whale, which is uniformly black. It is believed that the latter is extinct in Norwegian waters.

Populations

The bowhead whale has a circumpolar distribution that is strongly associated with Arctic drift ice. The International Whaling Commission (IWC) has defined five populations of bowhead whales in the Arctic. There are two populations in the Pacific; one in the Sea of Okhotsk consisting of just a few hundred animals and a large population in the Bering Sea with about 10,000 animals. In addition, there are two populations in the area between East Canada and West Greenland, in

Photo: L. Walløe

Figure 5.7.2
A bowhead whale caught by Eskimos at Point Barrow on the north coast of Alaska. Note the very long and narrow baleen plates. The whale is lying on its back.

Hudson Bay/Foxe Basin and Baffin Bay/Davis Strait respectively. In total, there are 5,000–7,000 bowhead whales in this area. The Spitsbergen population is the last of the five populations. It can be found in ice-filled waters in the area between East Greenland and the western parts of the Russian Arctic east to the Kara Sea. The Spitsbergen population is considered the "Norwegian" population, since it lives primarily in the area around Svalbard. Today, it is estimated that the population numbers less than 100 individuals.

It is, however, uncertain whether this is a separate population or whether individuals migrate here from other areas of the Arctic. A new genetics technique has been developed over the last few years where DNA is extracted from ancient material. Along the coast of Svalbard, there are lots of large whale bones that have drifted ashore over thousands of years. Samples of these whale bones have been gathered and dated in order to study post-glacial sea level history on Svalbard. DNA has also been extracted from the bones in order to analyse the population structure of the bowhead whale in the Arctic after the last ice age. Using this method, we have compared the Spitsbergen population with bowhead whales that are found in the Bering Strait today. No genetic differences were found. This indicates that there has been contact between the Bering Strait and Svalbard whales over time. In light of this, we can ask the question whether the division of the bowhead whale into five populations, as suggested by the IWC, is correct. Bowhead whales probably migrate between populations to a greater extent than was previously assumed, and bowhead whales from other areas may migrate to the Svalbard area. In addition, the bone analyses demonstrate a lot of genetic variation among whales that lived during and after the great whaling period of the 17^{th} and 18^{th} centuries. Despite the fact that this whaling was intensive, it did not, apparently, lead to a genetic bottleneck in this population.

The bowhead whale was probably a species that developed in the northern hemisphere about 8 million years ago. Genetic exchange between whales found in different areas was probably possible in the warm periods between ice ages that followed. After the last ice age, about 10,000 years ago, the bowhead whale entered the Arctic Ocean via the Bering Strait and spent parts of the year in the Beaufort Sea. The population in the Davis Strait between Greenland and Canada may have come from the Bering Sea population or from a population that survived the last ice age in the Gulf of St Lawrence in Canada or from the Spitsbergen population in Svalbard. The population in Hudson Bay in Canada probably comes from the St Lawrence population, while the Spitsbergen population probably consists of descendants from a population that survived the last ice age in the Northeast Atlantic. This knowledge of migration after the last ice age is based on finds of old whale bones along the Arctic coasts. These bones have been dated using the C^{14} method so we know when the animals died. This is then compared with other information about the extent of the ice over the last 10,000 years.

Population dynamics

Bowhead whales reach sexual maturity when they are about 14 meters long and probably about 25 years of age. Mating takes place in March–April. The female is courted by one or more males. They vocalise noisily in order to communicate with each other. The gestation period is about 14 months, so their calves are born in late spring or early summer. They are about 4 meters long when they are born. Females care for their calves for an extended period of ~3 years, and there can be a period of 4 years or more between births.

As a general rule, the ages of mammals are determined by counting growth zones in the teeth, which are similar to the annual rings in trees. This is not possible with baleen whales because they have no teeth. But we know that bowhead whales can reach very old ages from other information. In the 1980s and 1990s, remains of harpoons made from stone and walrus teeth were found in bowhead whales caught in Alaska. Harpoons like this were used by the Inuit up until the 1880s, when they shifted to iron harpoons. This indicated that these harvested animals were very old. Recent research into the determination of the ages of whales is based on gradual changes in the molecular structure of an amino acid (aspartic acid) in the lens of the eye. This method suggests that bowhead whales can live over 200 years. So, the bowhead whale is not only one of the largest creatures ever to have lived on our planet, it is likely also one of those that live longest. Some of the whales swimming today at Svalbard may have been born before 1814, when Norway got its Constitution!

Food

When the bowhead whale feeds, it swims with its mouth open at the surface (or at greater depth). The engulfed water is filtered through up to 400 four-metre long baleen plates that hang down from the upper jaw. Enormous quantities of planktonic crustaceans measuring 1–30 mm in length are filtered out of the water and then swallowed. Spring is an important feeding period for the bowhead whale. When the ice melts, the blooming of phytoplankton begins. This leads to zooplankton such as copepods, that have spent the winter at great depths, coming up to the surface to feed. These copepods are the main diet of bowhead whales. Studies using instruments fastened to bowhead whales have shown that they dive to depths where the concentration of copepods is greatest. But when the whales swim with their huge mouths open, many different organisms are eaten. Stomach contents of bowhead whales caught in Alaska have contained hundreds of different species.

It is difficult to estimate how much food a bowhead whale needs to eat. Researchers in western Greenland have estimated that the whales that are there in the spring eat just under a tonne of copepods a day. So it is easy to understand that, if the population was as large as 100,000 individuals before whaling began, the bowhead whale must have had an enormous impact on the energy budget of the Arctic ecosystem in the area.

Today's whaling

The Spitsbergen population of bowhead whales is one of the most threatened whale populations in the world and, consequently, is totally protected. The population is red-listed by both the International Union for Conservation of Nature (IUCN), and the Norwegian Biodiversity Information Center. In other areas, some whaling still goes on. In Alaska, an estimated 50 animals are caught each year in a traditional manner by local Inuit. This whaling is sustainable and the population is growing. Over the last few years, the hunting of just a few individuals in both eastern Canada and western Greenland has been allowed. This whaling is also sustainable and approved by the IWC.

The Spitsbergen population today

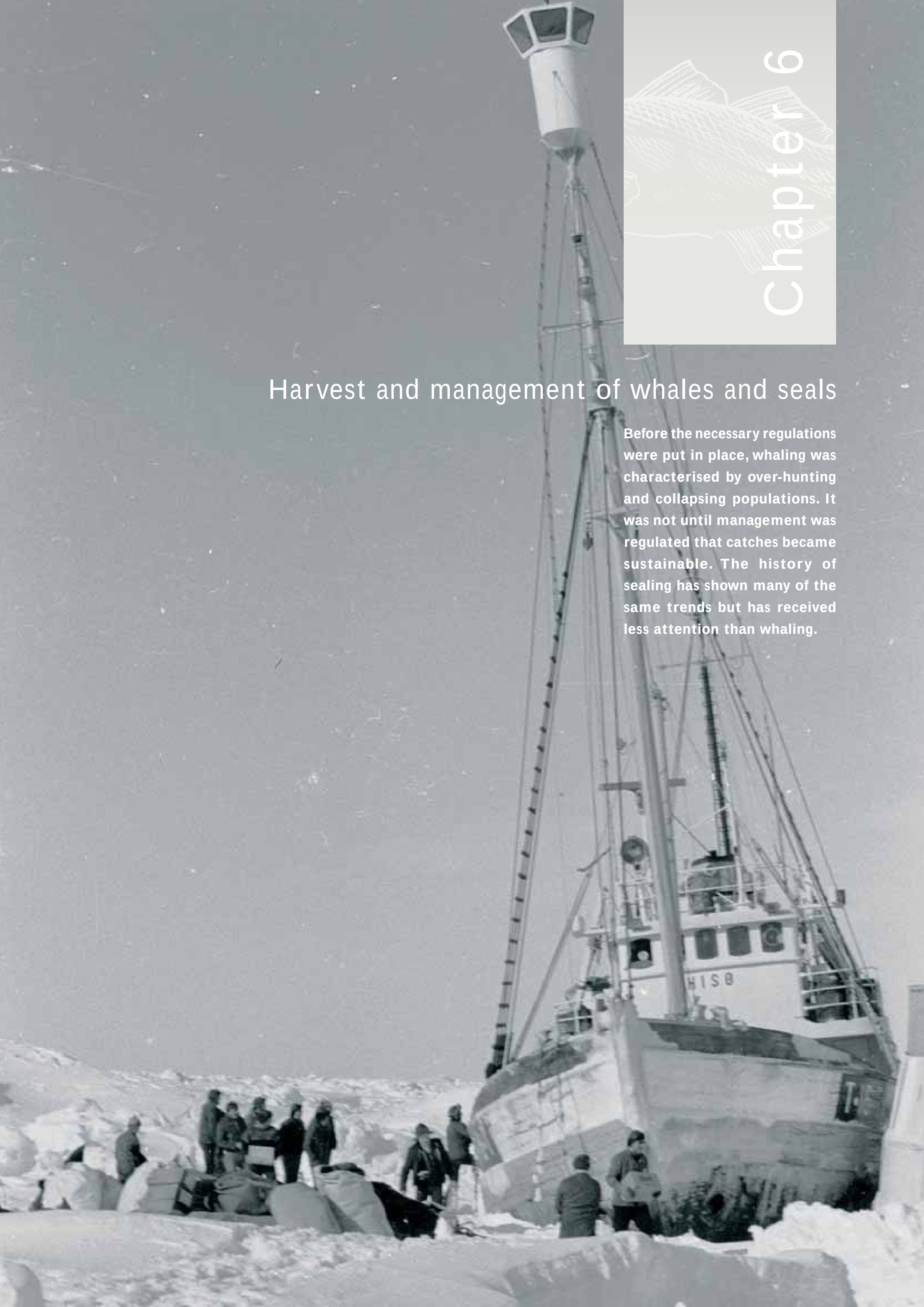
Although the Spitsbergen population is extremely threatened, more and more observations of bowhead whales have been made in the area between eastern Greenland and Frans Josef Land. In Norway, it is the Norwegian Polar Institute and Institute of Marine Research that record such observations. If we combine Norwegian observations west of 45° east with observations made on the east coast of Greenland, only 6 observations of the bowhead whale were made in the period from 1940 to 1979. From 1980 to 1999, there were 21 observations, while there have been as many as 52 in the last 10 years. This suggests an increase in the population. However, human activity has also increased in this area, so the increased number of observations must be interpreted with caution. These observations have mainly come from whalers, cruise ships and different research vessels.

In 2006, we carried out our first dedicated bowhead expedition, using the research vessel "Lance" in order to locate bowhead whales in the Fram Strait between Svalbard and Greenland. The expedition concentrated on an area close to 80º north and the meridian line, which has been named "The Northern Whaling Ground" or "Whalers Bay". This is an ice-free bay in the drift ice, which is kept open by a branch of the Gulf Stream that comes from the south along the west coast of Svalbard. The whalers used to say that the whales came from the south into this area in the spring. Many bowhead whales were caught here in the 17th and 18th centuries. In 2006, the area up to 82° north was totally ice-free. Nevertheless, we located bowhead whales in the area where they used to be found many hundreds of years ago. The reason they migrated to this area and still do so is perhaps driven by the great spring plankton bloom in this area. Spring is the mating season for the bowhead whale, so this may also be of significance. Expeditions looking for bowhead whales were also carried out in the Fram Strait in 2008 and 2010.

Today, the ice conditions at Svalbard are very different from how they were in the 17th and 18th centuries, but their migration patterns appear to be unchanged. Bowhead whales are found in the Fram Strait in the spring and then spread to eastern Greenland and into the Barents Sea in the summer. In order to obtain information regarding when the bowhead frequents the area, a listening buoy was set out on a research rig that the Norwegian Polar Institute has put out at the bottom of the Fram Strait. This listening buoy was retrieved in in the autumn of 2009 after having continually recorded all sounds in the area for a year. It turned out that there was vocalisation by bowhead whales throughout the entire winter. The Fram Strait appears to be a very important winter habitat for this species.

During expeditions over the last few years to the Fram Strait to search for bowhead whales, the intention was also to collect skin samples for genetic studies of today's whales living in the area. The skin samples were collected using a crossbow. An arrow with a hollow blade with a diameter of about 8 mm with internal barbs at the end is fired into the skin of the whale and collects a small sample for genetic analyses. In the coming years, we will also use satellite transmitters on the whales in order to obtain more information on their migration patterns and the diving behaviour of this threatened whale population.

We can only hope that the Spitsbergen population of the bowhead whale is now recovering. If the number of bowhead whales increases, they will perhaps again become an important ecological component in the marine ecosystem at Svalbard.



Chapter 6

Harvest and management of whales and seals

Before the necessary regulations were put in place, whaling was characterised by over-hunting and collapsing populations. It was not until management was regulated that catches became sustainable. The history of sealing has shown many of the same trends but has received less attention than whaling.

Arne Bjørge
arne.bjorge@imr.no

The framework in international law for the management of living marine resources is defined in the UN's Convention on the Law of the Sea (UNCLOS) from 1982. Articles 61 and 62 of the Convention describe the conservation and harvest of living marine resources in the economic zones of the coastal states. Articles 63 and 64 describe species that occur in more than one country's economic zone and migratory species. As yet, these are general provisions, but it is worth noting that special provisions have been defined for marine mammals. Article 65 actually lays down that there is nothing in this Convention to restrict a coastal state or an international organisation's right to ban, restrict or regulate the hunting of marine mammals in a stricter manner than prescribed in this section of the Convention. States are directed to work together on the conservation of marine mammals and, in the case of the whale, states are to work together through international organisations for conservation, management and scientific studies.

Articles 118 and 119 describe the conservation and regulation of living marine resources in international waters ("high seas") and Article 120 lays down that Article 65 regarding marine mammals also applies to international waters.

In order to understand why marine mammals have been given such special treatment in central, international regulations, it is necessary to know a bit about the history of whaling and sealing. The history of whaling and sealing actually encompasses a great number of situations in which over-hunting has led to collapsing populations. Some populations have, after being protected for a long time, increased again and serve as examples of the benefits of conservation. Other species and populations, such as Stellar's sea cow and the grey whale in the Atlantic, are gone for ever.

The main epochs in whaling and sealing are described below with a short discussion on international agreements and organisations for today's management of marine mammals.

6.1 THE HISTORY OF WHALING

We must distinguish between small-scale hunting for marine mammals along the coasts, where the proceeds are mainly for local use and consumption, and industrial harvest, which often occurs over great areas of the ocean and where the products form part of international trade. Industrial whaling has gone through many phases that have been dependent on the discovery of new whale resources and the development of new hunting methods.

6.1.1 ANCIENT COASTAL WHALING

A whale that had become stranded, living or dead, was of great value in pre-industrial times. We can see this from, among other things, the detailed regulations on the rights to stranded whales in the Gulating Law. This legislation dates back to about 950 but was not put in writing until the beginning of the 12th century. The finder's rights depend on the size of the whale, whether it was found stranded or driven ashore and whether the finder has contributed to getting it ashore.

We have, however, far older records of marine mammals being actively hunted in Norway. An approximately 4,000 year old rock carving on Rødøy in Nordland shows a hunter in his canoe-like boat hunting for porpoises and grey seal (Figure 6.1).

A special method for active hunting is known from Sotra outside Bergen, where this form of hunting continued until far into the 20th century. When whales entered narrow sounds or bays, the whales were shut in using whale nets. Some places where we know of hunting using this method are Skogsvåg and Telavåg in Store Sotra and the sounds on both sides of Bildøy between Store and Lille Sotra. If large whales, such as the minke whale, were trapped in in this manner, they had to be killed before they could be pulled ashore and butchered. They were shot using arrows from a crossbow. According to August Brinkmann Jr. at the University of Bergen, these arrows could be poisoned with "bacteria" that caused a disease called "braxy" in sheep. This disease has been known for hundreds of years in Sotra. Once the whales were sufficiently weakened by the infection, they could be pulled ashore and killed. This and similar forms of hunting have probably occurred in many places along the Norwegian coast where conditions were ideal for it.

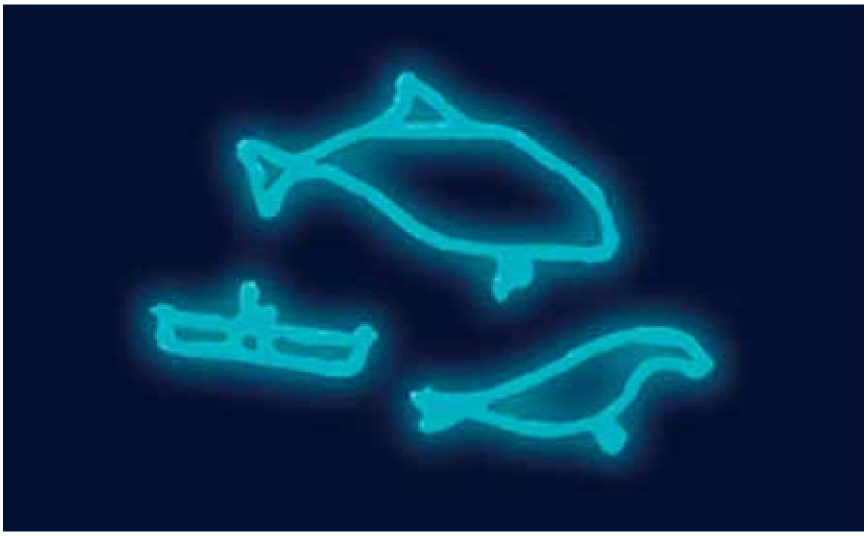


Figure 6.1.1.1
Reproduction of a rock carving on Rødøy in Nordland.

We must assume that different forms of coastal whaling have existed everywhere that people have lived along the coast and where marine mammals occur. Coastal whaling like this, following ancient traditions, still continue in the Faroe Islands, at Taiji in Japan, Indonesia and among many ethnic groups in the Arctic.

6.1.2 THE BASQUES HUNTING OF RIGHT WHALES IN BISCAY

As much as a thousand years ago, the Basques were involved in extensive hunting for great whales in Biscay. It was the North Atlantic right whale that formed the basis for this whaling. The North Atlantic right whale swam slowly and even floated once it had been killed. The North Atlantic right whale was, therefore, an easy target. In Biscay, this probably also began with whales drifting ashore. The meat could be eaten and the blubber boiled down into an oil that was particularly used in lamps. The Basques soon learned that whales coming close to land could be scared into shallow water and killed. In the 12th century, there were a great number of "whaling towns" in the Basque Country. Watch towers were built at strategic locations and the alarm was raised as soon as a whale was sighted and boats headed out to drive the whale towards land.

Gradually, it became rarer for North Atlantic right whales to come close to land, and the Basques set out to sea with bigger vessels in order to find them. North Atlantic right whales could, of course, be killed at sea since their bodies floated. Until the 16th century, the Basques were more or less the only people involved in whaling at sea and they have left many traces behind in the history of whaling. The word, harpoon, is said to come from a Basque word, "arpoi", which describes the hand weapon they used for killing.

In practice, the North Atlantic right whale was wiped out from the Northeast Atlantic but the Basques found new populations in Newfoundland and could continue their whaling for some time. This whaling is also said to have paved the way for cod fishing off Newfoundland. The Basques salted the cod at sea and took it back to Europe.

6.1.3 HUNTING BOWHEAD WHALES IN THE NORTH ATLANTIC

In the 16th century, rich communities grew up in Europe, communities that traded across the high seas. Portugal and Spain took the lead with trade routes to both Central and South America and to the Orient. The countries in the north wanted to go into competition with Portugal and Spain, and several attempts were made to find a northeast passage to India. On one of these expeditions, in 1596, the Dutchman, Wilhelm Barents, discovered the archipelago he gave the name Spitsbergen, i.e. pointed mountains. The Norse name for this "newly-discovered" archipelago was Svalbard, which means cold coasts, something that suggests that the Norsemen were familiar with the islands long before Barents' time. Wilhelm Barents reported great quantities of bowhead whale, walruses and seals and this rumour spread. As early as in 1610, the British began whaling operations at Spitsbergen and the Dutch followed them a couple of years later. Most of the ships had Basque crews. The whales were caught near land and the blubber boiled down into oil at land stations. Smeerenburg on Amsterdam Island was the best know of these land stations.

Whale resources close to land diminished and, from the middle of the 17th century, the ships began to search for whales further out to sea. Several hundred vessels were now whaling in the Arctic Ocean. The Dutch and British were in competition and, early in the 18th century, England became the leading whaling nation. The whale population was now showing signs of major decline and Spitsbergen had lost its importance as a hunting ground. In order to compensate for declining whale populations, the hunting grounds were extended to Greenland and the Davis Strait. But since they were hunting on the open sea, the blubber needed to be boiled down on board. This was done on deck and was a considerable risk. Over the course of the 18th century, this resource dried up. The bowhead whale was now commercially extinct in the North Atlantic, although a few individuals could still be found.

6.1.4 SPERM WHALE HUNTING

Photo: Paula Olsen

Whaling also went on in the New England states on the northeast coast of America. The decline in the population of right whales forced whalers further out to sea, both in the north and south of the Atlantic. One anecdote tells us that Captain Christopher Hussey, who sailed from the Massachusetts coast, was taken by surprise by a powerful storm that took him far out to sea. Once the weather had calmed down and visibility improved, he found himself in the middle of a herd of great whales with a spout that was different to the right whale spouts he had seen before. He had ended up in a herd of sperm whales. Hussey succeeded in catching one of them and towed it back to Nantucket.

The sperm whale was considered inedible but it quickly became obvious that the oil from the blubber was very valuable, because it had good properties for many technical purposes. In addition, spermaceti wax from an organ in the head had a particularly high value. Some sperm whales also had ambergris, a wax that occurred in the intestinal canal and that commanded a high price, particularly within the perfume industry. Whaling expeditions were sent out from towns such a Nantucket and New Bedford to all the oceans of the world to hunt for sperm whales. The hunting method was the same at the Basques used on right whales. That is to say, the large ships held many small, open whaling boats. A hand harpoon would be thrown at the whale from these small boats. The harpoon was attached to a line with floats at the end. Used on big, fast sperm whales, this was a very dangerous way of hunting. Sperm whale hunting took much human life and was surrounded by many myths. Herman Melville's 1851 novel, Moby Dick, portrays this whaling, which was called Yankee Whaling.

Sperm whale hunting culminated in the middle of the 19th century. Primarily because the resources were over-hunted, but also because people began to extract other oils that would gradually outstrip sperm whale oil. The last whaling ship set out from New Bedford in 1924. The species was not protected by the IWC until 1984 but, by then, the species had, in practice, become commercially extinct. It was only a handful of whalers in the Azores who continued to hunt using the old method with small open boats. But, without the IWC being aware of it, sperm whale hunting still goes on in Indonesia using the old method and twenty or so sperm whales are taken every year.

As the old form of whaling was coming to an end, new populations of right whales, including the bowhead whale, were being discovered in the Bering Sea as well as a few populations in the southern hemisphere. These were quickly hunted down, and all species of great whale that could be hunted using the old method were reduced to unprofitable presences.

Photo: A. Bjørge

Figure 6.1.5.1
A harpoon gun on the restored whaling boat, *Southern Actor,* which now rests in the harbour in Sandefjord.

After the last known populations that were open to being hunted using the old method had been hunted down towards the end of the 19th century, enormous whale populations still existed. But these were the large and fast-swimming species within the fin whale group, which also sank as soon as they were killed. To hunt these species, it would be necessary to find a method of killing and securing the whale in the same operation.

Experiments began on new hunting methods. Svend Foyn from Sandefjord has been given the credit for developing a grenade harpoon that both killed and hooked the whale. The harpoon was attached to a line that made it possible to winch the whale in to the side of the boat. Hunting whales using this method is described as modern whaling, but we will see that modern whaling can also be divided into several epochs.

Photo: The Whaling Museum in Sandefjord

Figure 6.1.5.2
Two sunken whaling boats alongside the quay at the land station in Grytvika in South Georgia.

Foyn had earned a fortune sealing and he used this to, among other things, build the whaling ship, "Spes & Fides", (which means Hope and Faith), at Nyland ship yard in 1863. "Spes & Fides" was the first specially built steamer for whaling and was put into operation off the coast of Finnmark in 1864. Initially, Foyn was the only whaler hunting with a large vessel equipped with a harpoon gun and grenade harpoons. This led to bigger and more profitable catches and, in the 1880s, major industrial whaling grew up along the Finnmark coast. Several companies and up to 35 vessels took part. This led to over-hunting, a decline in catches and reduced profitability towards the turn of the century. The fisheries were also unprofitable and suffered bad years with social unrest in Finnmark. In 1904, the fishing population in Mehamn rebelled and demanded protection for the whale in order to save the fisheries. The link between whaling and unsuccessful fishing was said to be that the whales had previously scared the herring in towards the coast so that they became accessible to the coastal fishermen. Now when the whales were gone, the fish no longer came in to the coast. The Mehamn uprising was the direct cause of the fin whale being given local protection in the north.

From as early as the 1880s, whale resources off Finnmark were in the process of being overhunted. The whaling companies, which mainly came from Vestfold, took to searching for whale resources in other areas of the sea, first in Iceland but later in all the oceans. From 1904, there was regular hunting of the enormous populations in the Antarctic. In 1911–12, 15 companies were involved in hunting around South Georgia and South Shetland. Several whaling stations grew forth on the southern islands. Perhaps the best known is the Grytvika station on South Georgia (Figure 6.1.5.2). The land stations were most important during the period from 1910 to 1927, but the station in Grytvika was in operation right up until 1965.

In addition to the land stations, several ships were sent that boiled the oil on board. These floating factory ships relied on calm waters because the whales were flensed along the side of the ship. The small island of Deception in the South Shetlands was an important harbour for these ships. Great Britain asserted its authority over the Antarctic islands and demanded that whaling be subject to British permits and licences. The British restricted hunting and the number of licences and introduced an export charge on whale oil. This led to diplomatic conflict between Great Britain, Norway, Argentina and Chile. But it also led to another development: In 1925, the first factory ship was equipped with a slipway so that the whales could be hauled on board and flensed on deck. Now the factory ships were no longer dependent on land. This was the beginning of modern pelagic whaling and led to rapid development. In the 1930–31 season, there were more than 10,000 Norwegians hunting in the Antarctic and they took more than 40,000 whales and produced 3,600,000 barrels of whale oil. But the development of pelagic factory ships also led to all whale populations becoming accessible for hunting. One by one, the populations were hunted down: first the easily caught humpback whale, then the biggest and most profitable of all, the blue whale. Then, in turn, the fin whale and the sei whale and, by the 1970s, only the smallest species, the minke whale, was still abundant enough for commercial whaling (see Figure 6.2.1).

6.1.6 NORWEGIAN WHALING FOR MINKE WHALES

Norwegian whaling for minke whales in the Northeast Atlantic is not a direct continuation of the commercial whaling in the Antarctic, which was mainly conducted from the Vestfold towns. It was the residents of Møre who began hunting minke whales in the 1920s. They used the same harpoon guns and harpoons they had experience of from hunting northern bottlenose whales and basking sharks. This was a so-called cold harpoon: a harpoon without an explosive grenade. While the northern bottlenose whale was hunted for blubber for oil and meat for animal feed, the tasty meat of the minke whale was gradually used for consumption.

Over the 1930s, this form of whaling spread to all parts of the Norwegian coast. From 1938, participation in minke whale hunting was subject to a permit and we have a total summary of catches since this period (Figure 6.1.6.1). The annual catches increased up until about 1950 and varied from 2,000 to 4,000 before stabilising at around 2,000 throughout the 1970s and 1980s. This level was mainly the result of regulations.

When the IWC classified the Northeast Atlantic population of minke whales as protected (see Chapter 6.2.2.), Norway called a temporary halt to hunting in order to carry out more detailed studies of the population. But Norway reserved the right not to adhere to the protection measure so that it could resume whaling if it proved to be the case that the population could withstand hunting. A programme to count whales was commenced under the management of the Norwegian Research Council to get an idea of the size of the population (see Chapter 5.4.). Once the IWC's Scientific Committee had developed a revised management procedure (Chapter 6.2.3) that would ensure the sustainable harvesting of whale populations, Norway decided to reopen commercial whaling from the 1993 season. These catches have remained stable at 500–700 whales a year, and the meat goes to the domestic consumer market.

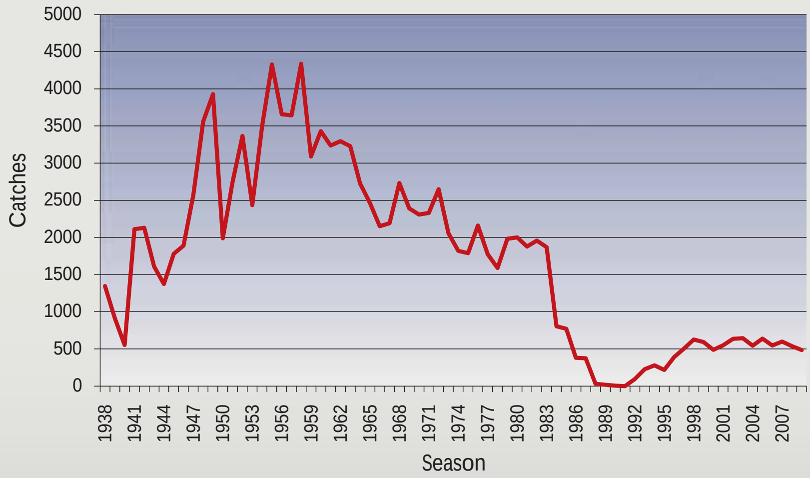


Figure 6.1.6.1
Norwegian minke whale hunting became subject to permits from 1938 onwards.

Photo: K. A. Fagerheim

Figure 6.1.6.2
A minke whale has just been shot and is ready to be hauled on board.

6.2 INTERNATIONAL REGULATION OF WHALING

By the 1930s, it was already clear that whale populations were being very much over-exploited and that international regulation of catches would be necessary. The first step was taken by the League of Nations in 1931 when they proposed that the right whale and females with calves be protected. This had little effect, however, on catches in the Antarctic. The next stage came during an international conference in 1937 where minimum lengths for each species were laid down, full protection for the right whale and grey whale was introduced and conservation areas were established in the Antarctic. Then the Second World War came long, which, in practice, led to whaling being interrupted for a five-year period (Figure 6.2.1).

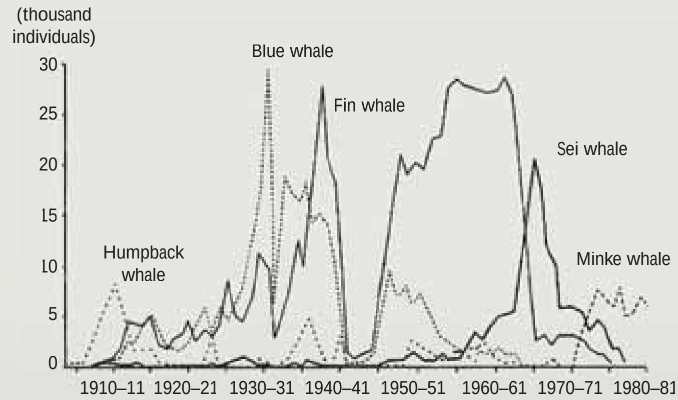


Figure 6.2.1
Catches of whales in the Antarctic showing that it was first the humpback whale and blue whale that were reduced by hunting, then the fin whale and sei whale, before it ended up being the smallest species, the minke whale, that was hunted.

6.2.1 THE INTERNATIONAL WHALING COMMISSION (IWC)

Photo: Torger Øritsland

Figure 6.2.1.1
A whaling boat with a whale alongside in the Antarctic. A floating factory ship in the background.

After the Second World War, work on the international regulation of whaling was again resumed and, in December 1946, 15 nations were able to meet in Washington to sign the International Convention for the Regulation of Whaling (ICRW). Some important elements of the new convention were that an International Whaling Commission (IWC) would be set up. In order to administer the Convention and prepare for the Commission, a secretary and a permanent secretariat were to be appointed and a Scientific Committee was to be set up.

The actual text of the Convention would be ratified and the ongoing regulations would be specified in a supplement to the text of the Convention (the Schedule). The Schedule can be changed with a three quarters majority in the Commission. All other decisions at the IWC require only a simple majority. Regulations in the Schedule are binding on the member states unless they reserve the right not to adhere to a decision within 90 days of it being made. This right of reservation is the legal basis for Norway's minke whale harvest.

The Convention also contains a provision (Article VIII) that each member state can, regardless of other provisions in the Convention, issue permits for its citizens to catch whales for scientific purposes. One of the conditions is that the whale products must, as far as possible, be used even if the whale is caught for scientific purposes. Each country that issues such licences must report this to the IWC and the results of research catches must also be reported. This provision is the legal basis for Japan's research catches in the northern Pacific and Antarctic: activities that are very controversial within the IWC.

Even with a Commission and a Scientific Committee, it was difficult to reach consensus on restricting catches and applying quotas appropriate for the individual species and population. To begin with, the IWC introduced a regulation based on blue whale units. At best, this could regulate the total catches of whales, but it still allowed for the hunting of species that were already over-hunted. This is clearly illustrated in Figure 6.2.1 where catches from the time of the IWC being set up were mainly based on the fin whale (the second biggest species), while blue whales were caught up until the 1960s. Once fin whale numbers had been reduced by hunting, whalers moved on to the sei whale, but they still continued to take the over-hunted fin whale when they came across it. In this way, the catches of the smaller whales continued to "subsidise" catches of the large whales.

Throughout the 1950s and 1960s, there was a great degree of disagreement internally within the IWC and the Scientific Committee on how to get out of the mess regarding blue whale units. For this reason, an expert committee was appointed in 1961 with three independent experts in population dynamics: Douglas Chapman from the USA, Sidney Holt from FAO and Kay Allen from New Zealand. The committee, which was to evaluate the situation in the Antarctic, came to be called "the three wise men". The committee was later supplemented with John Gulland from the UK. This group went further than the Scientific Committee in recommending catch restrictions and proposing protection for the humpback whale and blue whale in the southern hemisphere. Norway, the Netherlands and the UK pulled out of whaling in the Antarctic and falling prices for whale oil also made it less attractive to continue hunting for the remaining nations. But the main problem had not been resolved; an agreed procedure for how to set quotas for the individual populations was still lacking.

A UN conference in Stockholm in 1972 adopted a resolution on a ten-year moratorium (protection) against commercial whaling while more information on whales and how to manage them was obtained. The proposed moratorium was not accepted by the IWC, which had, however, started the process of obtaining more knowledge of whales in the Antarctic and developing procedures for the management of whaling. A procedures called the New Management Procedure (NMP) was adopted in 1976. Kay Allen was the main architect behind this procedure, which was based on theory from fishery biology.

The purpose of the NMP was to manage the whale populations so that they provided the maximum yield (Maximum Sustainable Yield, MSY). Figure 6.2.2.1 shows the yield curve, which reaches its maximum where the population was 60% of the original population size. For populations greater than or equal to 60% of the original size, the quota could be set at 90% of MSY. If the population fell to 54% of the original population size, it was to be protected.

6.2.2 PROTECTION AND THE GROWTH OF RESEARCH WHALING

In principle, the NMP represented major progress, but, in practice, the procedure did not work. One of the main problems was that the NMP did not contain any instruction on how the original and current population sizes should be calculated. The fact that the NMP took no account of uncertainties in the population estimates gradually became more crucial. Opposition to commercial whaling was increasing and the NMP did not contribute towards resolving antagonism in the Scientific Committee and IWC, in fact the opposite applied. More and more countries mobilised in the fight against whaling. The number of member countries in the IWC increased, while the number of active whaling nations decreased. In 1982, there was a sufficient majority in the Commission to agree on a moratorium on commercial whaling from the 1986 season. This decision also contained a statement that the moratorium would be reassessed in light of the best possible scientific advice. At latest by 1990 the Commission should carry out a comprehensive assessment of the impact of protection on the populations and propose modifications to the moratorium and set catch quotas.

Norway exercised its right to reserve not to adhere to the decision and argued that the moratorium applied in general to all populations and was not based on scientific advice.

The sharp limit of 54% of the original population size was the difference between a population that could be hunted and a protected population. This limit was the subject of divisive tugs of war within the Scientific Committee. Because Norway had reserved the right not to apply the moratorium on catches and was, therefore,

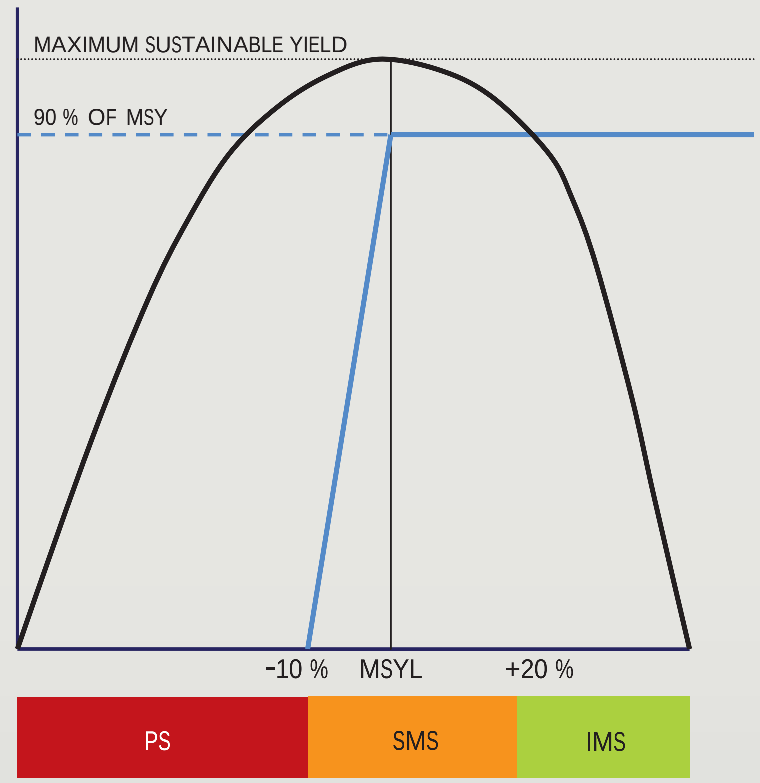


Figure 6.2.2.1
The IWC's New Management Procedure for classifying populations and setting quotas. The arched curve shows the annual growth of the population, which was assumed to be greatest (MSY) when the population was 60% of the original size (MSYL). If the population was greater than 60%, a quota equivalent to 90% of MSY could be taken (blue line). If the population fell to 54% (10% of MSYL under MSYL) of the original size, it would be classed as protected (Protection Stock, PS) and the quota set to zero. Populations between 54% and 72% were classed as Sustained Management Stock (SMS) and populations above 72% as Initial Management Stock (IMS).

within its rights to continue hunting the North Atlantic minke whale, extra focus was put on this population. In 1984, Sidney Holt presented a document that showed that the population could, given certain conditions, be less than 54% of its original size. On the basis of Holt's analysis, the Commission decided that the North Atlantic minke whale should be classed as protected, although the Scientific Committee had made no clear recommendation on this. Norway again exercised its right to decline to accept this decision, but nevertheless decided on a voluntary, temporary halt to hunting until there was a better basis for estimating the population. This is how the Norwegian marine mammal programme became set up, with its main focus on the minke whale.

Within the IWC, there was no great interest in reconsidering the decision on a moratorium, but, in 1984, following pressure from Norway, the Commission instructed the Scientific Committee to revise the management procedure. This was the beginning of ground-breaking scientific work, which resulted in what we know as the Revised Management Procedure (RMP). The RMP has acted as an example of game management in many countries and it is the principles in the RMP that form the basis for the setting of Norwegian quotas for minke whale. The RMP is, therefore, discussed in a separate chapter.

Japan and Iceland also exercised their right not to apply the moratorium, but both countries withdrew their reservations following international pressure. On the other hand, they were able to apply Article VIII and issue licences for scientific catches. Both Norway and Iceland have used this option for time-limited studies of the minke whale and the fin whale and minke whale respectively. Japan, on the other hand, has set up comprehensive, continuous programmes for catching whales, in both the North Pacific and the Antarctic. Article VIII was probably intended to provide the option of giving permission for studies of whales in the calving areas or to search for whale resources in new areas. The article could hardly have been intended to provide authority for extensive catches over a period of several years. For this reason, Japan's research catches are very controversial within the IWC. The current Japanese research whaling programmes have an annual quota of 1,500 whales, split into the minke whale (1290), sei whale (100), Bryde's whale (50), fin whale (50) and sperm whale (10). These programmes have been continual without any definite year in which they will end.

6.2.3 THE IWC'S REVISED MANAGEMENT PROCEDURE (RMP)

In 1984, when the Commission instructed the Scientific Committee to commence work on revising the management procedure, the Commission defined three objectives for the revised procedure:

1. The procedure should provide as stable quotas as possible;
2. Quotas should not be set for populations smaller than 54% of the original population;
3. The quotas should provide the highest possible yield from the population.

The Commission also decided that Objective 2 would be the greatest priority. Apart from this, the Scientific Committee did not receive many guidelines for its work on revising the management procedure. When the Committee began its work, it was obvious that any revised management procedure would need to be able to work without exact information on the populations. The uncertainties of historical catches, statistical uncertainty in population estimates and the uncertainty involved in splitting into populations would need to be able to be handled by the management procedure without the population being put at risk. The way to do this is through simulations of the parameters included in the procedure at wide intervals. The Scientific Committee decided on simulations over 100 years in order to see the effect of different initial values and harvest levels.

The RMP consists of two components: (1) a core procedure for estimating quotas for a management area, and (2) a set of rules for modifying the quotas in the event of uncertainty regarding a division into populations for the area managed.

The core procedure – the Catch Limit Algorithm (CLA) – begins with two sets of data, historical catches in the management area and one or more estimates (stating the level of uncertainty) of the absolute abundance in the same area and it then calculates a quota for this management area. This is shown in the form of a diagram in Figure 6.2.3.1. The quota depends on the population level (the population as a proportion of the original level, "depletion") and productivity ("MSYR"). In practice, the RMP calculates nominal quotas for a set of probable values for population levels and productivity. A nominal quota with a high probability is set as the catch quota.

The RMP is a "learning" procedure that will initially assume wide intervals for population levels and productivity and then use the new data on abundance and cumulative catch data to narrow down probable intervals for the parameters. Repeated estimates of abundance every five or six

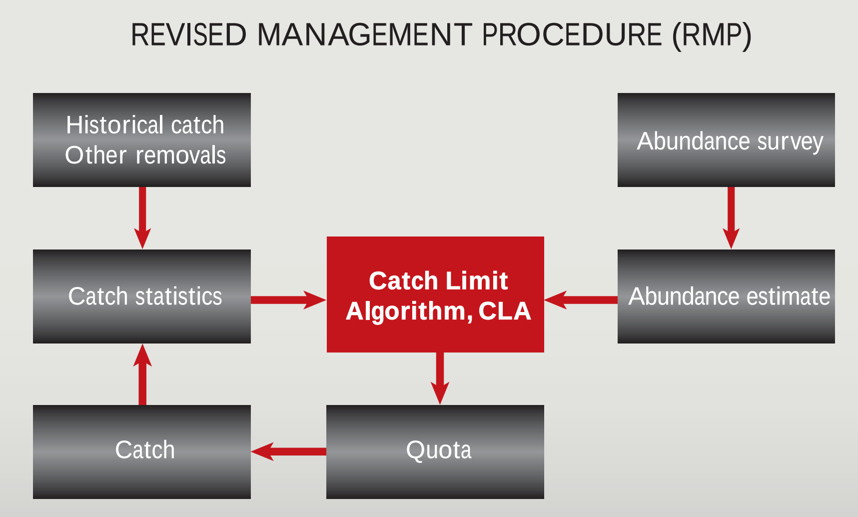


Figure 6.2.3.1
A presentation of RMP in the form of a diagram, where a central algorithm (formula) calculates quotas based on estimates of absolute abundance and catch statistics. If the population estimates are not updated every five or six years, the quotas will be gradually phased out. Data for the population estimates must be gathered and processed in accordance with a protocol adopted by the IWC's Scientific Committee.

years are necessary if the procedure is not to phase out catches.

If it has not been demonstrated that the entire management area consists of one population, the rules for modifying quotas will apply. There are three levels for this:

The entire management area is split into small areas, but in such a way that we know the abundance of whales in each of the small areas. The CLA is applied to each of the small areas and this calculates catch quotas for each of the areas independently of each other.

The core procedure can also be used in a combination of small areas and the entire management area. If the sum of the quotas for the small areas is greater than the quota for the entire area, they must be reduced proportionally. This is called ”Catch capping” and generally gives the smallest quotas.

The CLA can also be used for the entire management area in order to calculate a quota that is split into the small areas proportionally by abundance. This is called ”Catch cascading” and generally provides the largest quotas.

The core procedure can be calibrated by determining the "tuning" level. This is the population level defined as the long-term management objective (initially 100 years ahead in time). During the development of the management procedure, the Scientific Committee investigated an interval for "tuning" levels from 0.60, which is equivalent to the "classic" production model's MSYL, to 0.72. The Commission adopted the most conservative value (i.e. 0.72) within this interval as the basis for its application of the RMP.

6.3 THE HISTORY OF SEALING

In the same way as whaling, sealing has probably occurred along the coasts throughout the ages in places where seals and people came into contact with each other. Bones found in Vistehola in Jæren and Skipshelleren in the Bolstad Fjord show that the grey seal and harbour seal were important elements in the diet of the early cave dwellers. Sealskin was probably also important for clothing and perhaps in the building of small boats. Finds in Jæren and at the Bolstad Fjord also show that the coastal seals had more or less the same geographical distribution as they have now, with the grey seal on the outer coast and harbour seals further inland, in the fjords. The economic value of the coastal seals gradually becomes clear in, among other things, Frostating's Law and Magnus Lagabøte's Law (1726) where the right to hunt the grey seal and harbour seal belonged to the landowner. But seal hunting could be leased to seal hunters, perhaps an early form of transferrable quota. In early notes of taxes to the Church and the Crown, we also find descriptions of seal products as means of payment.

6.3.1 THE HUNT FOR LUXURY – THE TRAGEDY OF FUR SEALS

The northern fur seal was a stable source of food and clothing for the ethnic Arctic groups in Alaska and Siberia for several thousand years. But, after the Europeans discovered the seal colonies on Commander Island in 1741 and the Russian Pribilof found seal colonies on the Pribilof Islands in 1786, large-scale industrial sealing began. It is likely that about 2.5 million seals were killed between 1786 and 1867, when the USA bought Alaska from Russia. Russia had introduced restrictions on sealing in the 1830s but the USA had a very liberal approach to sealing. The population continued to dwindle right to the beginning of the 20th century, by which time only 200,000 individuals remained from a population that must originally have numbered several million.

Over-exploitation became more and more visible and, in 1911, the North Pacific Fur Seal Convention was established following negotiations and signed by Japan, Russia, the USA and the UK (on behalf of Canada). This was one of the very first international agreements on the conservation of wildlife resources.

Following the introduction of stricter regulations in 1911, the population has increased and now provides a foundation for regulated hunting. Only the indigenous peoples on the islands between Alaska and Siberia are are allowed to catch these animals. Population growth varies between different seal colonies and is probably governed by oceanographic conditions and the availability of food.

After Captain James Cook discovered South Georgia and the South Sandwich Islands in 1774/75 and reported the great abundance of fur seals, it was not long before Europeans and Americans were conducting extensive hunting for fur seals in the Antarctic. During the 1800/01 hunting season, 112,000 Antarctic fur-seals were caught on South Georgia and the population was soon practically wiped out on the island. In the South Shetland Islands, which were discovered in 1819, the entire population was taken over the course of two years. In the 1820/21 season, there were as many as 91 sealing vessels operating at the South Shetland Islands and one ship returned with 60,000 skins.

By 1830, the species was considered almost extinct and only a few individuals remained on remote islands. At the beginning of the 20th century, the population on South Georgia consisted of about 100 individuals. In the 1960s, the population increased by 16% a year and, by 1976, the population had increased to 100,000. The population continues to increase and has now passed 2.7 million. About 66,000 fur seals inhabit Bouvet Island, which is a Norwegian territory and nature reserve.

Photo: A. Bjørge

Figure 6.3.1.1
Male and female fur-seals in Namibia.

The Cape fur seal, the fur seal that inhabits the coasts of South Africa and Namibia, but which also occurs on the south coast of Australia was the target for sealing from the end of the 18th century. The species was greatly reduced but many of the southern fur seals have a partly overlapping range and it is not entirely clear which species and subspecies were hunted.

The population of Cape fur seals has increased again since it was made protected. Now there are about 2 million seals in South Africa and Namibia. The species is now protected in South Africa while there sealing in Namibia is regulated.

6.3.2 THE ELEPHANT SEAL – AN OIL SOURCE IN A TIME OF SCARCITY

Photo: A. Bjørge

Figure 6.3.2.1
Elephant seal in California.

The large, fat-rich elephant seal provided high quality oil. This oil became valuable, perhaps because the supply of oil from right whales and the sperm whale was beginning to dry up over the 19th century. The northern elephant seal lived along the coast of Baja California in Mexico, California in the USA and a few islands just off the coast, and the species was totally wiped out from its known range as a result of intense sealing. In 1890, there was only a group of 100 individuals left on the island of Guadeloupe. These had escaped capture because Guadeloupe, which lies far out at sea off Mexico ,was very difficult to access. With strict protection of both the elephant seal and its breeding grounds, the population has recovered. There are now more than 127,000 northern elephant seals and the population is increasing by 6% annually. But the reduction to 100 individuals has left its mark. Almost all genetic variation has disappeared from the species, something that could lead to difficulty adapting if their living conditions change rapidly.

The southern elephant seal had a much wider range and was less available to the sealing industry. It was hunted right into the 20th century and right up to 1964 in South Georgia. It is unclear by how much the population of southern elephant seals was reduced, but the populations appear to be experiencing regrowth in several places. The total population is now about 640,000 individuals.

6.3.3 SEALING IN THE NORTH ATLANTIC

Originally, the Dutch and British were the biggest sealing nations in the North Atlantic. Sealing vessels hunted seals along the edge of the ice from late winter and throughout the spring/early summer. Blubber for oil and skins for fur and leather were the most important products. It is unclear how many seals were caught in the 18th and 19th centuries, but we do have an idea of Norwegian sealing figures back to about 1860 (Figure 6.3.3.1).

Norway was a latecomer to sealing in the Arctic Ocean and, when the Norwegians first arrived, they were involved in two completely different forms of sealing. From 1794, expeditions from Hammerfest departed to spend the winter in Svalbard. They hunted for walrus, polar bears, reindeers, seals and foxes. Hides for furs were

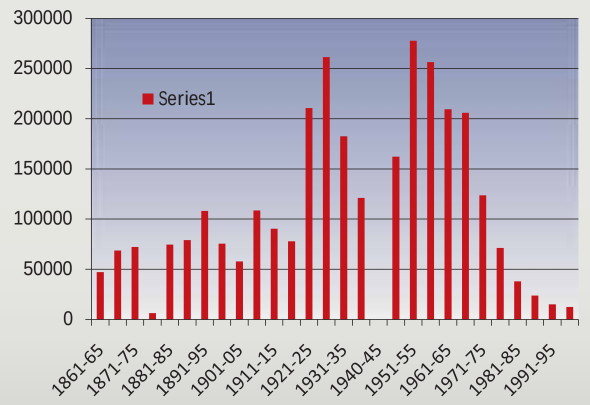


Figure 6.3.3.1
Summary of total Norwegian sealing (average catches for 5-year periods) back to 1860.

an important product. Although there have been many such expeditions spending the winter at Svalbard over the ages, and many legendary hunters, this form of hunting is of limited importance in terms of socio-economics and employment.

The second form, with boats heading for the drift ice in the late winter and spring was on an industrial scale and was an important industry with large profits and considerable employment. It was primarily boats from the established shipping environments in Østfold and Vestfold that took part from the first half of the 19th century. It was not until 1898 that three small boats from Sunnmøre took part. The first Sunnmøre boats were ordinary sail-driven fishing boats. The first steamer from Sunnmøre arrived in 1905 and the first vessel specially built to penetrate ice came in 1910. Sunnmøre and, later, Troms, were to become the centres of this sealing as the shipping companies in Vestfold had focused their attention on the more profitable whaling. 1918 was the peak year for participation in sealing with as many as 321 vessels involved.

The hunting grounds were the Western Ice at Jan Mayen, the White Sea and Newfoundland and the harp seal and hooded seal were the most important species. Once the Soviet Union had shut Norwegian sealers out of the White Sea, Norwegian sealing continued in the Eastern Ice, in the Barents Sea north of the mouth of the White Sea. Sealing at Newfoundland came to an end in 1992 when the EU introduced trade restrictions on sealskin. We have little information on catch quantities before 1860, but Figure 6.3.3.1 shows catches from 1860 to 2009. In the period from 1921 to 1925, more than 200,000 animals were landed annually. In the next five year period, up until the Second World War, catches fell and we should interpret this as an indication of over-exploitation. After the Second World War, catches rose again with an average of more than 200,000 seals a year right up to 1970. The peak year was 1959 with 67 vessels landing almost 300,000 seals. In retrospect it is obvious that the populations could not withstand this excessive hunting, and catches gradually reduced in all the hunting grounds.

Throughout the 1970s, catches were regulated by quotas. This led to the regrowth of all three populations of harp seal. The Newfoundland population of individuals a year or more old is now about 5.9 million, the White Sea population about 2 million and the Western Ice population around 0.6 million. Trends in the hooded seal populations are more uncertain. It appears that the marked reduction in the Western Ice has come to a halt, and ICES has recommended a moratorium on the hunting of this population (see Chapter 5.2).

Photo: The Institute of Marine Research's archives

Figure 6.3.3.2
Boats hunting in the Western Ice. This sealing was of great importance for employment in Sunnmøre and Troms in the last century.

Photo: K. A. Fagerheim

Figure 6.3.3.3
Sealskin for furs was the most important product for the economy of the sealing industry.

6.4 INTERNATIONAL REGULATION OF SEALING IN THE NORTH ATLANTIC

When requested to do so by participating countries, the International Council for the Exploration of the Sea (ICES) provides scientific advice on the management of the harp seal and the hooded seal in the North Atlantic. Following a request from the coastal states, a joint working group of ICES and the Northwest Atlantic Fisheries Organization (NAFO) is convened to assess the population situation and advise whether individual populations should be hunted or protected. As a general rule, the actual hunting takes place within the exclusive economic zone of the individual coastal state and, in more recent times, sealing in the North Atlantic has been regulated through agreements between the coastal states. Until Norwegian catches in Newfoundland ceased in 1992, it was NAFO who recommended quotas and the division of these quotas between participating nations, i.e. Canada, Norway and Denmark (Greenland). Catches in the Western Ice and Eastern Ice are regulated through bilateral agreements between Norway and Russia.

The hunting of grey seal and harbour seal along the Norwegian coast is based on national, scientific advice and are not presently subject to international quality assurance. The UN's Convention on the Law of the Sea (UNCLOS), however, instructs the coastal states to cooperate on conservation and the management of marine mammals. For this reason, White Paper no. 46 (2008–2009) lays down that, once work on management plans for coastal seals is complete, national advice must be quality assured through international organisations. ICES and the North Atlantic Marine Mammal Commission (NAMMCO) have been mentioned as relevant arenas for this.

Chapter 7

Scientific advice for management in Norway

Since 2009, the Marine Mammal Advisory Board has assisted the Institute of Marine Research by providing scientific advice for research into and management of marine mammals in Norway. A wide range of specialities, experts and institutions are involved in the Board.

Arne Bjørge
arne.bjorge@imr.no

In 2009, the Ministry of Fisheries and Coastal Affairs reorganised the area of scientific advice for the management of marine mammals in Norway. The Marine Mammal Advisory Board, a research group with wide competence in marine mammals was set up under the Institute of Marine Research. The role of the Board is to assist the institute on matters regarding management advice and to provide information on what challenges should be addressed on the research side.

The composition of the Marine Mammal Advisory Board should reflect the entire range of the Government's advisory needs. The head of the Board will be the Government's central adviser in matters regarding research into and management of marine mammals. The specialist areas, experts and institutions involved in the Marine Mammal Advisory Board are shown below. The Ministry of Fisheries and Coastal Affairs and Directorate of Fisheries are observers.

Specialist area	Expert	Institution
Head of the Board	Dr. Arne Bjørge	The Institute of Marine Research
Acoustics and marine mammals	Dr. Petter Kvadsheim	The Norwegian Defence and Research Establishment
Arctic and Antarctic species	Dr. Kit Kovacs	The Norwegian Polar Institute
Population biology – whales	Dr. Nils Øien	The Institute of Marine Research
Population biology – seals	Dr. Tore Haug	The Institute of Marine Research
Management and advice – whales	Professor Lars Walløe	University of Oslo
Physiology and environmental physiology	Professor Lars Folkow	University of Tromsø
General biology and taxonomy	Professor Øystein Wiig	University of Oslo
Statistical methods, modelling	Professor Hans J. Skaug	University of Bergen
Environmental toxins, biological effects	Dr. Janneche Utne Skåre	The National Veterinary Institute
Marine mammal products, health aspects	Dr. Livar Frøyland	NIFES
The national DNA register – whales	Dr. Kevin Glover	The Institute of Marine Research
Spatial modelling and ecology	Dr. Mette Skern-Mauritzen	The Institute of Marine Research
Veterinary medicine and humane killing	Dr. Egil Ole Øen	
Ecosystem modelling	Dr. Dag Hjermann	University of Oslo

The first meeting of the Board was held on 11 and 12 November 2009 and the following six pages are a summary of the Board's discussions, conclusions and recommendations. The next meeting is planned for October 2010.

The Marine Mammal Advisory Board 2009

Bergen, 11–12 November

1 Whale populations

1.1 Reports

Nils Øien reported on the annual whale counts and abundance estimates for minke whale and other species recorded on the surveys. Lars Walløe reported on how the maximum quotas for Norwegian whaling are calculated in accordance with the IWC's management procedure (RMP) and gave an account of the conditions that provide guidelines on the maximum quotas for 2010. Kevin Glover reported on the National DNA Register for minke whales and Hans Skaug referred to how the DNA register could possibly be used in mark-recapture estimates of abundance. Kit Kovacs provided information on the narwhal, white whale and bowhead whale. A report on the bowhead whale, written by Øystein Wiig, was presented by Arne Bjørge.

1.2 The Marine Mammal Advisory Board's Statements

- The Board notes the method for calculating quotas for Norwegian whaling and recommends that today's scheme form the basis for the remaining seasons of the current six-year period.

- The Board notes that the current Norwegian whaling policy sets out that the minke whale population should be monitored in accordance with the protocol produced as part of the IWC's management procedure (RMP) and that the quotas are set in accordance with a procedure produced by the IWC's Scientific Committee. The Board assumes that the Institute of Marine Research will attend to the continuation of whale counts in accordance with the IWC protocol and use sufficient resources so that the abundance estimates are of the accuracy necessary for use in the RMP (i.e. within the limits of uncertainty the IWC prescribes for use in the RMP).

- Alternative methods (e.g. abundance estimates by means of genetic mark/recapture) should be investigated with a view to finding cost-effective methods for abundance estimates for the minke whale. The transition to the new method will, however, require us to get the IWC's acceptance of the method and a protocol being produced and then approved by the IWC. This will be several years in the future and, in the interim, the present whale counting scheme must continue.

- If alternative methods for abundance estimates for the minke whale are developed (e.g. genetic mark/recapture), we will lose data from the counting surveys that can be used for abundance estimates for other species of whale (humpback, fin whale, sperm whale etc.)

- The Board recommends an increase in the tagging of whales, particularly with new technology for satellite tagging, in order to both increase knowledge of the distribution of the whales in time and space while they are at their feeding grounds in the Norwegian maritime zones and to map their migrations to their calving areas.

2 Seal populations

2.1 Reports

Tore Haug reported on counts, the population situation, management principles and catches of the harp and hooded seals in the Western Ice and the harp seal in the Eastern Ice. Kjell T. Nilssen reported on counts, quota advice, hunting and proposals for management plans for the grey seal and harbour seal. Kit Kovacs reported on the Arctic species – the walrus, ringed seal, bearded seal and Svalbard's population of harbour seals – and Antarctic species.

2.2 The Marine Mammal Advisory Boards's Statements

- The Board notes the quota regulations for 2010 for the harp seal and the hooded seal and recommends that the management principles and harvesting rules drawn up by ICES form the basis for setting quotas.

- The Board recommends that the monitoring of the harp seal and hooded seal in the Western Ice and the harp seal in the White Sea continue at a level that dictates that the populations can be managed as data-rich in accordance with ICES' terminology.

- Furthermore, the Board emphasises that the state of health of hooded seals in the Western Ice must be examined in order to understand which factors may have contributed to the reduction in pup production observed. A complete veterinary science study should be carried out on a number of females with pups and a number of females in the moulting areas with a view to mapping any changes in their condition, age at reaching sexual maturity, pregnancy rates and what could be the cause of any changes.

- The Board also recommends that an aerial survey is carried out over a considerably greater area than the traditional breeding grounds in the Western Ice. This is to see whether the decrease in pup production observed in the hooded seal is due to a change in breeding grounds as a result of less and poorer ice in the edge of the Western Ice. The Board would also like to encourage the carrying out of similar reconnaissance flights outside the traditional breeding grounds for harp seals in the White Sea (including the area east of Kap Kanin, along Novaya Zemlya and in the western Kara Sea) as the results of counts for this population also show a reduction.

- The Board notes that the Institute of Marine Research's recommendation on quotas for coastal seals in 2010 has already been submitted to the Directorate of Fisheries. The Board recommends that the Institute of Marine Research draw up proposed quotas for 2011 and the remainder of the period until the next population estimate is available and present these to the Marine Mammal Advisory Board at the next meeting of the Board. The quotas should be prepared in accordance with the principles in the proposed management plans and focus on achieving the political targets set for the sizes of the grey seal and harbour seal populations. It is important that the management of coastal seals is introduced in a form that means that management measures do not end up being the reason for the species being listed on the national red list.

- The Board recommends that management advice on coastal seals be quality assured through an international body (for example, NAMMCO) so that advice for coastal seals comes into line with advice on Arctic seals.

- The Board notes that harbour seals are managed by administrative areas (by county) and recommends that a genetic mapping of the harbour seal's population structure is carried out so that the administrative units can be more in accordance with the biological divisions.

- The Board assumes that the monitoring of grey seals and harbour seals will continue so that the populations can be managed as data-rich in accordance with the ICES' terminology.

3 Marine mammals in the ecosystems

3.1 Reports

Lars Folkow reported on pysiological studies and, in particular, on the energy cost of metabolism. Dag Hjermann and Lars Walløe reported on current multi-species models and Mette Skern-Mauritzen on spatial modelling of baleen whales in the Barents Sea in relation to the extent of capelin and zooplankton.

3.2 The Marine Mammal Advisory Board's Statements

- The Board noted that measurements of respiratory rates are probably the only realistic approach to studying the cost of metabolism in great whales. In species where controlled experiments can be carried out, other methods (e.g. telemetric measurement of heart rates) and a combination of several methods are possible.

- In order to satisfy the requirements for ecosystem based management (implemented through international agreements and in the Marine Resources Act), the Board has emphasised the importance of working more intensively on operational multi-species models. It is important to carry out simulations in order to test the properties of different model types. The Board recommends a simulation project under the direction of NAMMCO for testing modelling approaches such as Gadget and Eco Path with EcoSim and regression-based modelling. The Board notes than many of the ideas developed in Scenario Barents Sea, including the spatial division of the area should be captured and continued in the Gadget modelling tool.

- The harp seal is a top predator with a large biomass in the Barents Sea. The harp seal can switch between several species of prey and, in connection with testing multi-species models, it is particularly important to get data on the harp seal's diet updated. It is also important to increase knowledge of the reasons for changes in the harp seal's condition and productivity (see point 6). It also appears that there have been changes in the harp seal's range in their feeding areas. The Board recommends, therefore, that the planned programme of satellite tracking of harp seals be carried out.

- The minke whale is another top predator with a large biomass in the Barents Sea. New diet data is needed for multi-species models. The Board recommends that this data is gathered from commercial whaling, preferably in connection with the gathering of blubber samples for the analysis of stable isotopes and amino acid profiles.

- Data on stomach contents is not available for the other baleen whales. Here, whale data from the ecosystem surveys are particularly important, particularly because data is also collected simultaneously on the occurrence of potential prey. Simultaneous data from several trophic levels is of central importance for multi-species and ecosystem studies. The Board emphasises the importance of the ecosystem expeditions being continued and preferably being extended in time and space.

- The Board notes that a scheme has been set up that, with the assistance of the Coastal Reference Fleet, collects data that is suitable for monitoring bycatches of marine mammals and assumes that the scheme will be continued at at least the present level.

- It is difficult to obtain concrete knowledge of the damage marine mammals (and coastal seals in particular) inflict on fisheries and the fish-farming industry. The Board recommends that the industry itself become involved in recording the kinds and extent of any damage caused by marine mammals. It has proved to be difficult getting financing from the Research Council for this type of research and the Board recommends that the Fisheries and Fish-Farming Research Fund [Fiskeri- og Havbruksnæringens Forsøksfond] contributes towards financing this.

4 Environmental conditions that could affect marine mammals

4.1 Reports

Janneche Utne Skåre reported on the environmental toxins and the effects on marine mammals. Petter Kvadsheim reported on sonars, seismic and marine mammals. In her report on Arctic species, Kit Kovacs emphasised the changing environmental situation for a number of ice-dependent species as a result of climate change. The Board decided to make a statement on these conditions under this agenda item.

4.2 The Marine Mammal Advisory Board's Statements

- The Board notes that, some ten years after the ban on the production and use of PCB and DDT (so-called "old environmental toxins"), the concentrations of these substances were declining in marine mammals but that there is a delay in the reduction in Arctic populations. The concentration of new environmental toxins, such as brominated compounds produced as fire inhibitors and perfluero compounds, such as PFOS (ampholytics) are, on the other hand, still on the increase. The Board believes that it is important to monitor the occurrence and levels of relevant environmental toxins and their active metabolites, including temporal trends in these substances and suitable model organisms for monitoring (e.g. the white whale and ringed seal) are required.

- The rise in temperature could lead to environmental toxins that have been deposited (in the permafrost, glaciers or sediments) being reactivated and accumulated in Arctic food chains. Environmental monitoring should capture these trends and the Board recommends that both "old" and "new" environmental toxins should be included in the monitoring programmes and that current trend-studies should continue.

- The effects of exposure to environmental toxins on the health of marine mammals can be measured at many levels with endocrine effects on reproduction, development and the immune system being the most important. The Board notes that some marine mammal populations, particularly in more polluted waters, are exposed to environmental poisons at levels close to or above the threshold level for adverse effects. There is a need for research into the combined effects of climate and environmental poisons and the development of biomarkers that can be used to monitor/map the health of marine mammals. In this context, it is also important to obtain biological information about sensitive periods in the lifecycles of different species of marine mammal.

- Climate change could also affect infectious diseases in marine mammals, as higher temperatures could result in a more northerly spread of different pathogens. For this reason, the Board recommends studies of pathogen-marine mammal interactions and possible connections to climate change and exposure to environmental poisons.

- The Board also believes that comparative studies of the environmental poison position in species existing in both the Arctic and temperate regions, such as the harbour seal, could be of interest.

- The Board notes that there has been a considerable increase in the level of noise pollution in the oceans of the world, and that it is not known what effect this is having on marine mammals. Globally, there have been reports of several "abnormal" strandings of several species of whale (including minke whales) in connection with the use of intense sources of sound such as military sonars and seismic sources. It is uncertain what is causing these strandings, but direct physical damage does not appear to arise unless the distance between the animal and source of sound is less than 100 metres. Mechanisms that involve behavioural changes appear, therefore, to be more likely. More recent research indicates that beaked whales, which are overrepresented in these strandings, are particularly sensitive, but which of the species of beaked whale this applies to is not known. Over the last few years, some research has been carried out into behavioural changes in a few species of toothed whale, but hardly any research on baleen whales.

- Further research into the negative effects of sonar and seismic activity on marine mammals should be mainly financed by the owners of the problem (the Ministry of Defence and the Ministry of Petroleum and Energy). Norway is on the cutting edge when it comes to knowledge of marine acoustics and effects on fish. Over the past few years, the Armed Forces have also invested considerable resources on research into the effect of sonar on marine mammals and we were one of the first nations to take protective measures. The Board notes that Norway has contributed little to research on the effects of seismic activity on marine mammals and is lagging behind other nations in implementing protective measures.

- Global increases in temperature are leading to dramatic changes in the Arctic where the extent of the sea ice in particular is rapidly reducing. Several species are strongly connected to the ice habitat (bowhead whale, narwhal, white whale, ringed seal, bearded seal, walrus, harp seal and hooded seal) and their continued existence could be threatened by climate change. The Board strongly recommends monitoring of the effects of climate change on these species.

- Climate change will probably lead to a change in the ranges (and abundance) of a number or species of marine mammals. This applies to, among others, pelagic dolphins that may enter Norwegian maritime zones from the south with increased water temperatures. The Board believes it is important that monitoring programmes record these changes.

5 Effect on human health of marine mammal products

5.1 Reports

Livar Frøyland reported and was supplemented by Lars Walløe.

5.2 The Marine Mammal Advisory Board's Statements

- The Board notes the positive and lasting (6 months) health effect on rheumatic pain and intestinal infections and ulcers after an intake of seal oil for a short period (10 days) but emphasised that major clinical testing of seal/whale oil compared with cod liver oil or salmon oil would be required.

- In addition, the effect of seal and whale oil on cardiovascular diseases and any additional gains in supplementing with antioxidants should be clarified. It is also important to gain a better knowledge of the characteristics of these oils with regard to their structures.

- It was emphasised that the industry should take increased responsibility for product development/commercialisation.

6 Methods for humane killing of animals

6.1 Reports

Egil Øen reported on animal welfare and humane killing methods for whales and seals.

6.2 The Marine Mammal Advisory Board's Statements

- The Board noted that today's methods for the humane killing of minke whales is functioning satisfactorily and that automated electronic monitoring is effective. In the mean time, the Board recommends "random sampling" with observers from the Directorate of Fisheries on board randomly selected boats.

- The need to improve the documentation of the effect of the current killing methods in connection with sealing, for example, the effectiveness of using a hakapik. The Board has noted that the functionality of hakapiks in rendering unconscious is not very well documented scientifically.

Summary of the priorities of the Marine Mammal Advisory Board's most important recommendations on research and management

Recommendation	Priority
The Institute of Marine Research should ensure the continuation of whale counts in accordance with the IWC's protocol and invest sufficient resources so that the abundance estimates are of the accuracy necessary for use in the RMP.	**Very high**
The state of health of hooded seals in the Western Ice should be mapped to provide answers to what factors could cause the observed reduction in pup production.	**Very high**
An aerial survey should be carried out of a considerably greater area than the traditional breeding grounds in the Western Ice in order to see whether the observed reduction in pup production among the hooded seal in the Western Ice is due to a change in breeding grounds as a result of less and poorer ice on the edge of the Western Ice.	**High**
The Board also encourages the carrying out of similar reconnaissance flights outside the traditional breeding grounds for harp seals in the White Sea.	**High**
The Institute of Marine Research should draw up proposed quotas for grey seals and harbour seals for 2011 and the remainder of the period until the next population estimate is available and present these to the Marine Mammal Advisory Board at the next meeting of the Board. The quotas should be prepared in accordance with the principles in the proposed management plans and focus on achieving the political targets set for the population sizes of the grey seal and harbour seal.	**Very high**
The work on developing operational multi-species models should be intensified. It is important to carry out simulations in order to test the properties of different model types. The Board recommends financing a simulation project under the direction of NAMMCO for testing different modelling approaches.	**Very high**
The planned programme of satellite tracking of harp seals in the Barents sea should be carried out as soon as possible and the results should form the basis for the design of a sampling programme if possible.	**Very high**
Data on stomach contents is not available for the large baleen whales. Here, whale data from the ecosystem surveys is particularly important, particularly because data is also collected simultaneously on the occurrence of potential prey. Simultaneous data from several trophic levels is of central importance for multi-population and ecosystem studies. The Board emphasises the importance of the ecosystem surveys being continued and preferably being extended in time and space.	**Very high**
Global increases in temperature are leading to dramatic changes in the Arctic where the extent of the sea ice in summer in particular is rapidly reducing. Several species are strongly connected to the ice habitat (bowhead whale, narwhal, ringed seal, harbour seal, walrus, harp seal and hooded seal) and their continued existence could be threatened by climate change. The Board strongly recommends monitoring the effects of the climate on these species.	**Very high**
Data on the diet of the minke whale should be gathered from commercial whaling, preferably in connection with the gathering of blubber samples for the analysis of stable isotopes and amino acid profiles.	**High**
The Coastal Reference Fleet collects data suitable for monitoring bycatches of marine mammals and this scheme should be continued at at least the present level.	**High**
Environmental toxins in marine mammals should be monitored, particularly in Arctic species and new toxins recorded.	**High**
Climate change could result in a more northerly spread of different pathogens, which could lead to infectious diseases in marine mammals. Studies of pathogen-marine mammal interactions and possible connections to climate change and exposure to environmental toxins should be carried out.	**High**
Studies of the effect of military sonars and seismics on behaviour should be continued to include our species of beaked whales and baleen whales, with particular focus on the minke whale.	**High**
The Board notes the positive and lasting (6 months) effect on rheumatic pain and intestinal infections and ulcers after an intake of seal oil for a short period (10 days), but emphasised that major clinical testing of seal/whale oil compared with cod liver oil or salmon oil would be required.	**High**
Seals should be prioritised in future work in order to improve documentation on humane killing methods.	**High**

Chapter 8

Table of all living species of marine mammal

The table on the next four pages is based on D.W. Rice's *Marine Mammals of the World – Systematics and Distribution. Special publication no. 4. The Society for Marine Mammalogy.* The English names for cetaceans are in keeping with the list of names used by the IWC's Scientific Committee.

8.1 THE ORDER CETACEA – WHALES

	Scientific name	English name	Norwegian name
The suborder Mysticeti		**Baleen whales**	**Bardehvaler**
The Balaenidae family		the Right Whale family	retthvalfamilien
	Eubalaena australis	southern right whale	sørlig retthval
	Eubalaena glacialis	North Atlantic right whale	nordkaper
	Eubalaena japonica	North Pacific right whale	
	Balaena mysticetus	bowhead whale	grønlandshval
The Neobalaenidae family		the Pygmy Right Whale family	
	Caperea marginata	pygmy right whale	
The Eschrichtiidae family		the Grey Whale family	
	Eschrichtius robustus	gray (grey) whale	gråhval
The Balaenopteridae family		the Fin Whale family	
	Balaenoptera acutorostrata	Common minke whale	vågehval
	Balaenoptera bonaerensis	Antarctic minke whale	antarktisk vågehval
	Balaenoptera borealis	sei whale	seihval
	Balaenoptera edeni	Bryde's whale	Brydes hval
	Balaenoptera musculus	blue whale	blåhval
	Balaenoptera physalus	fin whale	finnhval
	Balaenoptera omurai	Omura's whale	
	Megaptera novaeangliae	humpback whale	knølhval
The suborder Odontoceti		**Toothed whales**	**tannhval**
The Physeteridae family		the Sperm Whale family	
	Physeter macrocephalus	sperm whale	spermhval
The Kogiidae family		the Pygmy Sperm Whale family	
	Kogia breviceps	pygmy sperm whale	
	Kogia sima	dwarf sperm whale	
The Ziphiidae family		the Beaked Whale family	nebbhvalfamilien
	Tasmacetus shepherdi	Shepherd's beaked whale	
	Berardius bairdii	Baird's beaked whale	
	Berardius arnuxii	Arnoux's beaked whale	
	Mesoplodon pacificus	Longman's beaked whale	
	Mesoplodon bidens	Sowerby's beaked whale	nordspisshval
	Mesoplodon densirostris	Blainville's beaked whale	
	Mesoplodon europaeus	Gervais' beaked whale	
	Mesoplodon layardii	strap-toothed whale	
	Mesoplodon hectori	Hector's beaked whale	
	Mesoplodon grayi	Gray's beaked whale	
	Mesoplodon stejnegeri	Stejneger's beaked whale	
	Mesoplodon bowdoini	Andrews' beaked whale	
	Mesoplodon mirus	True's beaked whale	
	Mesoplodon ginkgodens	ginkgo-toothed beaked whale	
	Mesoplodon carlhubbsi	Hubbs' beaked whale	
	Mesoplodon perrini	Perrin's beaked whale	
	Mesoplodon peruvianus	pygmy beaked whale	
	Mesoplodon traversii	spade-toothed whale	
	Ziphius cavirostris	Cuvier's beaked whale	
	Hyperoodon ampullatus	northern bottlenose whale	nebbhval
	Hyperoodon planifrons	Southern bottlenose whale	

The Platanistidae family		River Dolphins	
	Platanista gangetica	South Asian river dolphin	
The Pontoporiidae family		River Dolphins	
	Lipotes vexillifer	baiji	
	Pontoporia blainvillei	fransciscana	
The Iniidae family		River Dolphins	
	Inia geoffrensis	boto	
The Monodontidae family		the Narwhal family	
	Delphinapterus leucas	white whale, beluga	hvithval
	Monodon monocerus	narwhal	narhval
The Delphinidae family		the Dolphin family	delfinfamilien
	Steno bredanensis	Rough-toothed dolphin	stroppetannet delfin
	Sousa chinensis	Indo-Pacific hump-backed dolphin	
	Sousa teuszii	Atlantic hump-backed dolphin	
	Sotalia fluviatilis	tucuxi	
	Sotalia guianensis	Guiana dolphin	
	Lagenorhynchus albirostris	white-beaked dolphin	kvitnos
	Lagenorhynchus acutus	Atlantic white-sided dolphin	kvitskjeving
	Lagenorhynchus obscurus	dusky dolphin	
	Lagenorhynchus obliquidens	Pacific white-sided dolphin	
	Lagenorhynchus cruciger	hourglass dolphin	
	Lagenorhynchus australis	Peale's dolphin	
	Grampus griseus	Risso's dolphin	arrdelfin
	Tursiops truncatus	bottlenose dolphin	tumler
	Tursiops aduncus	Indo-Pacific bottlenose dolphin	
	Stenella frontalis	Atlantic spotted dolphin	
	Stenella attenuata	pantropical spotted dolphin	
	Stenella longirostris	spinner dolphin	
	Stenella clymene	clymene dolphin	
	Stenella coeruleoalba	striped dolphin	stripedelfin
	Dephinus delphis	common dolphin	gulflankedelfin
	Delphinus capensis	long-beaked common dolphin	
	Lagenodelphis hosei	Fraser's dolphin	
	Lissodelphis borealis	northern right whale dolphin	
	Lissodelphis peronii	southern right whale dolphin	
	Cephalorhynchus commersonii	Commerson's dolphin	
	Cephalorhynchus eutropia	Chilean dolphin	
	Cephalorhynchus heavisidii	Heaviside's dolphin	
	Cephalorhynchus hectori	Hector's dolphin	
	Peponocephala electra	Melon-headed whale	
	Feresa attenuata	pygmy killer whale	
	Pseudorca crassidens	false killer whale	halvspekkhogger
	Orcinus orca	killer whale	spekkhogger
	Globicephala melas	long-finned pilot whale	grindhval
	Globicephala macrorhynchus	short-finned pilot whale	
	Orcaella brevirostris	Irrawaddy dolphin	
	Orcaella heinsohni	Australian snubfin dolphin	

The Phocoenidae family		the Porpoise family	
	Neophocaena phocaenoides	finless porpoise	finneløs nise
	Phocoena phocoena	harbour porpoise	nise
	Phocoena sinus	vaquita	vaquita
	Phocoena spinipinnis	Burmeister's porpoise	
	Phocoena dioptica	spectacled porpoise	brillenise
	Phocoenoides dalli	Dall's porpoise	

8.2 THE ORDER SIRENIA – SEA COWS

	Scientific name	English name	Norwegian name
The Trichechidae family		the Manatee family	
	Trichechus manatus	West Indian manatee	
	Trichechus senegalensis	African manatee	
	Trichechus inunguis	Amazonas manatee	
The Dugongidae family		the Dugong family	
	Dugon dugong	dugong	

8.3 THE ORDER CARNIVORA – CARNIVORES

	Scientific name	English name	Norwegian name
The Otariidae family		the Eared Seal family	
	Arctocephalus pusillus	Cape fur-seal	kappsel
	Arctocephalus gazella	Kerguelen fur-seal	
	Arctocephalus tropicalis	Amsterdam fur-seal	
	Arctocephalus townsendi	Guadalupe fur-seal	
	Arctocephalus philippii	Juan Fernandez fur-seal	
	Arctocephalus forsteri	Australian fur-seal	
	Arctocephalus australis	South American fur-seal	
	Arctocephalus galpagoensis	Galapagos fur-seal	
	Callorhinus ursinus	Northern fur-seal	
	Zalophus japonicus	Japanese sea-lion	
	Zalophus californianus	California sea-lion	
	Zalophus wollebaeki	Galapagos sea-lion	
	Eumetopias jubatus	Stellar's sea-lion	
	Neophoca cinera	Australian sea-lion	
	Phocartos hookeri	Hooker's sea-lion	
	Otaria flavescens	South American sea-lion	
The Odobenidae family		the Walrus family	
	Odobenus rosmarus		hvalross
The Phocidae family		the True Seal family	
	Erignathus barbatus	bearded seal	storkobbe
	Phoca vitulina	harbour seal	steinkobbe
	Phoca largha	spotted seal	largasel
	Pusa hispida	ringed seal	ringsel, snadd
	Pusa caspica	Caspian seal	kaspisel
	Pusa sibirica	Baikal seal	baikalsel

Halichoerus grypus	grey seal	havert
Histriophoca fasciata	ribbon seal	båndsel
Pagophilus groenlandicus	harp seal	grønlandssel
Cystophora cristata	hooded seal	klappmyss
Monachus monachus	Mediterranean monk seal	middelhavsmunkesel
Monachus schauinslandi	Hawaiian monk seal	hawaiimunkesel
Mirounga leonina	southern elephant seal	sydlig elefantsel
Mirounga angustirostris	northern elephant seal	nordlig elefantsel
Leptonychotes weddellii	Weddell seal	weddellsel
Ommatophoca rossii	Ross seal	rossel
Lobodon carcinophaga	crabeater seal	krabbeetersel
Hydrurga leptonyx	leopard seal	leopardsel

INSTITUTE OF MARINE RESEARCH
Havforskningsinstituttet
Nordnesgaten 50
P.O. Box 1870 Nordnes
NO-5817 Bergen
Tel: +47 55 23 85 00 – Fax: +47 55 23 85 31
E-mail: post@imr.no

INSTITUTE OF MARINE RESEARCH
TROMSØ DEPARTMENT
Sykehusveien 23
P.O. Box 6404
NO-9294 Tromsø
Tel: +47 55 23 85 00 – Fax: +47 77 60 97 01

INSTITUTE OF MARINE RESEARCH
FLØDEVIGEN RESEARCH STATION
NO-4817 His
Tel: +47 55 23 85 00 – Fax: +47 37 05 90 01

INSTITUTE OF MARINE RESEARCH
AUSTEVOLL RESEARCH STATION
NO-5392 Storebø
Tel: +47 55 23 85 00 – Fax: +47 56 18 22 22

INSTITUTE OF MARINE RESEARCH
MATRE RESEARCH STATION
NO-5984 Matredal
Tel: +47 55 23 85 00 – Fax: +47 56 36 75 85

RESEARCH VESSELS DEPARTMENT
Tel: +47 55 23 85 00 – Fax: +47 55 23 85 32

CENTRE FOR DEVELOPMENT
COOPERATION IN FISHERIES, CDCF
Tel: +47 55 23 85 00 – Fax: +47 55 23 85 79
E-mail: cdcf@imr.no

PUBLIC RELATIONS AND COMMUNICATION
Tel: +47 55 23 85 00 – Fax: +47 55 23 85 55
E-mail: informasjonen@imr.no

www.imr.no

Photo: George McCullam og Arne Bjørge