

## Seasonal distribution, exploitation and present abundance of stocks of large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters

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An account of the annual distribution and previous exploitation of Greenland right (*Balaena mysticetus*), blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), humpback (*Megaptera novaeangliae*) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters is presented. Where possible, the present abundances of these species are updated with data from sightings surveys conducted in these waters in 1987–1989. The Greenland right whale is rarely seen and is probably nearly extinct. The blue whale seems to be regularly migrating into the Norwegian Sea up to the west of Spitsbergen in summer, but its abundance is not known. Recent survey estimates indicate a fin whale population of some thousands in the Norwegian Sea in summer. The recent sightings surveys have revealed no new information on sei whale abundance in these areas. Humpbacks amount to approximately 1000 whales in the Norwegian and Barents Seas, while sperm whales number several thousand in the Norwegian Sea. In total, up to 10 000 individuals of the large whale species inhabit these northern waters during the summer.

Key words: whales, Norwegian waters, abundance, distribution.

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### Introduction

Sightings surveys of cetaceans were conducted in Norwegian and adjacent waters during summer in the years 1987–1989 (Øien, 1989, 1990, 1991). The main target species of these sightings surveys was the minke whale (*Balaenoptera acutorostrata*), but other species were also recorded systematically, providing an opportunity to evaluate their present status with regard to abundance and summer distribution. These other species include the sperm whale (*Physeter macrocephalus*) as well as several large baleen whale species, i.e. Greenland right (or bowhead) whale (*Balaena mysticetus*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*) and humpback whale (*Megaptera novaeangliae*), which were important resources in earlier whaling activities in Norwegian waters (Risting, 1922; Ingebrigtsen, 1929; Jonsgård, 1974). The aim of this paper is to evaluate the status of these large whale species based on the results from the Norwegian sightings surveys. Special emphasis is

put on the 1989 surveys, which covered the largest area (see Øien, 1991). A presentation of the 1988 sightings data was given by Øien (1990). In addition to the abundance data, we present a review of previous exploitation as well as available information on the seasonal distribution of the actual species in Norwegian and adjacent waters.

### Materials and methods

Information, mainly from available literature, about the exploitation of large whales in Norwegian waters has been reviewed. Most information about the seasonal distribution of large whales in Norwegian waters was also drawn from existing literature. Additionally, some information on incidental sightings has been extracted from a database at the Institute of Marine Research (IMR), Bergen, comprising data from various sources since 1968: IMR research vessels, inspectors on certain small-type whaling vessels, reports from fishing and small-type whaling vessels and reports from coast guard

vessels. These reports include all or some of the following information: observation date and position, school size and comments about activity and behaviour. As there is no quantitative information on the effort involved in searching for cetaceans, the data from incidental sightings cannot be used for estimating absolute abundance nor trends in abundance. Nevertheless, the data yield useful information on distribution. Incidental sightings of humpback whales, which are particularly easy to distinguish from other species in the field, are especially numerous and are given special emphasis in this paper.

Line transect surveys have been conducted in Norwegian and adjacent waters from 1987 to 1989. Minke whales were the target species of these surveys, but sightings of other species were also recorded. Abundance estimates, based on the survey carried out in July 1989, are presented. Standard line transect analyses have been applied, in which hazard-rate detection functions have been fitted to sets of perpendicular distance data to estimate effective search-widths. Abundances,  $N$ , have then been calculated as:

$$N = (n/L)(1/2w)(s)(A),$$

where  $n/L$  is the sightings rate,  $w$  is the effective half search width,  $s$  is the mean school size and  $A$  is the area of the block surveyed. For these calculations, it is assumed that all whales on the track line are seen ( $g(0) = 1$ ; see Schweder, 1990). The blocks surveyed are defined and given in Table 3. For further details and information about survey design and sightings procedures, the reader is referred to Øien (1991).

## Results and discussion

### Greenland right whale (*Balaena mysticetus*)

#### Seasonal distribution

Historically, the Greenland right whale (or bowhead whale), which is exclusively confined to the northern hemisphere, had a nearly circumpolar distribution with five recognized geographically separated stocks (Reeves, 1980). The Greenland right whales, inhabiting Norwegian waters, belong to the East Greenland–Spitsbergen stock. This stock was very heavily exploited during the period lasting from 1611 to the beginning of the present century, and it is generally accepted that the present status of the stock must be very close to extinction (Ruud, 1937; Reeves, 1980; Jonsgård, 1981, 1982; McQuaid, 1986). Accordingly, both the distribution and migration patterns of Greenland right whales in Norwegian waters, of which all information stems from the period of whaling, when the magnitude of the stock probably ranged between 20 000 and 30 000 animals (see Reeves, 1980), may have changed considerably.

Traditional whaling for the Greenland right whale in the North Atlantic took place during spring, summer

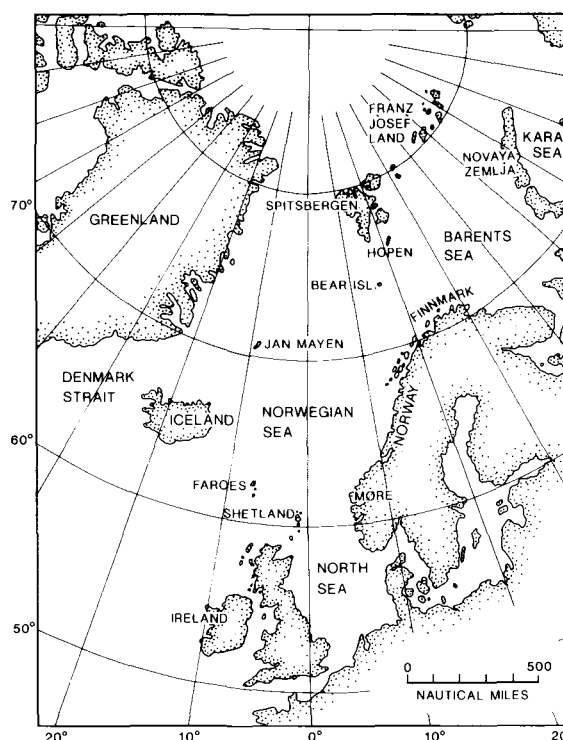


Figure 1. North-east Atlantic localities mentioned throughout the text.

and autumn, and the wintering areas for the species are, therefore, unknown. Given the Greenland right whale's pagophilic nature, it is likely that the stock remained close to the southern boundary of winter ice in the Norwegian Sea (Fig. 1). As the ice cover receded and disintegrated, the whales moved north-east, passing by the Jan Mayen island, with some arriving in Spitsbergen waters in April–May (Eschricht and Reinhardt, 1866; Ruud, 1937; Reeves, 1980; Braham, 1984). Reeves (1980) considered that the species appeared to disperse along (and to a certain extent within) the drift- and pack-ice belt between Greenland and Spitsbergen during summer. Reeves (1980) also refers to observations of Greenland right whales in the northern Barents Sea between Spitsbergen and Novaya Zemlja, and suggests that these might either be an eastern part of the East Greenland–Spitsbergen stock, or come from a separate Barents and Kara Sea stock. In the old literature, certain differences were described between Greenland right whales taken between Spitsbergen and Greenland (“West Ice whales”), and those taken south of Spitsbergen (“South Ice whales”) (see Eschricht and Reinhardt, 1866). The South Ice whales were said to come from the east and return to the east during the exceptional years when they appeared at all near Spitsbergen. Observations of several individuals of the species in the localities of Franz Josef Land and Novaya Zemlja during the last 20 years, compared with

Table 1. Previously unreported incidental and sightings survey observations of bowhead whales in Norwegian and adjacent waters.

Date	School size	Geographical area	Notes
24 July 1992	1	Jan Mayen, Norwegian Sea	
11 April 1967	1	Norwegian Sea, east of Iceland	
7 July 1989	1	Eastern Barents Sea	Sightings survey 1989

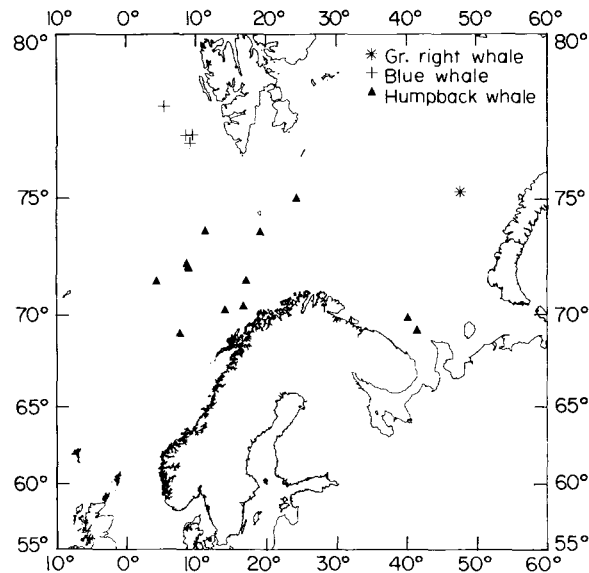


Figure 2. Sightings of Greenland right, blue and humpback whales during the July 1989 survey.

very few observations further west in the supposed distributional area of the Spitsbergen stock (see Belikov *et al.*, 1989; Wiig, 1991), support the idea of two possible stocks inhabiting the areas to the west and east of Spitsbergen. Due to the low present stock level, the problem of such potential geographic variability within what is now called the East Greenland–Spitsbergen Greenland right whale stock is difficult to resolve (Reeves, 1980).

#### Exploitation

Originally, the Greenland right whales were numerous in the Arctic. Their presence off Spitsbergen was detected in about 1600, and in 1610 catch operations were started there by the British, who were soon followed by Basques, Dutch, Danish and Norwegian whalers (de Jong, 1983). The Greenland right whaling was carried out from many land stations at Spitsbergen and the Jan Mayen island, but these were already closed in 1670 when the whales had disappeared from the Arctic coasts. Pelagic Greenland right whaling was, however, continued until the end of the 19th century.

In the course of the 18th century, a gradual decline in the Spitsbergen stock of Greenland right whales occurred. Whaling after 1790 included methods that resulted in

the killing of nursing females, sucklers and immature animals, and this proved to be disastrous for the stock (see de Jong, 1983). A rapid decline in the Spitsbergen stock followed this massive killing which decimated these animals to almost complete extinction by the end of the 19th century. This situation seems to have prevailed up to the present (Reeves, 1980).

#### Present abundance

The few observations made of Greenland right whales in Norwegian and adjacent waters in this century (Ruud, 1937; Reeves, 1980; Jonsgård, 1981, 1982; McQuaid, 1986; Belikov *et al.*, 1989; Clark and Brown, 1991; Wiig, 1991) indicate that the species is at a very low stock level here. There are a few previously unreported incidental observations from the Barents and Norwegian Seas (Table 1). During the sightings surveys conducted in recent years, only one bowhead has been recorded. This individual was sighted while in primary searching mode in the eastern Barents Sea (Fig. 2). A single sighting does not, however, allow an estimate of abundance of this species, but the numbers of Greenland right whales in the Barents and Norwegian Seas are most probably in the tens.

## Blue whales (*Balaenoptera musculus*)

### *Seasonal distribution*

The distribution of blue whales in the north-east Atlantic spans the areas from the Cape Verde Islands in the south to the pack-ice or the ice-edge (in some years beyond 80°N), in the north (Jonsgård, 1966a). It is thought that different stocks of blue whales, with different migration routes and feeding grounds, inhabit the eastern and western North Atlantic (Ingebrigtsen, 1929; Jonsgård, 1955; Rørvik and Jonsgård, 1981). The degree of discreteness among these stocks has been a matter of dispute, owing to, among other reasons, recoveries of harpoons of foreign origin in blue whales caught off Iceland and north Norway (Hjort, 1902; Collett, 1912; Jonsgård, 1955; Rørvik and Jonsgård, 1981; Mitchell and Reeves, 1983).

Our knowledge of blue whale migration habits in these areas stems mainly from observations made during whaling operations around the turn of the century. The blue whale appears to be very regular in its movements, with a northward feeding migration in spring and a southward return to unknown breeding areas (see Jonsgård, 1966a) in autumn. According to Ingebrigtsen (1929), two major blue whale stocks mingle north of Iceland during March to April. One western branch comes northward along the East Greenland coast through the Denmark Strait and another eastern branch migrates northward west of the British Isles and further up between the Faroe Islands and Iceland (Fig. 1). From the areas north of Iceland, Ingebrigtsen (1929) suggested that the blue whales proceed further north-eastward to the Spitsbergen and Bear Island banks, where they arrive in May, and then move south-eastward to the coast of Finnmark, north Norway. They remain in north Norway and feed upon euphausiid crustaceans (krill) which are particularly abundant during June and August in these areas (see Hjort and Ruud, 1929). Some blue whales might migrate eastward into the Barents Sea, possibly to spend the summer there feeding on euphausiids (Jonsgård, 1955). It has been suggested that blue whales may move in and out of the feeding grounds in response to plankton fronts along the edge of the continental shelf (Evans, 1980). Ingebrigtsen (1929) assumed that the southward migration (in September) takes place along the same migration routes as the northward migration in spring. These migrational patterns would facilitate a large degree of mingling of "western" and "eastern" blue whales during summer, and thus support previous suggestions of possible exchange of individuals between east and west (see Hjort, 1902; Collett, 1912; Ingebrigtsen, 1929; Jonsgård, 1955; Rørvik and Jonsgård, 1981).

It is clear that most blue whale stocks in the North Atlantic were heavily depleted during the last quarter of the 19th and the first half of the 20th century (Jonsgård, 1955). With the possible exception of Icelandic and adjacent waters, where in fact an apparent annual

increase of about 5% in stock size seems to have prevailed during the past 20 years (Sigurjonsson and Gunnlaugsson, 1990), the post war abundance of blue whales is still low in the North Atlantic. This is particularly true in Norwegian and adjacent waters where only insignificant numbers of the species have been observed along the coast of Finnmark and on the banks to the west of Bear Island and Spitsbergen during summer (Jonsgård, 1955; Christensen, 1980). This calls into question whether the descriptions by Ingebrigtsen (1929) of the migratory pattern of the species in the North Atlantic still holds true.

### *Exploitation*

The history of exploitation of blue whales in these waters is closely connected with the history of modern whaling (see Risting, 1922). In February 1864, Svend Foyn, on the schooner "Spes & Fides", left Tønsberg in southern Norway on the first whaling expedition to the northern coasts of Norway in modern times. Foyn used the same equipment as traditionally used for catching Greenland right whales. He was only able to catch a few blue whales on the first trip, and the next few years he worked on developing new equipment based on his experience from unsuccessful trips. In 1868 he caught 30 blue whales from "Spes & Fides" with the new equipment; in 1869 he caught 17 blues. In 1872, Foyn received exclusive rights from the Norwegian Government to catch whales for 10 years off the coast of Norway. The main whaling area in this early period was the easternmost part of the coast of Finnmark (Varangerfjord), the northernmost county of Norway. The catch statistics in the following year are somewhat confusing, but it is clear that the number of blue whales caught in the fjords decreased rapidly (Fig. 3). The number of whaling vessels increased, and after a few years the blue whale became very rare off Finnmark (Ingebrigtsen, 1929). This caused an expansion to other areas, and summer operations started at Bear Island in 1897. A peak in the catches was reached in 1904, after which they decreased year by year until whaling ceased in 1912. Up to 1904 it appears that about 3500 blue whales were killed in north Norwegian waters (a substantial proportion of the large whales taken were unspecified) (Rørvik & Jonsgård, 1981). A summary of catches is given in International Whaling Statistics (IWS, 1981).

From 1920 to 1955 the catches of blue whales in the eastern North Atlantic by factory ships and land stations were: pelagic 366, Faroe Islands 91, Iceland 154, Ireland 27, Norway 133, Shetland 218, Spitsbergen 5, in total 988 blue whales. The blue whale was protected in the North Atlantic by the International Whaling Commission (IWC) in 1955.

### *Present abundance*

Incidental sightings (Table 2) include observations mainly from the south-eastern Barents Sea and the southern part of the Norwegian Sea. From recent sightings surveys

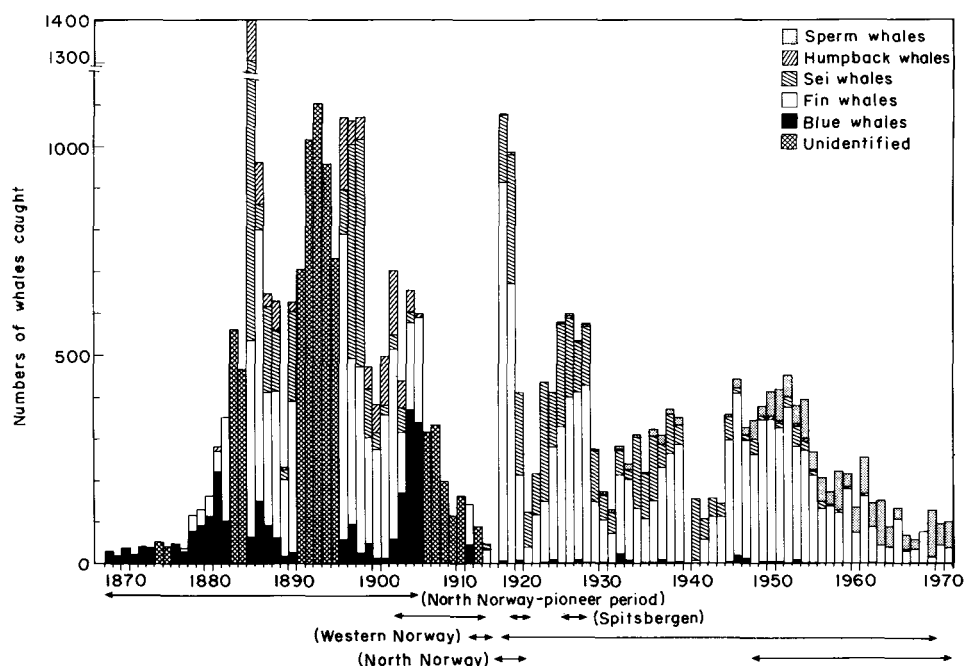


Figure 3. Norwegian catches of large whales during 1864–1971.

Table 2. Previously unreported incidental and sightings survey observations of blue whales in Norwegian and adjacent waters.

Date	School size	Geographical area	Notes
11 April 1967	1	Norwegian Sea, east of Iceland	
29 May 1973	1	South-east Barents Sea	
29 May 1973	1	South-east Barents Sea	
10 May 1979	1	Varanger Fjord, Barents Sea	
23 July 1979	1	South-east Barents Sea	
2 June 1980	1	South-east Barents Sea	
3 June 1980	1	Varanger Fjord, Barents Sea	
10 May 1981	1	South Norwegian Sea	
3 July 1982	1	South Norwegian Sea	
5 July 1983	1	South-east Barents Sea	
17 July 1989	1	West Spitsbergen	
7 July 1989	1	West Spitsbergen	Sightings survey 1989
8 July 1989	1	West Spitsbergen	Sightings survey 1989
14 July 1989	1	West Spitsbergen	Sightings survey 1989
14 July 1989	1	West Spitsbergen	Sightings survey 1989

(Øritsland *et al.*, 1989; Øien, 1990) blue whales have been recorded in the Jan Mayen area, west of Lofoten and west of Spitsbergen. During the 1989 survey, four primary sightings of solitary animals were made west of Spitsbergen (Table 2, Fig. 4). These sightings do not give any basis for calculating abundance, although we think they indicate that blue whales are regularly summering in these waters. Based on sightings surveys in 1987, Gunnlaugsson and Sigurjónsson (1990) gave a maximum estimate of 442 for the number of blue whales in Icelandic waters. Sightings surveys in Icelandic waters in 1989

revealed a higher number, probably in excess of 1000 whales (J. Sigurjónsson, pers. comm.).

### Fin whales (*Balaenoptera physalus*)

#### Seasonal distribution

The distribution of fin whales in the North Atlantic includes almost all waters between 30°N and the ice-edge, at latitudes beyond 80°N (Jonsgård, 1966a, b). The question of stock identity or separate breeding populations of North Atlantic fin whales is by no means

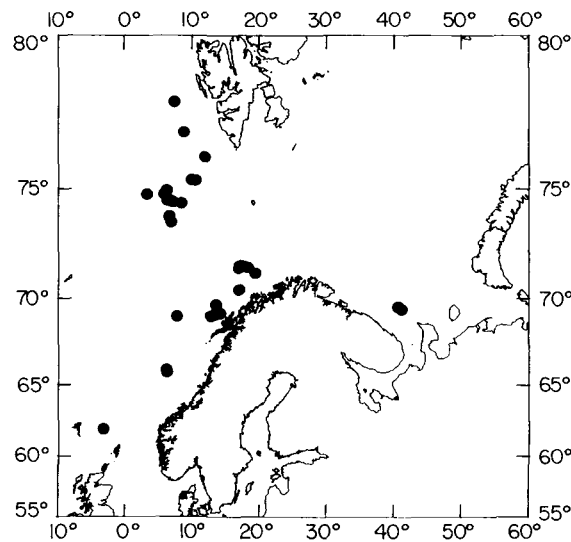


Figure 4. Sightings of fin whales during the July 1989 survey.

resolved (see Arnason, 1981). Most recently, the IWC Scientific Committee concluded that available evidence did not allow it to determine the location of boundaries for stocks of fin whales (IWC, 1992), although it found that the fin whales exploited off Iceland and Spain were from different breeding stocks. This conclusion was based on a review of genetic, morphological and discovery mark analyses, as well as distributional patterns and other evidence. However, for the purpose of this paper, we will refer to the IWC Schedule, which recognizes seven fin whale management stocks in the North Atlantic (Rørvik and Jonsgård, 1981; IWC, 1991). Three of these are of relevance to Norwegian and adjacent waters, namely: the East Greenland–Iceland stock, the North Norway stock, and the West Norway–Faroe Islands stock. There is some indication that the latter two stocks are geographically separated to such an extent that they should be treated as individual management units (Jónsson, 1965; Jonsgård, 1966b; Haug, 1981). Whether the East Greenland–Iceland stock and the North Norway stock constitute one common, or two separate units is more debatable. Jónsson (1965), Jonsgård (1966b), Rørvik *et al.* (1976) and Rørvik and Jonsgård (1981) all argue that the two latter stocks belong to the same breeding population which migrates north and south through the Denmark Strait (Fig. 1) and might have been subjected to catches both off north Norway and off Iceland. This conclusion has, however, been doubted (e.g. Sergeant, 1977; Sigurjónsson and Gunnlaugsson, 1985), but genetic studies are in progress and might resolve this question (J. Sigurjónsson, pers. comm.).

During summer the fin whales may be found in almost all their area of distribution in the North Atlantic. At high latitudes, however, they are more abundant at this time of the year than in winter suggesting a certain degree of

seasonal north–south migrations (Jonsgård, 1966b). It has been suggested that fin whales may be more irregular with regard to their general movements than other baleen whales in the North Atlantic. This could be due to the feeding habits of the fin whale, which is not exclusively plankton consuming, but also a predator upon shoaling pelagic fish species (see Jonsgård, 1966a, b).

During the pioneer period of modern whaling in north Norway, it was well known that the occurrence of fin whales along the coast of Finnmark in spring coincided with the occurrence of large shoals of spawning capelin (*Mallotus villosus*) (Collett, 1877; Sars, 1881; Ingebrigtsen, 1929). According to Ingebrigtsen (1929), the fin whales appeared at the Finnmark coast in the latter half of March, coming from the north and north-east. Jonsgård (1966b) suggested that this southward-directed migration of fin whales during spring, which certainly differs from migrations reported for other areas, must be a local phenomenon caused by the abundance of capelin. Ingebrigtsen (1929) reports that most fin whales disappeared from the coast of Finnmark in April, the bulk of them presumably moving westward into the Norwegian Sea. In June, however, they were again found off Finnmark and, at this time, fin whales also appeared simultaneously in Bear Island and Spitsbergen waters (see also Hjort, 1902). Here they preyed upon euphausiids during the entire summer, and then in autumn (after August) part of the stock proceeded eastward into the Barents Sea, whereas others left for the Norwegian Sea. The wintering areas for this stock are rather uncertain. The suggestion by Ingebrigtsen (1929) that part of the stock might stay in the Arctic Barents Sea during winter (possibly facilitated by the year-round occurrence of capelin) was doubted by Jonsgård, 1966b). Possible migration routes of fin whales southward from the Norwegian Sea

are also rather unclear, although it has been suggested, as we have already mentioned, that they move north and south through the Denmark Strait.

In previous years it was believed that the herring (*Clupea harrengus*) was just as important for the West Norway–Faroe stock of fin whales as the capelin for the stock in north Norway (Sars, 1881; Collett, 1912; Ingebrigtsen, 1929). According to Ingebrigtsen (1929), fin whales approached the Norwegian coast in the Møre area in association with the appearance of herring by the end of January, followed the coast towards the south-west in February and March, and disappeared towards Shetland in April. Probably, the whales did not proceed far west in the Atlantic, since at the end of May they again appeared on the banks off Møre. Ingebrigtsen (1929) reports that the fin whales stayed in these areas [along the outer edge of the banks off Møre, ca. 60–80 nautical miles (n miles) off the coast], pursuing euphausiids as their main prey until the end of August, when they disappeared towards the north and the north-east. The wintering areas of fin whales from the West Norway–Faroe Islands stock, i.e. where they stay during the period between August and January, is not known (see Jonsgård, 1966b).

#### Exploitation

The first known catches of fin whales in the modern history of whaling was Svend Foyn's catch of three fins at the coast of Finnmark (Varangerfjord), in 1876 (see Risting, 1922). During the pioneer whaling period of 1868–1904 on the coast of Finnmark, an increasing number of fin whales were taken along with the blue whales each year, and from 1882 onwards the fin whales were the dominating species in the catches (see Fig. 3). Rørvik and Jonsgård (1981) suggested that ca. 10 500 fin whales were killed from 1868 to 1904, mostly during the last 20 years of the period. After a few years, the availability of fin whales off Finnmark decreased and the whaling vessels had to operate further north and west to find whales. As for the blue and, later on, the humpback whale, it became necessary to search the waters off Bear Island to find these species, and then tow the carcasses to the land stations at the coast of north Norway.

The first expedition to Spitsbergen was sent by Svend Foyn in 1890, but it was not until 1903 that whaling was regularly conducted from Spitsbergen (see Risting, 1922). One land station was built at Spitsbergen and one at Bear Island. Seven other companies were whaling off Svalbard, using some kind of floating factories. The whaling off Svalbard was difficult and the season short, and the whaling operations ceased there in 1909.

There was a 3-year period of whaling off Finnmark from 1918 to 1920 from a land station established there by the Norwegian Government, but it was eventually closed down due to lack of whales.

A shore station for whaling from west Norway was established in 1912 and, as in Finnmark, the Government

initiated whaling operations in 1918 from three stations at the west coast of Norway. In the first year, three blue whales, 605 fin whales, 154 sei whales and one humpback whale were caught (IWS, 1931). Fin whale catching continued in these waters until the West Norway–Faroe Island stock was protected in 1970 (Jonsgård, 1977). The fin whale fishery in north Norway resumed in 1948 and continued until 1971 when the station was closed due to marketing problems.

#### Present abundance

The recent sightings surveys have given some new information on the abundance of fin whales. Results based on the July 1989 survey are given in Table 3, while the fin whale sightings from that survey are shown in Figure 4. The perpendicular sightings distance distribution for all primary sightings is shown in Figure 5. The perpendicular distance data were truncated at 0.8 n miles, the last bin with non-zero observations. The number of primary observations by block ranged from 1 to 13, so the effective search-width was calculated for all blocks pooled, giving the detection function:

$$g(y) = 1 - \exp(-y/0.645)^{**}(-1.756)$$

and the effective half-width 0.6682 n mile (coefficient of variation 0.2088). The total abundance over all blocks surveyed is 2245 (c.v. 0.33), but according to the present stock boundaries as defined by IWC (IWC, 1988), these whales belong both to the North Norway stock and the West Norway–Faroe Islands stock. If, for simplicity, we disregard the fact that the boundary between these stocks follows 67°N while the block boundary used in the survey follows 66°N, the contribution to the first stock is 1900 fin whales (c.v. 0.37), while the contribution to the second is 340 fins (c.v. 0.69).

This estimate for the north Norway stock is fairly consistent with the corresponding estimate from the July 1988 survey of 1000 fin whales (c.v. 0.41) (Øien, 1990), where the general distribution pattern was the same with most of the fins appearing in the Norwegian Sea and Lofoten, with some additional animals along the Finnmark and Kola coasts.

Based on the sightings surveys conducted in 1987, the abundance of the East Greenland–Iceland stock was estimated to be 11 563 (c.v. 0.26), including data from Icelandic survey vessels (Gunnlaugsson and Sigurjónsson, 1990) and an estimate from Norwegian vessels of 5806 fin whales (c.v. 0.502) in the Jan Mayen–Norwegian Sea area (IWC, 1989). A corresponding estimate for the Jan Mayen–Norwegian Sea area, based on the 1988 survey is 1265 (c.v. 0.46) (Øien, 1990).

#### Sei whales (*Balaenoptera borealis*)

##### Seasonal distribution

Apparently, sei whales are more restricted to temperate waters than the other baleen whales in Norwegian and

Table 3. Abundance estimates of fin whales based on results from the 1989 sightings survey. The effective half search-width was estimated to be 0.6682 (c.v. 0.2088) n miles from perpendicular distances pooled over blocks and truncated at 0.8 n miles. Numbers in parentheses are coefficients of variation. The sighting rate is truncated at 0.8 n miles. The blocks (see also Øien, 1991) are: VSN, the continental shelf west of Spitsbergen; SV, the deep waters to the west of this shelf; KO, the banks off the Kola coast; FI, the Finnmark coast; LO, the areas around Lofoten; NØ, the eastern parts of the Norwegian Sea; SN, the southern parts of the Norwegian Sea.

Block	Sighting rate	School size	Whale density (no./n mile <sup>2</sup> )	Area of block (n mile <sup>2</sup> )	Abundance estimate
VSN	0.0020 (3.7117)	1.0 (0)	0.0015 (3.7176)	5501	8 (3.7176)
SV	0.0056 (0.6535)	1.0 (0)	0.0042 (0.6860)	25 323	106 (0.6860)
KO	0.0008 (0.8741)	1.0 (0)	0.0006 (0.8987)	26 840	16 (0.8987)
FI	0.0017 (1.0162)	2.0 (0)	0.0025 (1.0374)	26 221	67 (1.0374)
LO	0.0129 (0.5589)	1.93 (0.1148)	0.0186 (0.6076)	35 784	667 (0.6076)
NØ	0.0043 (0.4174)	3.18 (0.2740)	0.0102 (0.5412)	101 823	1042 (0.5412)
SN	0.0020 (0.6266)	1.67 (0.2000)	0.0025 (0.6901)	135 953	340 (0.6901)
Total for all blocks					2245 (0.3297)

N Norway stock:  
1906 (0.3685)

West Norway/  
Faroes stock

adjacent waters. In the north-eastern part of the Atlantic and in the Norwegian Sea, few reach further north than 72°N, although stragglers have been seen as far north as 79°N (Ingebrigtsen, 1929; Jonsgård, 1966a). According to Ingebrigtsen (1929) the southern limit of the species in the eastern North Atlantic is somewhere between Cape Verde and the Canary Islands.

In their review of the different stocks of balaenopterids in the North Atlantic, Rørvik and Jonsgård (1981) concluded that very little is known about the identity of the sei whale breeding populations in the area. It is known, however, that a northward migration in spring or early summer with an autumn return to the south is characteristic of the species (see Jonsgård, 1966a). The northward migration seems to take place in open waters far from shore, and the time of their first arrival at the coast of Norway (usually off Møre; Fig. 1) seems to be April to May (Risting, 1928; Hjort and Ruud, 1929; Ingebrigtsen, 1929; Jonsgård and Darling, 1977). The yearly abundance of sei whales in Norwegian waters, in particular along the coast of north Norway, seems to be characterized by sudden appearances and disappearances. Ingebrigtsen (1929) suggests that such irregularities are due to variations in the occurrence of their main food, in particular the copepod *Calanus finmarchicus*. Thus, if the sei whales found enough of their favourite prey off Møre, they might remain there throughout the whole summer (i.e. until the beginning of September). In years with unfavourable food conditions in these areas, the animals might proceed further northward to the coast of Finnmark, appearing in July and staying until the end of August. Among the

whalers, years with such northward invasion were usually termed "sei whale years". A contributory cause to a more permanent disappearance of the species may have been the overexploitation which was certainly imposed upon the sei whale stock in Norwegian waters (Jonsgård, 1966a, 1974). This is particularly evident from the very rare occurrence of the species north of Møre after World War II, and from its sparse occurrence off Møre (where it was captured until the late 1950s) after approximately 1960 (Jonsgård, 1974; Jonsgård and Darling, 1977). The sei whales usually leave Norwegian coastal waters and migrate southward by the end of August and at the beginning of September (Ingebrigtsen, 1929).

#### Exploitation

Owing to the irregular appearance of sei whales in Norwegian waters, large fluctuations occur in the numbers of whales caught here (Fig. 3). The catch history of sei whales started in 1885 when 724 individuals were caught off north Norway. Since then, the sei whale catches have followed the same declining pattern as that of fin whales off north Norway. A total of ca. 5000 sei whales were taken in this area from 1885 to 1904 (Rørvik and Jonsgård, 1981). The species has been observed very infrequently in north Norway in this century, and during the last period of land-based whaling here (1948–1971), only three sei whales were taken. Off the coast of western Norway, however, these whales were quite common until several years after World War II (Jonsgård, 1974). This is also evident from the catch statistics (Fig. 3). After 1960,



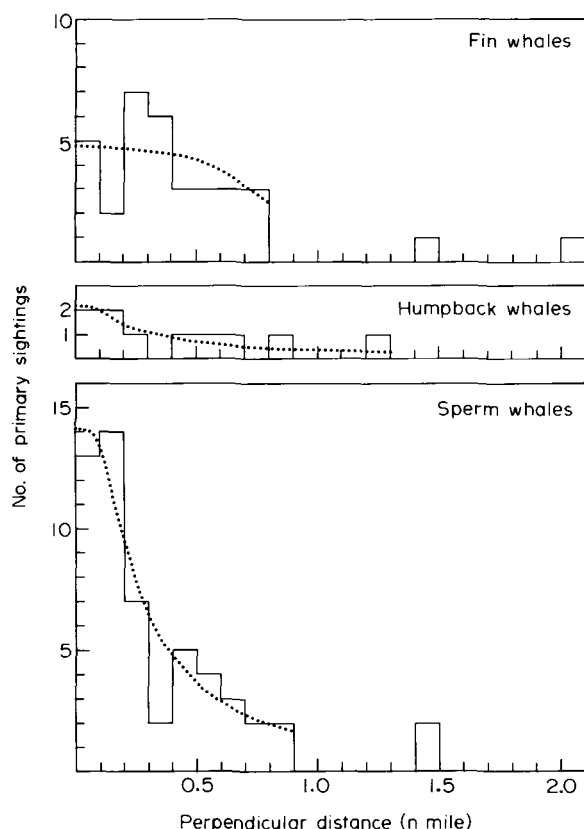


Figure 5. Frequency distributions of perpendicular distances to primary sightings of fin whales, humpback whales and sperm whales based on 1989 survey data. Perpendicular distances are grouped by 0.1 n miles.

very few sei whales were observed in any of the Norwegian whaling areas, and this may be due to overexploitation (Jonsgård, 1974).

#### Present abundance

Only one sei whale has been observed during the recent sightings surveys in Norwegian and adjacent waters. It was sighted 18 July 1987 in the Norwegian Sea. There are some incidental observations of sei whales from the Norwegian Sea area (Table 4), but virtually nothing is known about their present abundance in Norwegian waters.

#### Humpback whales (*Megaptera novaeangliae*)

##### Seasonal distribution

The geographic range of the humpback whale in the North Atlantic extends from the Arctic to tropical regions (Jonsgård, 1966a). Stock identification of the North Atlantic humpbacks is unresolved, although it is commonly acknowledged that several feeding substocks may

exist (Mitchell and Reeves, 1983; Balcomb, 1984; Katona, 1986; Katona and Beard, 1990).

From analyses of catch statistics throughout the season, Ingebrigtsen (1929) suggested that humpbacks in the north-east Atlantic stay in their northern feeding areas during most of the year, migrating out only during a short period in spring for breeding purposes. During these migrations to the breeding areas, the humpbacks were frequently encountered in January–March, coming from their wintering areas along the edge of the pack-ice in the south-eastern Barents Sea (Fig. 1), and moving westward very close to the coast of Finnmark before proceeding into the Norwegian Sea (Collett, 1912; Ingebrigtsen, 1929). In the 1890s humpbacks were said to occur frequently off the coast of western, and to a certain extent southern Norway in winter (January to April) in connection with the high abundance of herring (see Collett, 1912). This seemed, however, not to be the case after 1920 (Ingebrigtsen, 1929). Ingebrigtsen (1929) suggested that the disappearance of humpbacks off western Norway during the winter might be due both to heavy exploitation and to the increase in motor and steam boat traffic in connection with the herring fisheries in the area.

It is suggested that the humpbacks return to Norwegian and adjacent waters in May, usually first in the waters around Bear Island (where they prey upon euphausiids), and later, also in coastal waters off Finnmark (Hjort, 1902; Ingebrigtsen, 1929). From Bear Island and Finnmark, the humpbacks proceed further north and east later in the summer (August) to the areas between Spitsbergen, Franz Josefs Land and Novaya Zemlya, or towards the edge of the ice in the Barents Sea where they stay during September to January feeding on the shoals of capelin. The occurrence of humpback whales in the Arctic regions during the whole winter in the north-east Atlantic differs from observations in other Arctic and Antarctic regions, and may be attributable to the high abundance of capelin in the Barents Sea (Jonsgård, 1966a). Ingebrigtsen (1929) emphasized that it was probably mainly the adult whales which took part in the breeding and feeding migrations described above, whereas the younger animals were presumably more erratic in their migrations, about which very little is known.

There is, as yet, no conclusive evidence of either the migration routes to, or the localization of, the breeding areas of the north-east Atlantic humpbacks. Owing to their scarcity along the more southern coasts of the eastern North Atlantic, as well as the recovery of an American bomb lance in a humpback whale caught off Finnmark in 1899, it has been suggested that humpbacks in the north-east Atlantic constitute a feeding aggregation of the stock breeding further west in the North Atlantic, and that the migration route is through the Denmark Strait (Collett, 1912; Ingebrigtsen, 1929).

The exact location of the calving area is unknown, although Ingebrigtsen (1929) presumed that it might

Table 4. Incidental and sightings survey observations of sei whales in Norwegian and adjacent waters.

Date	School size	Geographical area	Notes
4 June 1978	2	Norwegian Sea south	
15 Sept 1978	1	Jan Mayen/Norwegian Sea	
4 July 1980	3	West Bear Island/Norwegian Sea	
23 July 1980	3	Lofoten	
24 July 1980	2	Lofoten	
3 Aug 1982	–	Norwegian Sea south	
11 Aug 1985	1	Lofoten	
13 June 1986	2	Norwegian Sea	
18 July 1987	1	Norwegian Sea	Sightings survey 1987

be located in an area not far from Ireland. Photo-identification studies of humpbacks in the western North Atlantic suggest the existence of several feeding substocks (including one in the Denmark Strait) which migrate to common breeding grounds at low latitudes in the north-western Atlantic in winter (Balcomb, 1984; Katona, 1986). Additional photographic studies of humpbacks from the eastern North Atlantic are needed in order to discover whether those whales also breed in the western North Atlantic (a conclusion questioned by Mitchell and Reeves, 1983) or at some location in the eastern sector (see Katona, 1986; Katona and Beard, 1990).

#### Exploitation

The first humpback whale catches in the area were made off north Norway in 1881 (Fig. 3). After this time the species occurred more or less regularly in the catches taken in north Norwegian waters until the whaling operations were closed by Norwegian authorities in 1904 (Risting, 1922; Jonsgård, 1977). Humpback catches in other areas of Norwegian and adjacent waters were much lower and more spasmodic than those in north Norway. The total documented number of humpbacks taken at the Norwegian land stations during 1881–1904 was 1084. Due to the unspecified catch in certain years, the real number taken is higher, probably totalling close to 1500 (Ingebrigtsen, 1929). Between 1904 and 1955, when humpbacks were given total protection in the North Atlantic, fewer than 50 humpbacks were caught in Norwegian waters (Jonsgård, 1977).

#### Incidental sightings

The incidental sightings data presented in Figure 6 are consistent with previous suggestions of the migration routes of humpbacks in the area. Thus, most humpback sightings made from May to July were recorded along the coast of Kola and north Norway, south to Lofoten, and north to Spitsbergen, with a particularly dense occurrence in Bear Island area. In August, the situation changed; humpbacks were no longer observed along the coast of Kola and parts of north Norway (Finnmark). The few observations from September and October were nearly all

made in the areas north-east of Hopen Island which is consistent with the general pattern of movement to the north and east towards the end of the summer and in the autumn. Sightings records from winter and early spring are very few and inconclusive.

It has already been mentioned that capelin is a key prey species for humpback whales in the Norwegian Sea area (see Ingebrigtsen, 1929). A severe collapse occurred in the Barents Sea stock of capelin in 1985–1986 (Anon., 1992; Hopkins and Nilssen, 1992). Incidental sightings of humpback whales made in the area before and after this collapse (prior to and after 1986, Fig. 7) suggests a possible change in distribution of this species. Before 1986, incidental sightings of humpbacks were frequently recorded along the coast of Finnmark and Kola and also to the east and north-east of Hopen Island throughout the season. After this year, however, very few such observations were made. The collapse in capelin stocks may have contributed to this observed change. The Barents Sea capelin stock was given protection from exploitation for several years and has now recovered (Anon., 1992). It will be interesting to observe if an increased capelin stock will lead to a shift back to the pre-1986 distribution of humpback whales in the area.

Average school size as observed in incidental sightings was 2.1. For comparison, during the sightings surveys the average humpback school sizes were 1.48 in 1988 and 1.43 in 1989.

#### Present abundance

Only 12 primary sightings of humpback whales were made during the 1989 survey (Fig. 2). The observations were made in the northern part of the Norwegian Sea, around Bear Island and in the south-eastern Barents Sea. Ten of the primary sightings were useful for calculating perpendicular distances, and their distribution is shown in Figure 5. The detection function fitted to this distribution has the form:

$$g(y) = 1 - \exp(-y/0.192)^{**}(-1.0)),$$

which gives an effective search half-width of 0.4627 (c.v. 0.6617) n miles. The abundance estimates based on the

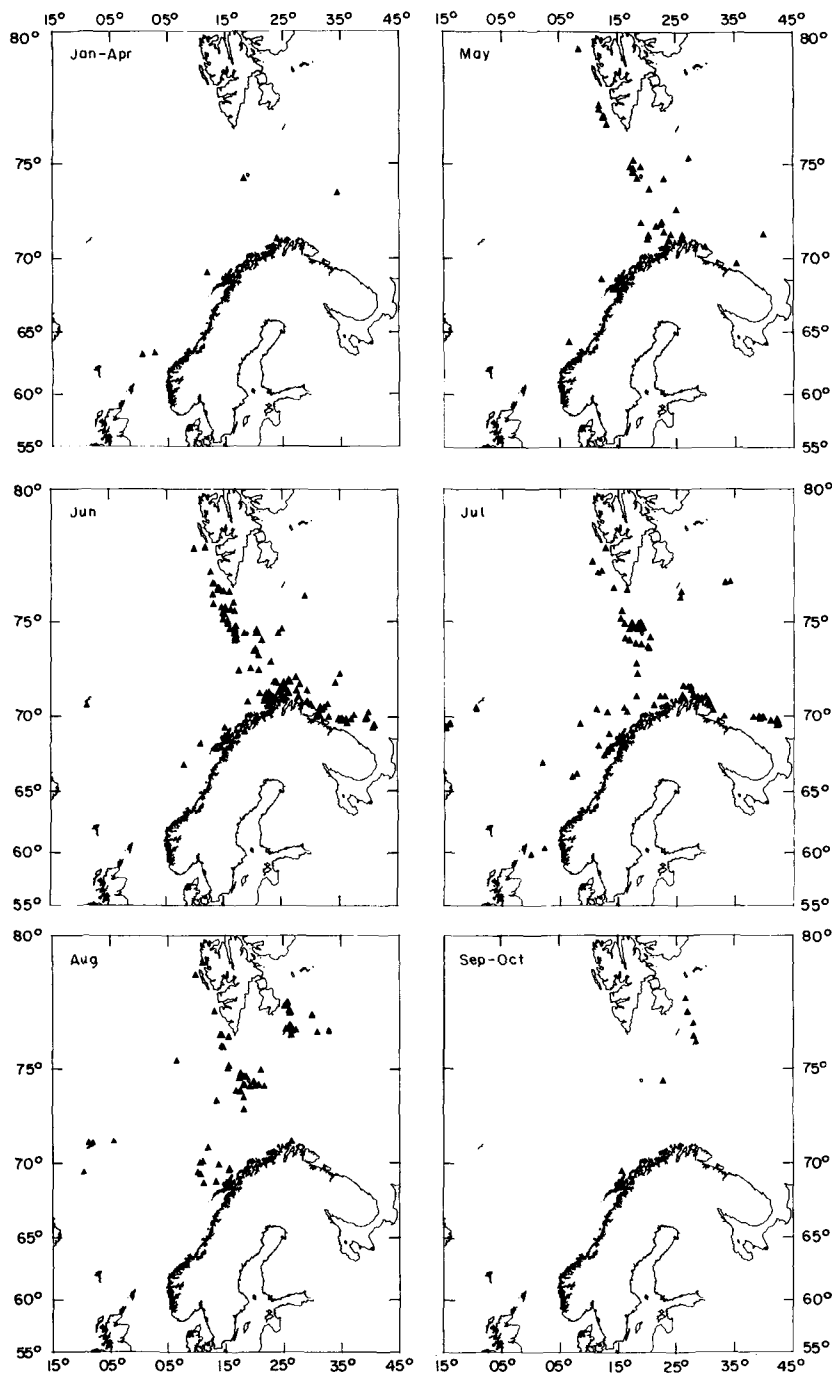


Figure 6. Incidental sightings of humpback whales at different times of the year during 1968–1989 in the Norwegian and Barents Seas.

1989 data are given in Table 5. The estimate of total abundance in the survey area is 700 animals (c.v. 0.59), which compares with the estimate for corresponding areas from the 1988 survey of 1025 animals (c.v. 0.31) (Øien, 1990). Thus, the recent survey results indicate a present abundance of humpback whales of ca. 1000 in the Norwegian and Barents Seas.

#### Sperm whales (*Physeter macrocephalus*)

##### Seasonal distribution

The main distribution areas of sperm whales are in tropical and subtropical waters. The social organization in sperm whale populations is quite peculiar, and results in a seasonal segregation with respect to sex, age/size and

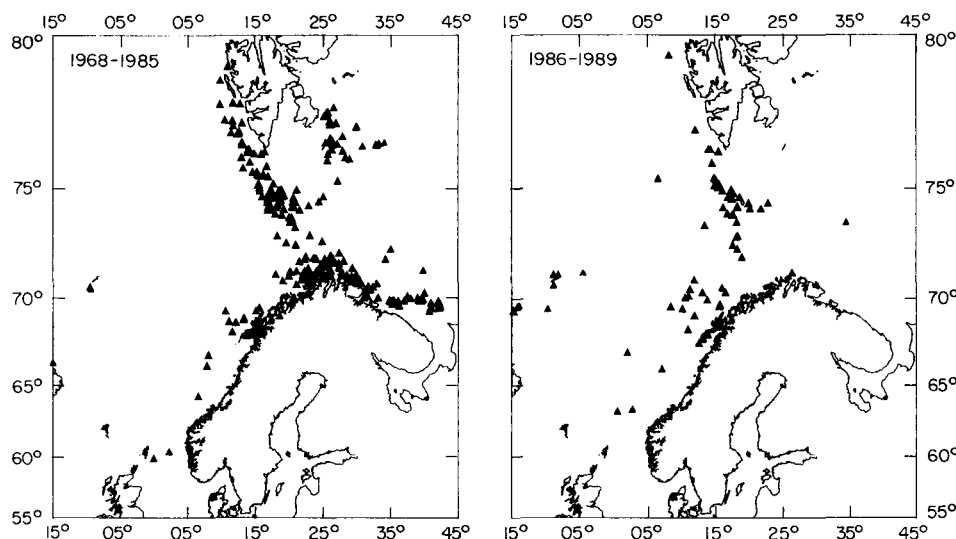


Figure 7. Incidental sightings of humpback whales throughout the year in the Norwegian and Barents Seas during 1968–1985 and 1986–1989.

Table 5. Abundance estimates of humpback whales based on results from the 1989 sightings survey. The effective half search-width was estimated to be 0.4627 (c.v. 0.6617) n miles from perpendicular distances pooled over blocks. Numbers in parentheses are coefficients of variation. Blocks are as defined in Table 3, except BJ which is the Bear Island area (Øien, 1991).

Block	Sighting rate	School size	What density (no./n mile <sup>2</sup> )	Area of block (n mile <sup>2</sup> )	Abundance estimate
BJ	0.0012 (0.6622)	3.0 (0)	0.0039 (0.9361)	21 548	84 (0.9361)
KO	0.0015 (0.6141)	1.0 (0)	0.0016 (0.9028)	26 840	44 (0.9028)
LO	0.0020 (1.5259)	1.33 (0.2500)	0.0029 (1.6819)	35 784	103 (1.6819)
NØ	0.0032 (0.3625)	1.33 (0.1581)	0.0046 (0.7709)	101 823	468 (0.7709)
Total for all blocks					698 (0.5867)

sexual status (for review, see Caldwell *et al.*, 1966; Best, 1974, 1979). Thus, while all females and the small immature males remain gregarious and stay in tropical and subtropical waters throughout the year, sexually mature males become more or less solitary and may migrate towards high latitudes during the summer. In the eastern part of the North Atlantic, females have never been reported north of the Azores (Clarke, 1956), whereas males have been sighted, captured and observed stranded both around Iceland and along the coast of north Norway (Fig. 1) up to Finnmark (Collett, 1912; Risting, 1922; Øynes, 1957; Jonsgård, 1974; Martin, 1980; Christensen, 1980, 1990; Haug and Gulliksen, 1981). One sighting was reported from as far north as 77°40'N on the east side of Spitsbergen (Benjaminson, 1970).

The stock identity of sperm whales in the North Atlantic is unresolved. The whereabouts of the main

population that recruits males to Norwegian waters are, therefore, uncertain, although it is likely that breeding occurs at low latitudes. Also, the travelling routes of the migrating males are unknown, and there is no conclusive evidence as to whether their north–south migrations are annual or if they remain at high latitudes for one or several winters (see Martin, 1980). In Norwegian waters, the sperm whales are known to occur most frequently in the deep waters along the continental slope. In previous years of whaling, the largest sperm whale catches were made in the slope waters off Møre and off Vesterålen (north Norway) (Øynes, 1957).

#### Exploitation

The sperm whale was of little interest to the industry during the first period of modern whaling off north

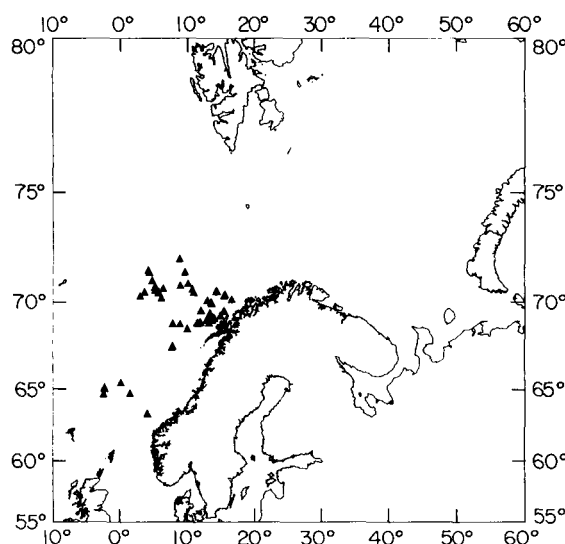


Figure 8. Sightings of sperm whales during the July 1989 survey.

Table 6. Abundance estimates of sperm whales based on results from the 1989 sightings survey. The effective half search-width was estimated to be 0.3634 (c.v. 0.2560) n miles from perpendicular distances pooled over blocks and truncated at 0.9 n miles. Numbers in parentheses are coefficients of variation. The sighting rate is truncated at 0.9 n miles. The blocks are as defined in Table 3.

Block	Sighting rate	School size	What density (no./n mile <sup>2</sup> )	Area of block (n mile <sup>2</sup> )	Abundance estimate
LO	0.0199 (0.5144)	1.45 (0.1099)	0.0397 (0.5850)	35 784	1421 (0.5850)
NØ	0.0129 (0.2724)	1.56 (0.1387)	0.0277 (0.3987)	101 823	2819 (0.3987)
SN	0.0053 (0.8334)	1.00 (0)	0.0073 (0.8718)	135 953	991 (0.8718)
Total for all blocks					5231 (0.3142)

Norway. Reduced availability of the large baleen whales seems, however, to have made this species more attractive for the catchers in this century (see Fig. 3). A limited number of sperm whales (374) were taken off western Norway during 1925–1969; during the last period of land-based whaling in 1948–1971, the sperm whale was the main target species along with the fin whale (Jonsgård, 1977, 1978), when a total of 1088 sperm whales were caught.

#### Present abundance

The observations of sperm whales during the sightings survey in 1989 are shown in Figure 8. The main concentration was in the Norwegian Sea west of the continental slope, but there was also one north-west of Møre in southern Norway. In all, 54 primary sightings of sperm whales were made during the 1989 survey. The perpendicular distance distribution of these is shown in Figure 5. The detection function:

$$g(y) = 1 - \exp(-y/0.201)^{-(1.374)}$$

was fitted to the perpendicular distance data truncated at 0.9 n miles, giving an effective half search-width of 0.3634 n miles (c.v. 0.2560). The abundance estimates are given in Table 6. The total abundance in the survey area was estimated to be 5200 sperm whales (c.v. 0.31), of which ca. 1000 were in the southern part of the Norwegian Sea. Based on the 1988 survey, the abundance of sperm whales in the northern part of the Norwegian Sea was found to be 2500 individuals (c.v. 0.27) (Øien, 1990). Given the very long dives of sperm whales, it could be called into question whether the initial assumption that “all whales on the track line are seen” (or  $g(0)=1$ ; see Schweder, 1990) is applicable for the species. More likely, the above estimates of sperm whale abundance should be regarded as “surface estimates”. Nevertheless, it seems safe to conclude that a summering population of sperm whales in the Norwegian Sea of a few thousand animals are indicated.

## Conclusions

The recent sightings surveys have revealed that up to 10 000 of the large baleen whales (mainly fin and humpback whales) and sperm whales may reside in Norwegian waters during parts of the year (summer). However, their migratory behaviour and stock identity are poorly understood, and more research on these topics is needed in order to facilitate interpretations of the results on abundance from the sightings surveys. It is important to note that migrational patterns are likely to change with time due to changes in environment and stocks. The latter may include the stock of the actual species itself as well as stocks of competitors (e.g. other whale species, seals and sea birds) and prey organisms. Historical information need not, therefore, always be applicable to the present day situation. At least for some of the species, for example humpback whales, some of the research goals could be fulfilled by using non-lethal techniques (e.g. photo-identification).

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