Distribution and Abundance of Harbour Porpoise, *Phocoena phocoena*, in Norwegian waters

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ABSTRACT

This paper presents information on the distribution of harbour porpoise in Norwegian coastal and adjacent waters based on incidental sightings during the period 1964–1968, bycatches in the driftnet salmon fishery in 1988 and two dedicated cetacean sightings surveys in 1988 and 1989. Estimates of pod size and abundance of harbour porpoise in the Norwegian and Barents Sea are given. The information available indicates a divided offshore distribution during summer for harbour porpoises in Norwegian waters, with a southern component in the North Sea area and a northern component from Lofoten and into the Barents Sea. The abundance estimates were about 82,600 porpoises (CV 0.24) for the southern component and about 11,000 porpoises (CV 0.44) for the northern component.

KEYWORDS: HARBOUR PORPOISE; ASSESSMENT; SURVEY-SHIP; SIGHTINGS-INCIDENTAL; INCIDENTAL CAPTURE; NORTH ATLANTIC

INTRODUCTION

When the International Whaling Commission (IWC) Scientific Committee reviewed the status of stocks of harbour porpoise (*Phocoena phocoena*) in 1983, both Andersen and Clausen (1983) and Gaskin (1984) reported that a significant population decline had occurred in the Baltic and North Sea region. This decline was assumed to be a consequence of pollution, disease or incidental catches (or a combination of these). The Committee noted (IWC, 1984) the paucity of information available and recognised that the population(s) in that region may have been seriously reduced. It further noted that the coast of Norway may be of great importance as the eastern North Sea habitat of this species. The Committee advised an augmentation in harbour porpoise research by member countries, including increased effort with respect to stock identification, abundance estimation and the reporting of bycatches. Despite this, in most countries relatively little additional research occurred and the Committee has repeated its concerns over harbour porpoises in the eastern North Atlantic since then (e.g. IWC, 1994).

A research project on the harbour porpoise was initiated in Norway in 1988. The aims of this project were to assess the incidental catches of harbour porpoises and to collect samples from incidentally caught porpoises for further analysis of *inter alia* growth and reproduction, feeding and genetic stock identification. This paper summarises the results of the bycatch studies and presents the first abundance estimates of harbour porpoises in Norwegian waters.

MATERIAL AND METHODS

This study is based on information from three sources: (1) incidental sightings in the period 1964–1988; (2) systematic records of sightings and effort made during a Norwegian

Sighting Survey in 1988 and as part of the North Atlantic Sighting Survey in 1989 (NASS-89); and (3) incidental bycatches in driftnets set for salmon in 1988.

Incidental sightings

Incidental sightings have been recorded at the Institute of Marine Research (IMR) since 1964 (reported by letter or telephone from the public, IMR research vessels, coastguard, whaling and fishing vessels). The lack of quantitative information on effort makes it impossible to infer trends in abundance but the information can be used to support the other findings on the distribution of porpoises in Norwegian waters.

Systematic sightings

In July 1988, a sighting survey covering the Norwegian and Barents Seas was conducted by Norway (Øien, 1990). In July of the following year, Norway, as part of NASS-89 (a multinational survey of the North Atlantic), covered the northern North Sea, the eastern parts of the Norwegian Sea, the Barents Sea and the waters west of Spitsbergen as shown in Fig. 4. As the main objective of these surveys was to assess the abundance of minke whales and other large whales in the Northeast Atlantic, they did not have optimum stratification with regard to harbour porpoises. An earlier survey (part of NASS-87) only covered waters north of *ca* 67°N and made few (9) harbour porpoise sightings (Øritsland *et al.*, 1989); it is not discussed further in this paper.

Abundances have been calculated by block using standard line transect methods (Burnham *et al.*, 1980) with abundance N

$$N = \left(\frac{n}{L}\right) \cdot \left(\frac{1}{2w}\right) \cdot s \cdot A$$

where (n/L) is the sighting rate, $2w$ the effective search width, s the mean school size and A the area of the block. Effective search half-widths w have been estimated by fitting a hazard-rate model with a detection function of the form

$$g(y) = (1 - \exp [- \left(\frac{y}{a}\right)^{(1-b)}])$$

(Hayes and Buckland, 1983) to perpendicular distance data calculated from estimated radial distances and angles read from an angle board. The variance of N has been calculated by combining the variances of its components, where the variance of the sighting rate has been calculated from the daily variation. Abundances have been calculated assuming that $g(0)=1$. Only primary sightings, i.e. sightings made while running on transect in search mode and with estimated radial distances and angles to sightings recorded, have been used for abundance calculations. Confidence intervals have been estimated as suggested by Buckland (1992).

Incidental catches

The salmon fishery in Norway is organised into 34 salmon districts. Until 1988, driftnetting was allowed in 18 of these districts on the west and north coast. The salmon districts are shown and compared with marine fisheries statistics areas in Fig. 2. A total of 580 fishermen were licensed for the salmon driftnet fishery and all licensed fishermen were requested to report on incidental catches of harbour porpoises during a six-week period from late May to early July 1988. The incidental catches were recorded by licence-holder, day and salmon district. Good information on effort was available for this fishery, and effort, given as driftnet-meter-hours per week and salmon district, is used in this paper to compare the incidental catch per unit fishing effort (CPUE) in different areas.

RESULTS

Incidental sightings

A total of 90 incidental sightings of harbour porpoises were recorded between 1964 and 1988. The sightings are given by Marine Fisheries Statistical Area in Table 1 and their geographical distribution is shown in Fig. 1a.

Information on pod size was recorded for 58 of the 90 incidental sightings of harbour porpoises (Table 2). The estimated mean pod size from these is 5.02 (CV 0.3493). The recorded number for one of these sightings were 100 porpoises. Excluding this gives a mean pod size of 3.35 (CV 0.1648).

Table 1

Incidental sightings (1964-88) and bycatches of porpoises in driftnets set for salmon. Incidental sightings are recorded by Norwegian Marine Fisheries Statistics Areas. No effort data are available for these sightings. Incidental catches are recorded by Salmon Fisheries Districts* and then grouped to approximate marine fisheries statistics areas. Salmon districts are grouped to approximate the marine fisheries areas. **Effort in the salmon fishery is given as 1,000 net-meter-hours. ICNMH is Incidental Catch per Net Meter Hour.

	Incidental sightings		Bycatches in salmon driftnets (May-July 1988)			
Marine fisheries statistics area	May-July	All months	Salmon districts*	No.	Effort**	ICNMH
08 Egersundbanken	11	13	11-12-14	5	6,927	0.72
28 Vikingbanken	11	22	15-16-17	18	14,958	1.20
07 Møre	0	2	18-19-20-22	19	23,916	0.79
06 Helgeland	0	0	24-25	16	33,550	0.48
00+05 Vestfjorden-Malangsgr.	4	10	26-27-28	20	13,620	1.47
04 Vest-Finnmark	5	8	29-30-31	18	27,710	0.65
01-02-03-10-11-12-13-14	25	32	-	-	-	-
20-21 Bear island and West	0	3	-	-	-	-
Totals	56	90	-	96	120,681	0.80

Table 2

Pod sizes from the Norwegian Sighting Survey July 1988, the North Atlantic Sighting Survey 1989 (NASS-89) and from incidental sightings. *Numbers in brackets are the overall mean pod sizes.

	Incidental sightings		Sighting survey 88		NASS-89	
Pod size	Frequency	%	Frequency	%	Frequency	%
1	25	43.1	18	47.4	67	45.0
2	9	15.5	13	34.2	33	22.1
3	8	13.8	4	10.5	20	13.4
4	2	3.4	1	2.6	12	8.1
5	5	8.6	1	2.6	5	3.4
6	1	1.7	0	-	1	0.7
7-10	3	5.2	0	-	5	3.4
11-15	3	5.2	1	2.6	4	2.7
16-20	0	-	0	-	0	-
21-50	1	1.7	0	-	2	1.3
51-100	1	1.7	0	-	0	-
Total sightings*	58 (5.02)		38 (2.15)		149 (2.92)	

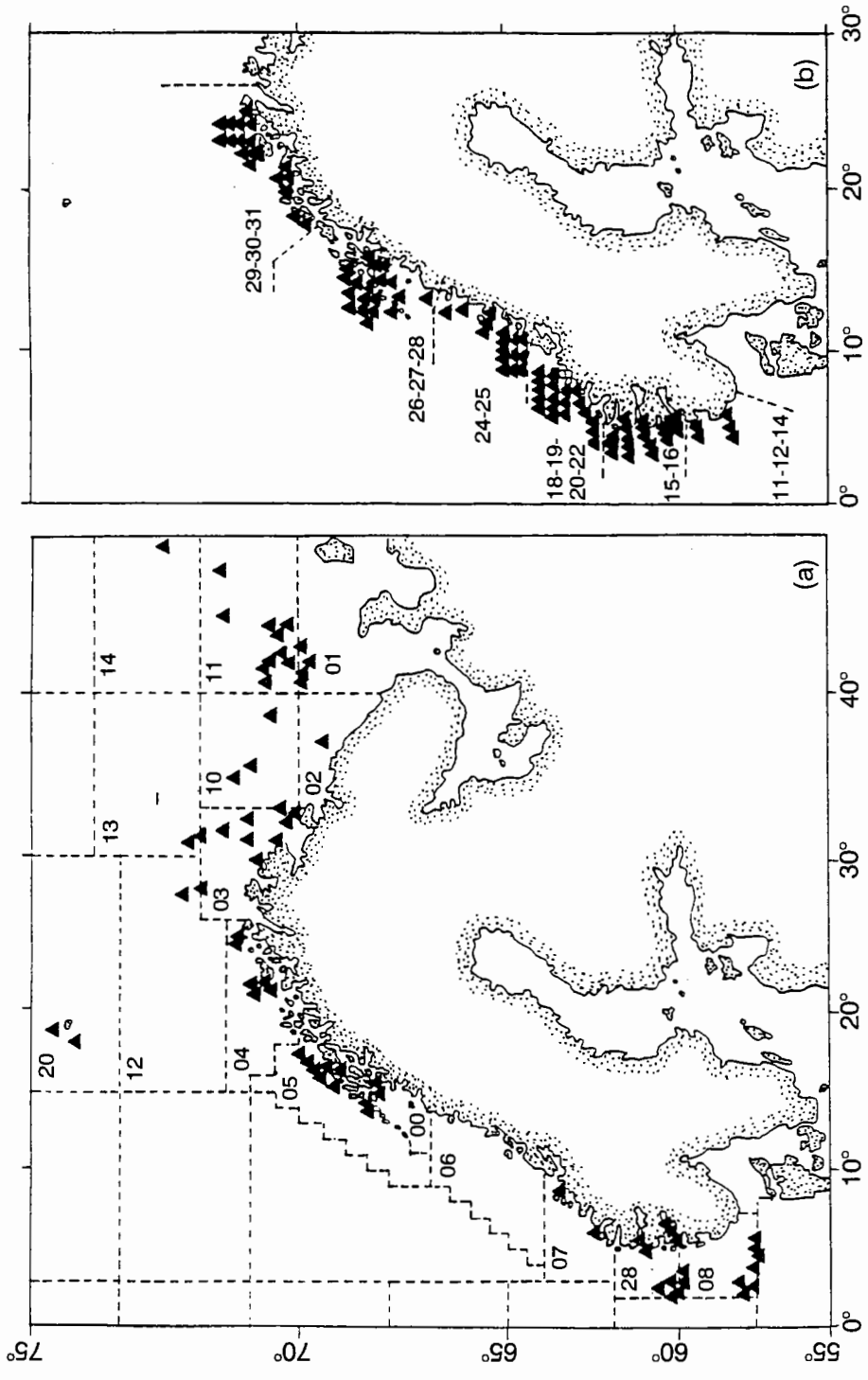

Fig. 1. (a) Shows the geographical distribution of incidental sightings of harbour porpoises recorded in Norwegian coastal and adjacent waters in the period 1964–1988, and the Marine Fisheries Statistics Areas. There is an additional incidental sighting at 77°N off the southwest coast of Spitsbergen, Svalbard. Each plot may represent more than one sighting recorded at the same position. (b) Shows the incidental bycatches of harbour porpoises in driftnets set for salmon in June and July 1988, and the Salmon Districts grouped to approximate the Marine Fishery Statistics Areas.

Sighting surveys

The Norwegian Sighting Survey 1988

A total of 38 observations (79 individuals) of harbour porpoises were made during the Norwegian Sightings Survey 1988 (Fig. 2). Of these, 33 groups were observed during primary search effort of which 22 groups were recorded with radial distance and angle.

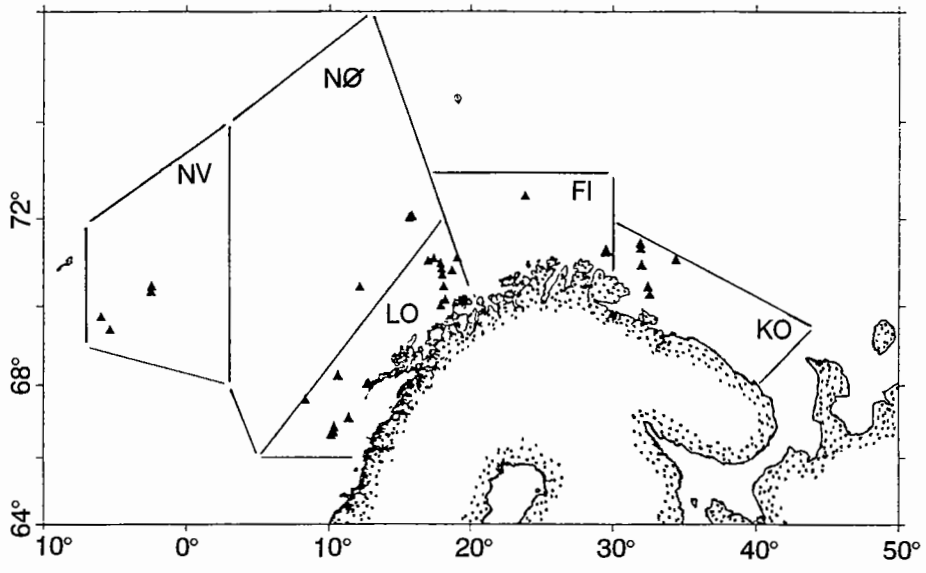

Fig. 2. Sightings of harbour porpoise and surveyed blocks at the Norwegian Sighting Survey 1988.

The perpendicular distance distribution of these sightings is extremely spiked with 15 observations seen less than 0.05 n.miles from the trackline and as many as 7 of these 15 seen on the trackline, which also raises the question of rounding errors in the data. All perpendicular distances were less than 0.27 n.miles. Fitting a hazard-rate function to these data is problematic and the resulting search widths varied non-systematically with degree of data grouping. In terms of goodness of fit, the fits were generally better as the number of groups decreased and the decision was taken to base tentative estimates on a grouping into 0.1 n.miles bins. This gives a detection function of the form $g(y) = 1\text{-EXP}\ [(-y/0.081)(1-3.69)]$ and an effective search half-width of 0.1105 n.miles (CV 0.447). Although this does not leave any degrees of freedom for testing the goodness of fit, it was still chosen as a conservative approach given the data and the following considerations: (i) fitting a negative exponential model to the data results in an effective search half-width of 0.0574 n.miles (CV 0.2840); (ii) the median in the data is less than 0.05 n.miles; (iii) the effective search half-widths based on the hazard-rate are less than 0.10 n.miles, and in most cases considerably so, when finer groupings than the one based on 0.1 n.miles are used; (iv) the resulting search-width is in accordance with the one estimated from the 1989 survey which was conducted in the same way as the 1988 survey operationally. It should be noted that narrow strip widths for harbour porpoises have also been reported from other surveys (e.g. Palka, 1995).

The estimated mean pod size from the 1988 data was 2.15 individuals (CV 0.19), although almost half (47.4%) of the porpoises were solitary. Excluding the single large observation (14 individuals, Table 2) gives a mean school size of 1.76 (CV 0.09). For the abundance estimates, the mean school size per block was used (a school of 14 animals was excluded for that block).

Estimates of density and abundance of harbour porpoises in each survey block are given in Table 3. The estimated total abundance in the surveyed area was 10,100 individuals (CV 0.45; 95% CI 4,370–23,200).

North Atlantic Sighting Survey 1989, NASS-89

A total of 149 pods of harbour porpoises comprising 429 individuals were recorded on Norwegian vessels during NASS-89. The observations are grouped into two geographical components (Fig. 3); a southern component mainly in the North Sea area and a northern component from Lofoten and northwards.

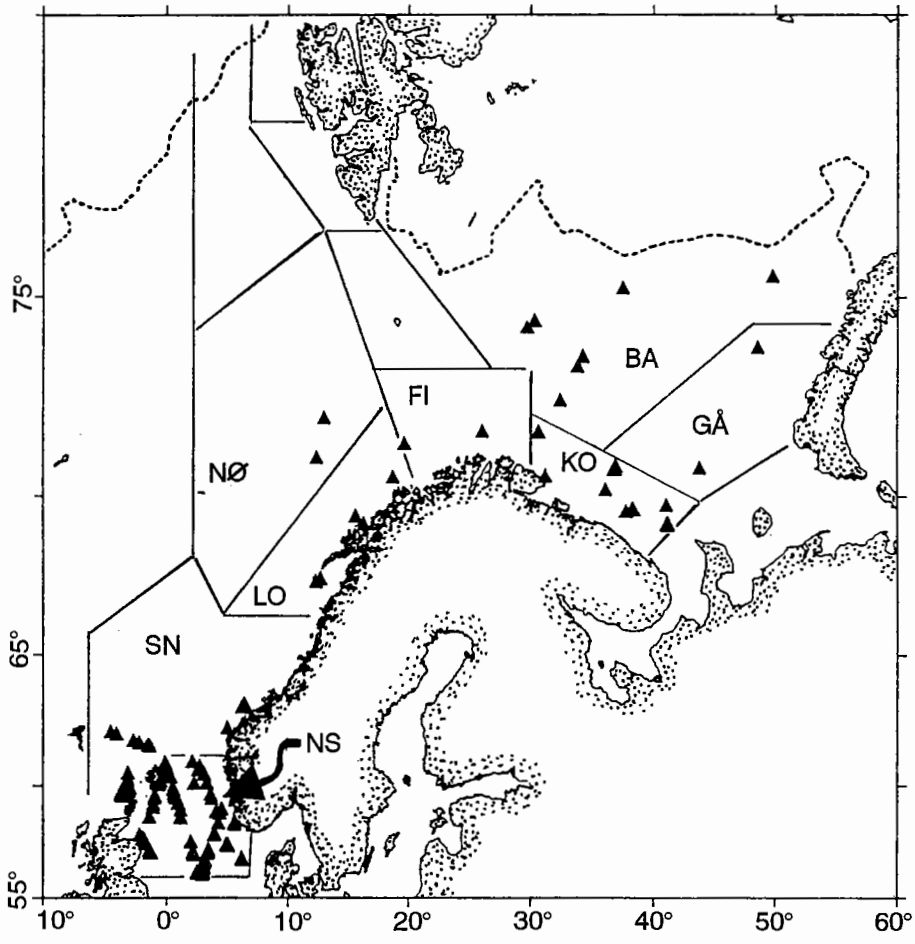

Fig. 3. Sightings of harbour porpoise and surveyed blocks by Norwegian vessels in NASS-89. The dotted line is the approximate ice-edge.

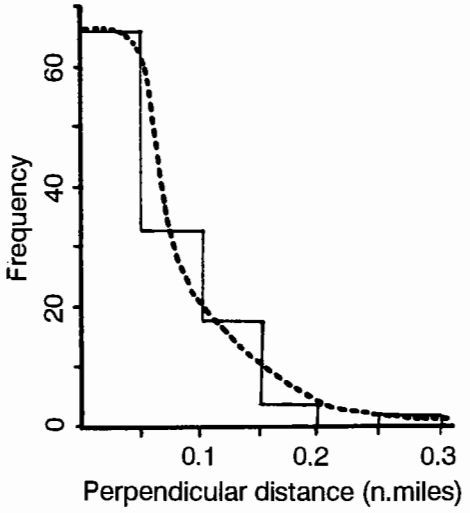

Fig. 4. Perpendicular distance distribution for harbour porpoise sightings recorded at NASS-89. The fitted detection function is shown as a dotted line.

Of the recorded pods, 123 were primary sightings and thus used for abundance calculations. For this purpose a hazard-rate detection function was fitted to the perpendicular distance data grouped by 0.05 n.miles (Fig. 4) to estimate the effective search width (Goodness of fit test: $\chi^2=6.3$, df = 3, $p>0.05$). The fitted detection function then has the form:

$$g(y)\ 1\text{-EXP}\ [-(y / 0.070)^{(1-3818)}]$$

The effective search half-width is 0.095 n.miles (CV 0.095). Total abundance in the surveyed area (Table 4) is 93,600 (CV 0.22; 95% CI 61,500–142,000); 82,600 (CV 0.24; 95% CI 52,100–131,000) in the southern component and 11,000 (CV 0.44; 95% CI 4,790–25,200) in the northern component (see Fig. 4). A comparison between blocks surveyed both years is given in Tables 3 and 4.

The effective search widths varied little between blocks and thus the pooled data have been used in these estimations. Information on pod size is given in Table 2. The maximum pod size recorded was 30 individuals. The large pod observations have not been included in the analysis although they have been recorded as primary sightings. This is because of the difficulties involved in recording distance and angle to a large pod.

Incidental catches

The salmon driftnet fishermen reported a total of 96 incidentally caught porpoises during the six-week period. The incidental catches and the fishing effort are given in Table 1 and the geographical distribution of the incidental catches is shown in Fig. 1b.

DISCUSSION

Distribution

Harbour porpoises have been recorded in all Norwegian waters from the fjords to deep oceanic waters at approximately 5°W and 70°N. The northernmost sighting was made at almost 77°N off the west coast of Spitsbergen, Svalbard. The incidental sightings are

Table 3

Abundance estimates of harbour porpoises based on records from the Norwegian Sighting Survey in July 1988, by blocks as defined in Øien, 1989. Effective search half width is estimated by fitting a hazard-rate detection function to perpendicular distances pooled over blocks. Numbers in brackets are coefficients of variation.

Block	NV	NO	LO	FI	KO
Search effort, L, aut.m.	487.7	2,010.9	1,089.3	548.5	904.0
Area: A, sq.nm	52,719	101,339	37,944	28,129	28,315
No. of pods, n	5	2	10	2	3
Sighting rate, n/L	0.0103	0.0010	0.0092	0.0036	0.0033
	(0.5715)	(0.4400)	(0.3780)	(0.6996)	(0.8784)
Effective search, half width, w, nm		0.1105	(0.4470)		
Mean pod size, s	2.00	1.67	1.92	1.40	1.71
	(0.3536)	(0.2000)	(0.1713)	(0.1750)	(0.1667)
Porpoise density, ind/sq.nm	0.0932	0.0076	0.0799	0.0228	0.0255
	(0.8071)	(0.6583)	(0.6099)	(0.8485)	(0.9996)
Abundance	4,914	766	3,033	641	723
	(0.8071)	(0.6583)	(0.6099)	(0.8485)	(0.9996)
Abundance all blocks		10,077	(0.4463)		

Table 4

Abundance estimates of harbour porpoises based on records from Norwegian vessels in the North Atlantic Sighting Survey July 1989 (NASS-89), by blocks as defined in Øien, 1990. Effective search half width is estimated by fitting a hazard-rate detection function to perpendicular distances pooled over blocks. Numbers in brackets are coefficients of variation.

Block:	BA	CA	KO	FI	LO	NO	SN	NS
Search effort, L, nm	1955.8	923.8	1299.5	582.6	1231.7	1858.4	1508.6	1751.1
Area: A, sq.nm	146,909	46,380	26,840	26,221	35,784	101,823	135,953	73,484
No. of pods, n	7	2	7	1	2	1	25	78
Sighting rate, n/L	0.0036	0.0022	0.0054	0.0017	0.0016	0.0005	0.0166	0.0445
	(0.3579)	(0.7164)	(1.0547)	(1.0162)	(1.2597)	(1.2296)	(0.3497)	(0.2356)
Effective search, half width, w, nm				0.095	(0.095)			
Mean pod size, s	2.86	1.0	1.5	2.0	2.0	1.0	1.79	3.56
	(0.4416)	(0)	(0.1782)	(0)	(0.5)	(0)	(0.1249)	(0.1433)
Porpoise density, ind/sq.nm	0.0542	0.0116	0.0427	0.0179	0.0169	0.0026	0.1566	0.8347
	(0.5764)	(0.7227)	(1.0739)	(1.0207)	(1.3586)	(1.2333)	(0.3834)	(0.2918)
Abundance	7,969	583	1,145	470	603	268	21,284	61,335
	(0.5764)	(0.7227)	(1.0739)	(1.0207)	(1.3586)	(1.2333)	(0.3834)	(0.2918)
Abundance all blocks					93,612	(0.2165)		
Abundance southern component (North Sea area)					82,619	(0.2381)		
Abundance northern component (Lofoten - Barent Sea area)					10,994	(0.4435)		

mostly from the southeastern Barents Sea (Fig. 1a), off the coast of northern Norway southwards to the Lofoten-Vestfjorden area, off the west coast of southern Norway and in the North Sea area. The distribution probably also reflects the general interests of IMR research vessels where certain areas receive more emphasis than other areas. However, a comparison of the incidental sightings with the incidental catches of porpoises per unit effort in the salmon fishery provides some indication of distribution and relative abundances. The porpoises seem to be relatively more abundant in the northern North Sea area and in the Vestfjorden-Vesteralen area, while being relatively less abundant in the intermediate Helgeland area.

The sightings made by NASS-89 further support the suggestion of a divided offshore summer distribution of harbour porpoises in Norwegian waters. Samples collected for genetic stock identification may provide further information on possible sub-population structures in Norwegian waters.

Abundance estimates

The systematic surveys were designed and conducted primarily to obtain information on the abundance of minke whales and other large whales and amongst other problems, the stratification chosen may therefore not be suitable for harbour porpoises. An additional problem is related to the rather small (albeit typical) perpendicular distances observed, resulting in a very narrow effective strip width. An alternative fitting of the perpendicular distances to a negative exponential model gives an effective search half-width of 0.0574 (CV 0.28), which illustrates the problems involved. The large coefficients of variation, further emphasise the associated uncertainty. However, except for the Lofoten area, where the estimate from 1988 was 3,033 and the estimate from NASS-89 was 603, the estimates for blocks surveyed both years were similar.

A major factor to be considered is that 'the assumption that all animals on the trackline are seen ($g(0)=1$), is probably violated. Preliminary estimates of $g(0)$ for harbour porpoises from an experimental survey in the North Sea in 1990 (Øien, 1992) indicate a $g(0)$ of around 0.7 for *two* observer teams combined. Evidence from other areas (e.g. Polacheck, 1995) also indicates that the assumption $g(0)=1$ for harbour porpoises probably introduces a negative bias in the abundance estimates'.

Incidental catches and mortality of porpoises in Norwegian fisheries

In the 1988 postal survey, 96 porpoises were reported caught during the six week period (about half the season) from late May to early July 1988. After the 1988 fishing season the government imposed a ban on the use of driftnets for salmon fisheries in Norwegian waters.

In 1989 and 1990 we have looked into other Norwegian gillnet fisheries to assess the incidental catches of porpoises. Reported bycatches indicate that the incidental catch of porpoises per unit fishing effort (net-meter-hour) in other net fisheries (bottom set nets) are far less than in the former salmon driftnet fishery. We therefore believe that in Norwegian waters porpoises are particularly vulnerable to surface driftnets as compared to bottom set nets due to the topography of these waters.

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