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The distribution and abundance of harbour porpoises and other small cetaceans in the North Sea and adjacent waters

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ABSTRACT

To provide accurate and precise estimates of abundance for harbour porpoises and other small cetaceans throughout the North Sea and adjacent waters, an intensive shipboard and aerial sightings survey was conducted in July 1994 as part of project SCANS - Small Cetacean Abundance in the North Sea. New methods of data collection and analysis were developed as part of the project. These methods included estimating g(0) and accounting for animal movement in response to survey ships using data collected from a primary and a tracker platform on each ship, and estimating g(0) for the aerial survey using data collected from two aircraft flying in tandem (one behind the other). The survey area included the North Sea (including waters north to 62°N), Skagerrak, Kattegat, western Baltic Sea, Channel and Celtic Shelf. Good weather enabled most of the area to receive excellent survey coverage, but too few data for analysis were collected in the Western Baltic. The three most commonly sighted species were harbour porpoises, whitebeaked dolphins and minke whales. Harbour porpoises were distributed throughout most of the North Sea, Skagerrak, Kattegat and Celtic Shelf. None were seen in the southern tip of the North Sea or the Channel. Whitebeaked dolphins were concentrated between 55° and 60°N, particularly in the western North Sea. Minke whales were seen mostly north of 55°N, particularly in the western North Sea, and on the Celtic Shelf. Common dolphins were seen almost exclusively on the Celtic Shelf. Other small cetacean species encountered in small numbers included whitesided dolphins, bottlenose dolphins, striped dolphins, Risso's dolphins, killer whales and pilot whales. Estimates of abundance for the entire survey area using the new methodology are 352,523 (CV=0.14) [95% CI: 267,000 - 465,000] harbour porpoises, 7,856 (CV=0.30) [95% CI: 4,000 - 13,300] whitebeaked dolphins, and 8,445 (CV=0.24) [95% CI: 5,000 - 13,500] minke whales.

INTRODUCTION

The status of small cetaceans, in particular the harbour porpoise, *Phocoena phocoena*, in the North Sea and adjacent waters has been a subject of concern for a number of years. This has stemmed from substantial incidental catches in past fishing operations (Clausen & Andersen 1988), from indications of declines in the number of animals using certain areas based on strandings records (Smeenk 1987; Collet *et al.* 1994) and incidental sightings made mainly in coastal waters (Evans 1990; Evans *et al.* 1986; Verwey & Wolff 1983), from the possibility that small cetaceans may be at risk from contaminants (e.g. Law *et al.* 1992; Law & Whinnet 1992; Kuiken *et al.* 1994), from the effects of disturbance (Evans, Canwell & Lewis 1992) and from the effects on their prey of over-fishing in the North Sea. Recent studies in the North Sea (Vinther 1995) and on the Celtic Shelf (Berrow, Tregenza & Hammond 1994) have confirmed that harbour porpoise bycatches continue in bottom-set gillnet fisheries.

The growing concern about the conservation status of small cetaceans in the North and Baltic Seas led to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) under the UN Convention on the Conservation of Migratory Species of Wild Animals (the "Bonn Convention") to which Belgium, Denmark, Germany, the Netherlands, Sweden, the UK and the EU are Parties. ASCOBANS recognizes the problems caused by lack of information about the numbers, distribution and threats to cetaceans in the North and Baltic Seas and, amongst other things, calls upon signatories to conduct surveys "in order to (a) assess the status and seasonal movements of the populations and stocks concerned, (b) locate areas of special importance to their survival, and (c) identify present and potential threats to the different species".

The problems faced by cetaceans in EU waters are recognized in the Commission Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (Council Directive 92/43/EEC, 21 May 1992). All cetaceans are listed in Annex IV - species of Community interest in need of strict protection, and two species (the harbour porpoise and the bottlenose dolphin, *Tursiops truncatus*) are listed on Annex II - species of Community interest whose conservation requires the designation of Special Areas of Conservation).

The need for quantitative information on the distribution and abundance of small cetaceans in the North Sea has also been recognised repeatedly in a number of other international fora including UNEP through its Global Plan of Action for Cetaceans, the International Council for the Exploration of the Sea (ICES) through its Marine Mammals Committee and its Working Group on Seals and Small Cetaceans in European Seas, and the 1990 North Sea Ministerial Conference. The Scientific Committee of the International Whaling Commission (IWC) has recommended that harbour porpoise abundance should be estimated using dedicated sightings surveys in the North and Baltic Seas, that attention should be given to estimating g(0) [the proportion of sightings detected on the transect line] for harbour porpoise surveys, and that trends in abundance should be monitored on the basis of systematic surveys (IWC 1992). In 1993, the Commission adopted a Resolution which recommended that range states take action to collect and analyse "additional data on population distribution and abundance, stock identities, pollutant levels and by-catch mortality levels" (IWC 1994).

To address the concerns expressed above, there is a need for basic information on a number of aspects of the biology of harbour porpoises and other small cetaceans, including their current abundance. Some quantitative data have been collected and used to estimate relative or absolute abundance (Bjørge & Øien in press; Camphuysen & Leopold, 1993; Danielsen *et al.* in press; Heide-Jørgensen *et al.* 1992,1993; Leopold, Wolf & van der Meer 1992; Northridge *et al.* 1995). But these studies address neither estimation of the probability of detecting animals on the transect line nor animal movement in response to the approaching survey vessel, and there remains a need for accurate and precise estimates of abundance of small cetaceans throughout the North Sea and adjacent waters.

Project SCANS - Small Cetacean Abundance in the North Sea (and adjacent waters) was initiated in 1993 to fulfill this need. The objectives of SCANS were:

(i) To identify major summer concentrations of harbour porpoises and other small cetaceans in the North Sea and adjacent waters;
(ii) To estimate the abundance of harbour porpoises and other small cetaceans in the area;
(iii) To provide information essential to conservation and management of these species, and to serve as a baseline for their future monitoring.

The project centred on an intensive sightings survey for harbour porpoises and other small cetaceans in the North Sea and adjacent waters. Harbour porpoises are a particularly difficult target species for sightings surveys because their small size and undemonstrative behaviour at the surface makes them hard to see. The majority of sightings are typically made within a few hundred meters of survey ships (eg Bjørge & Øien in press) and it was important to investigate the possibility that porpoises respond to the ships. Project SCANS, therefore, planned for accurate and precise estimation of g(0) and a correction factor which accounted for responsive movement. In addition, surveying can only be carried out effectively in very good weather conditions (ideally in conditions no worse than Beaufort sea state 2). Because of these factors, the amount of searching effort planned was much greater than is typically the case for sightings surveys of cetaceans. Planned coverage was also high to reduce sampling variability so that precise estimates of abundance suitable for serving as a baseline for future monitoring and research could be obtained.

The major work prior to the survey was the development of methods for collecting and analysing data from the survey. This work included a review of methods for large whales (e.g. Hiby & Hammond, 1989; Buckland *et al.*, 1993) which have been developed over a number of years and successfully applied in two major surveys in the North Atlantic in 1987 and 1989 (see, e.g., many papers in IWC 1989, 1991). In SCANS, the methodology for shipboard surveys was modified for application to harbour porpoises and other small cetaceans in the survey area and the modified methods tested on an experimental ship survey conducted in April 1994. The results of the experimental survey led to the adoption of the data collection methods for the main shipboard survey. These methods and the methods used to analyse the data collected on the shipboard survey are described in detail in Borchers *et al.* (1995). The development and application of the aerial survey data collection and analysis methodology are described in Hiby & Lovell (1995).

SURVEY AREA

The survey area was determined initially by reference to the area covered by ASCOBANS but excluding the Baltic Sea proper where densities were expected to be too low to conduct an efficient survey. Subsequently, the survey area was extended to cover the Celtic Shelf and part of the western Baltic. The Celtic Shelf was included so that estimates of harbour porpoise bycatches in bottom set gillnet fisheries in this area (Berrow, Tregenza & Hammond, 1994) could be put into context. The western Baltic was included in response to a request from a preliminary meeting of the Parties to ASCOBANS.

Figure 1 shows the area surveyed. It was stratified into blocks determined by logistical constraints and using existing information on cetacean distribution and relative abundance in the area, particularly for harbour porpoises (Camphuysen & Leopold 1993; Danielsen *et al.* in press; Evans 1980, 1990; Heide-Jørgensen et al. 1992, 1993; Northridge *et al.* 1995; P.G.H. Evans, pers. comm.).

Blocks A-I were surveyed by nine ships for a total of seven ship-months between June 27 and July 26, 1994. Between 26 June and 3 August, two aircraft surveyed blocks I' and L and one aircraft surveyed blocks J, K, M, X and Y.

SURVEY METHODS

Details of the data collection and analysis methods for the shipboard survey and the aerial survey are given in Borchers *et al.* (1995) for the shipboard surveys and in Hiby & Lovell (1995) for the aerial survey.

Shipboard survey methods were based on the method developed by Buckland & Turnock (1992) using two independent observation platforms (a primary and a tracking platform) so that duplicate sightings data could be used to calculate a correction factor for animals missed on the transect line, g(0), and for any movement of animals in response to the survey vessels. Observers on the primary platform searched with the naked eye in a standard way for line transect surveys; their data were used to estimate sighting rate and effective strip width. Observers on the tracking platform searched, with binoculars, farther ahead of the ship than the primary platform and attempted to track each animal or school via multiple sightings as it was approached by the vessel. One of the observers on the tracking platform was in contact with the primary platform and made judgements about which sightings made by the primary platform were duplicates of sightings made from the tracking platform. These duplicate sightings data were used to estimate a value for g(0) robust to any responsive movement which occurred within range of the tracking platform. Details of this methodology are given in Borchers *et al.* (1995).

Aerial survey methods also used two independent platforms to obtain duplicate sightings data. A proportion of survey effort was flown using two aircraft flying in tandem (one behind the other) so that the data collected from the two platforms could be used to estimate g(0). The analysis assigned, to each sighting made from the trailing aircraft, a probability that it was a duplicate of a sighting made by the leading aircraft based on their distances from the transect line, the elapsed time between sightings and a model of porpoise movements and diving behaviour, the parameters of which were estimated from the data. Estimates of g(0) under different conditions were calculated from these duplicate sightings probabilities. Estimates of g(0) from tandem aircraft effort were used to correct data collected when a single aircraft was flying. Details of this methodology are given in Hiby & Lovell (1995).

RESULTS

Searching effort

Figure 2 shows the cruise tracks searched by the ships and aircraft in all survey blocks. The weather was better than expected in most blocks enabling excellent coverage of almost all of the survey area. Two block received substantially less effort than hoped for, aerial survey blocks J and K, as a result of deteriorating weather towards the end of the survey period. Note that searching effort did not extend to coastal inlets in some areas. In particular, because of the complexity of the terrain, the fjord waters of western Norway were not covered.

Table 1 gives, for the ship surveys, the size of each survey block, the amount of searching effort achieved and the percentages of effort realised at or below each Beaufort sea state. For the aerial survey, only the size of each block is given. The other data are not readily available because abundance was estimated using the coverage probability method (see Hiby & Lovell 1995) which does not use length of transect searched in the calculations.

Distribution

Harbour porpoises

Figure 3 shows the distribution of harbour porpoises seen on the survey. Porpoises were seen throughout most of the North Sea, Skaggerak and Kattegat and on the Celtic Shelf. However, none were seen in the Channel and southern tip of the North Sea. Sightings appear to be concentrated in the central

North Sea but it is important not to over-interpret the data presented in this way. The number of sightings is a function of the distribution of effort within blocks and of the weather, which are accounted for in estimating abundance. Nevertheless, it is clear that during July there are large numbers of porpoises offshore as well as in coastal waters.

Whitebeaked and whitesided dolphins
Figure 4 shows the distribution of whitebeaked dolphins seen on the survey. All sightings were concentrated in a band across the North Sea between about 55° and 60° N, mostly to the west. Figure 5 shows the distribution of the few sightings of whitesided dolphins, and Figure 6 shows the distribution of sightings recorded as *Lagenorhynchus sp*, which could have been whitebeaked or whitesided dolphins.

Minke whales
Figure 7 shows the distribution of minke whales seen on the survey. Sightings were concentrated in the northwestern North Sea (north of about 55° N and west of about 2° E). Several sightings were also made off the south coast of Ireland.

Common dolphins
Figure 8 shows the distribution of common dolphins seen on the survey. All sightings except one were made in block A (see Figure 1).

Other small cetaceans
Figures 9 - 14 show the distribution of bottlenose dolphins, striped dolphins, dolphins identified as either striped or common, Risso's dolphins, killer whales and pilot whales, respectively, seen on the survey.

Abundance
There were sufficient data from the shipboard surveys to calculate estimates of abundance for harbour porpoises, minke whales, whitebeaked dolphins and for whitebeaked and whitesided dolphins combined (*Lagenorhynchus* sp.) using the methods described in Borchers *et al.* (1995). Table 2 gives the number of sightings of each of these species used in the calculation of abundance estimates.

For the aerial survey, there were sufficient data to calculate estimates of abundance only for harbour porpoises. These were calculated using the methods described in Hiby & Lovell (1995).

Harbour porpoises
Table 3 gives estimates of school abundance, mean school size, animal abundance and animal density for harbour porpoises. Abundance estimates were not calculated for block K because insufficient data were collected.

Minke whales
Table 4 gives estimates of school abundance, mean school size, animal abundance and animal density for minke whales.

Whitebeaked and whitesided dolphins
Table 5 gives estimates of school abundance, mean school size, animal abundance and animal density for whitebeaked dolphins. Table 6 gives the same results for whitebeaked and whitesided dolphins combined, including sightings identified as *Lagenorhynchus* sp.

Common dolphins
There were insufficient data to estimate abundance of common dolphins using the methods described in Borchers *et al.* (1995), but an estimate was made for block A (see Figure 1) using standard line transect methods; that is, with no correction for animals missed on the transect line or for responsive movement.

Table 7 gives estimates of school abundance, mean school size, animal abundance and animal density for common dolphins in block A calculated in this way.

DISCUSSION

The most important reason for undertaking this work was to provide the information on abundance that is an essential step in the formulation of a conservation and management plan for small cetaceans in this area, as is intended to be developed under ASCOBANS and supported by other international fora. In this primary aim, SCANS has been successful. There now exist baseline estimates of abundance for the main species of cetacean in the North Sea and adjacent waters which will serve as a reference point for decades to come and upon which a framework for a management and monitoring programme can be founded. The results presented here fill one of the key information gaps hindering assessment of the impact of threats to small cetacean populations in the area. The results will also aid European Union member states in fulfilling their obligations under the Habitats Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora.

The new survey methodology developed as part of the project worked very well. It is to be hoped that this and other experience gained from the project will be valuable to others conducting similar surveys in the future.

Despite the success of project SCANS, it is important to recognise the limits of its results. It has provided accurate and precise estimates of abundance for the key species in the North Sea and adjacent waters in the summer season. But these tell us nothing about seasonal changes in distribution and abundance. Some consistency among years might be expected but any statements about which areas are important for these species in the North Sea and adjacent waters must be limited to the summer season only. Project SCANS covered a large area but there are significant parts of the range of the harbour porpoise in European waters which were not surveyed. One such area is the Baltic Sea which is important because harbour porpoises used to be common there (Skora, Pawlizca & Klinowska 1988) but are now scarce. Another important area covers the waters to the west of Britain and Ireland where porpoises are known to be abundant (e.g. Leopold, Wolf & van der Meer 1992). It is important that these areas are also surveyed so that a more complete picture can be obtained of the abundance of harbour porpoises in European waters. The results provide baseline estimates of abundance but tell us nothing about whether any of the species are increasing or decreasing in abundance. This important information will only become available in the future after a series of similar surveys have been completed. It is important to recognise that determining whether or not a population is in decline takes a long time and that there are no quick alternatives to conducting periodic systematic surveys.

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REFERENCES

Berrow, S.D., Tregenza, N.J.C. & Hammond P.S. 1994. Marine mammal bycatch on the Celtic Shelf. Report to DG XIV/C/1 of the European Commission on Study Contract 92/3503.

Bjørge, A. & Øien, N. in press. Distribution and abundance of harbour porpoise, *Phocoena phocoena*, in Norwegian waters. Reports of the International Whaling Commission (Special Issue 16).

Borchers, D.L., Buckland, S.T., Clarke, E.D., & Cumberworth, S.L. 1995. Estimation of cetacean abundance from the SCANS shipboard surveys in summer 1994. *In* Hammond, P.S. (Ed.) Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and adjacent waters. Final Report to the European Commission under project LIFE 92-2/UK/027.

Buckland, S.T., Anderson, D.R., Burnham, K.P. & Laake, J.L. 1993. Distance sampling: estimating abundance of biological populations. Chapman & Hall, London.

Buckland, S.T. & Turnock, B.J. 1992. A robust line transect method. Biometrics 48: 901-909.

Burnham, K.P., Anderson, D.R., White, G.C., Brownie, C. & Pollock, K.H. 1987. Design and analysis methods for fish survival experiments based on release-recapture. American Fisheries Society Monograph 5. Bethesda, Maryland.

Camphuysen, C.J. & Leopold, M.F. 1993. The harbour porpoise *Phocoena phocoena* in the southern North Sea, particularly the Dutch sector. Lutra 36: 1-24.

Clausen, B. & Andersen, S. 1988. Evaluation of bycatch and health status of the harbour porpoise (*Phocoena phocoena*) in Danish waters. Danish Review of Game Biology 13 (5): 1-20.

Collet, A., Gourvenec, A., Firmin, V. & Leboulanger, F. 1994. Harbour porpoises and other small cetaceans off the French Channel coasts. Internal Report of the Centre de Recherche sur les Mammifères Marins, Musée Océanographique, La Rochelle, France.

Danielsen, F. Skov, H., Leopold, M.F. & Durninck, J. in press. Distribution, abundance and habitat use of the harbour porpoise (*Phocoena phocoena*) in the eastern North Sea. Ophelia.

Evans, P.G.H. 1980. Cetaceans in British waters. Mammal Review 10: 1-52.

Evans, P.G.H. 1990. Harbour porpoises (*Phocoena phocoena*) in British and Irish waters. Paper SC/42/SM49 presented to the IWC Scientific Committee. 16 pp.

Evans, P.G.H., Canwell, P.J. & Lewis, E.J. 1992. An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales. European Research on Cetaceans 6: 43-46.

Evans, P.G.H., Harding, S., Tyler, G. & Hall, S. 1986. Analysis of cetacean sightings in the British Isles, 1958-1985. Unpublished report to the Nature Conservancy Council, Peterborough, UK. 71 pp.

Heide-Jørgensen, M.P., Mosbech, A., Teilmann, J., Benke, H. & Schulz, W. 1992. Harbour porpoise (*Phocoena phocoena*) densities obtained from aerial surveys north of Fyn and in the Bay of Kiel. Ophelia 35: 133-146.

Heide-Jørgensen, M.P., Teilmann, J., Benke, H. & Wulf, J. 1993. Abundance and distribution of harbour porpoises *Phocoena phocoena* in selected areas of the western Baltic and the North Sea. Helgoländer Meeresuntersuchungen 47: 335-346.

Hiby, A.R. & Hammond, P.S. 1989. Survey techniques for estimating the abundance of cetaceans. Reports of the International Whaling Commission, Special Issue 11: 47-80.

Hiby, A.R. & Lovell, P.L. 1995. Estimation of harbour porpoise abundance from the SCANS aerial survey. *In* Hammond, P.S. (Ed.) Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and adjacent waters. Final Report to the European Commission under project LIFE 92-2/UK/027.

IWC 1989. Reports of the International Whaling Commission 39.

IWC 1991. Reports of the International Whaling Commission 41.

IWC 1992. Report of the Scientific Committee. Reports of the International Whaling Commission 42: 210.

IWC 1994. Chairman's report of the forty-fifth annual meeting. Reports of the International Whaling Commission 44:34-35.

Kuiken, T,. Hofle, U., Bennett, P.M., Allchin, C.R., Kirkwood, J.K., Baker, J.R., Appleby, E.C., Lockyer, C.H., Wotton, M.J & Sheldrick, M.C. 1993. Adrenocortical hyperplasia, disease and chlorinated hydrocarbons in the harbour porpoise (*Phocoena phocoena*). Marine Pollution Bulletin 26: 440-446.

Law, R.J. & Whinnett, J.A. 1992. Polycyclic aromatic hydrocarbons in muscle tissue of harbour porpoises (*Phocoena phocoena*) from UK waters. Marine Pollution Bulletin 24: 550-553.

Law, R.J., Jones, B.R., Baker, J.R., Kennedy, S., Milne, R. & Morris, R.J. 1992. Trace metals in the livers of marine mammals from the Welsh coast and the Irish Sea. Marine Pollution Bulletin 24: 296-304.

Leopold, M.F., Wolf, P.A. & van der Meer, J. 1992. The elusive harbour porpoise exposed: strip transect counts off southwestern Ireland. Netherlands Journal of Sea Research 29: 395-402.

Northridge, S.P., Tasker, M.L., Webb, A. & Williams, J.M. 1995. Distribution and relative abundance of harbour porpoises (*Phocoena phocoena*, L.), whitebeaked dolphins (*Lagenorhyncus albirostris*, Gray) and minke whales (*Balaenoptera acutorostrata*, Lacepede) around the British Isles. ICES Journal of Marine Science 52: 55-66.

Smeenk, C. 1987. The harbour porpoise *Phocoena phocoena* (L., 1758) in the Netherlands: stranding records and decline. Lutra 30: 77-90.

Verwey, J. & Wolff, W.J. 1983. The common or harbour porpoise (*Phocoena phocoena*). In Wolff, W.J. (ed.). Ecology of the Wadden Sea, Volume 2, part 7: Marine mammals, pp 51-58. A.A. Balkema, Rotterdam.

Vinther, M. 1995. Incidental catch of harbour porpoise (*Phocoena phocoena*) in the Danish North Sea gill-net fisheries: preliminary results. Proceedings of the Scientific Symposium on the 1993 North Sea Quality Status Report, 18-21 April 1994, Ebeltoft, Denmark.

Table 1 Block sizes and survey effort in kilometres (km) searched for the shipboard surveys. The columns headed "%Beaufort" show the percentages of effort realised at or below the indicated sea states, as measured on the Beaufort scale.

Block	Vessel	Surface Area	Total Effort (Beaufort≤6)	%Beaufort				
		(km^2)	(km)	≤ 4	≤ 3	≤ 2	≤ 1	= 0
A	Dana	201,490	2974	100	97	67	24	5
B	Henny	105,223	1470	100	76	54	22	5
C	Henny	43,744	1557	100	93	77	33	11
D	Abel-J	102,277	2552	99	83	43	13	1
E	Gorm	109,026	2556	96	76	49	17	2
F	Corvette	118,985	3118	100	78	50	21	3
G	Holland + Tridens	113,741	3372	99	93	65	30	8
H	Isis	45,515	854	100	93	80	33	6
I	Gunnar Thorsen	49,485	1475	100	100	94	63	25
All		889,486	19927	99	77	61	26	6

Block sizes for the aerial survey.

Block	Surface Area (km^2)
I'	8,170
J	31,059
K	65,369
L	18,176
M	12,612
X	5,810
Y	7,278
All	148,747

Table 2 Numbers of schools detected within the truncation distance of the trackline by Tracker, Primary and both (i.e. duplicates) in each block while on effort. HP - Harbour porpoises; MI - minke whales; WB - whitebeaked dolphins; LG - whitebeaked and whitesided dolphins, including *Lagenorhynchus* sp. For harbour porpoises, only data from sea states Beaufort 0-2 were used; for other species sea states Beaufort 0-4 were used.

	Seen	Block									
Species	by	A	B	C	D	E	F	G	H	I	Total
HP	Tracker	46	0	101	65	53	143	92	6	113	619
	Primary	32	0	113	92	32	104	119	10	154	656
	Both	6	0	32	20	5	16	18	2	19	118
MI	Tracker	9	0	13	22	4	16	79	0	1	73
	Primary	12	0	26	50	12	21	11	0	1	133
	Both	6	0	8	12	0	6	3	0	1	36
WB	Tracker	0	0	15	8	2	17	19	0	0	61
	Primary	0	0	28	13	1	19	30	0	0	91
	Both	0	0	11	4	1	7	15	0	0	38
LG	Tracker	2	0	31	9	2	23	25	0	0	92
	Primary	2	0	46	16	1	19	39	0	0	125
	Both	2	0	15	5	1	7	15	0	0	45

Table 3 Estimates of school abundance, mean school size, animal abundance and animal density for harbour porpoises. Abundance estimates were not calculated for block K because insufficient data were collected. Aerial subtotals and totals in the final row do not include block I' which was a subset of block I. Figures in round brackets are coefficients of variation; figures in square brackets are 95% confidence intervals calculated using the log-based method of Burnham *et al.* (1987) rounded to the nearest thousand.

Block	School abundance	Mean school size	Animal abundance	Animal density (animals.km^{-2})
A	22,050 (.58)	1.64 (.09)	36,280 (.57)	.180 (.57)
B	0	0	0	0
C	10,255 (.19)	1.65 (.07)	16,939 (.18)	.387 (.18)
D	26,154 (.27)	1.42 (.07)	37,144 (.25)	.363 (.25)
E	20,658 (.54)	1.52 (.24)	31,419 (.49)	.288 (.49)
F	63,542 (.26)	1.46 (.04)	92,340 (.25)	.776 (.25)
G	26,685 (.36)	1.45 (.10)	38,616 (.34)	.340 (.34)
H	2,850 (.35)	1.48 (.14)	4,211 (.29)	.095 (.29)
I	24,677 (.35)	1.46 (.06)	36,046 (.30)	.725 (.34)
subtotal	196,898 (.17)	1.49 (.04)	292,995 (.16)	-
I'	*6,701 (.25)*	*1.20 (.03)*	*8,060 (.25)*	*.987 (.25)*
J	26,277 (.33)	1.13 (.08)	29,781 (.34)	.959 (.34)
L	9,301 (.46)	1.62 (.08)	15,083 (.47)	.830 (.47)
M	5,096 (.26)	1.26 (.08)	6,403 (.27)	.508 (.27)
X	580 (.46)	1.50 (.15)	870 (.48)	.150 (.48)
Y	5,125 (.26)	1.45 (.10)	7,431 (.27)	1.02 (.27)
subtotal *	46,379 (.21)	-	59,528 (.30)	-
Total *	**227,074 (.133) [175,000 - 295,000]**	-	**352,523 (.14) [267,000 - 465,000]**	-

* aerial subtotal and Total do not include block I', which was a subset of block I.

Table 4 Estimates of school abundance, mean school size, animal abundance and animal density for minke whales. Figures in round brackets are coefficients of variation; figures in square brackets are 95% confidence intervals calculated from bootstrap percentiles.

Block	School abundance	Mean school size	Animal abundance	Animal density (animals.km^{-2})
A	1,195 (.49)	1.00 (.005)	1,195 (.49)	.0059 (.49)
B	0	-	0	0
C	1,032 (.40)	1.04 (.03)	1,073 (.42)	.0245 (.42)
D	2,920 (.41)	1.00 (.01)	2,920 (.40)	.0286 (.40)
E	787 (.35)	1.08 (.08)	853 (.37)	.0078 (.37)
F	1,354 (.36)	1.00 (.01)	1,354 (.36)	.0114 (.36)
G	751 (.62)	1.33 (.14)	1,001 (.70)	.0088 (.70)
H	0	-	0	0
I	49 (.87)	1.00 (-)	49 (.87)	.0010 (.87)
Total	**8,088 (.23)** **[4,957 - 12,745]**	**1.04 (.03)**	**8,445 (.24)** **[4,987 - 13,546]**	-

Table 5 Estimates of school abundance, mean school size, animal abundance and animal density for whitebeaked dolphins. Figures in round brackets are coefficients of variation; figures in square brackets are 95% confidence intervals calculated from bootstrap percentiles.

Block	School abundance	Mean school size	Animal abundance	Animal density (animals.km^{-2})
A	0	-	0	0
B	0	-	0	0
C	526 (.56)	4.47 (.22)	2,351 (.52)	.0538 (.52)
D	341 (.43)	3.40 (.31)	1,157 (.56)	.0113 (.56)
E	29 (1.09)		115 (1.09)	.0011 (1.09)
F	505 (.36)	4.00 (-)	1,790 (.42)	.0150 (.42)
G	679 (.49)	3.56 (.08)	2,443 (.54)	.0215 (.54)
H	0	-	0	0
I	0	-	0	0
Total	**2,080 (.26)** **[1,217 - 3,216]**	**3.78 (.12)**	**7,856 (.30)** **[4,032 - 13,301]**	-

Table 6 Estimates of school abundance, mean school size, animal abundance and animal density for whitebeaked and whitesided dolphins combined, including sightings identified as *Lagenorhynchus* sp. Figures in round brackets are coefficients of variation; figures in square brackets are 95% confidence intervals calculated from bootstrap percentiles.

Block	School abundance	Mean school size	Animal abundance	Animal density (animals.km^{-2})
A	88 (1.02)	9.50 (.26)	833 (1.02)	.0041 (1.02)
B	0	-	0	0
C	836 (.51)	4.86 (.16)	4,063 (.50)	.0929 (.50)
D	420 (.44)	3.73 (.24)	1,569 (.51)	.0153 (.51)
E	29 (1.03)	4.00 (-)	116 (1.03)	.0011 (1.03)
F	494 (.39)	3.92 (.14)	1,937 (.36)	.0163 (.36)
G	880 (.46)	3.68 (.08)	3,242 (.47)	.0285 (.47)
H	0	-	0	0
I	0	-	0	0
Total	**2,747 (.23)** **[1,668 - 4,130]**	**4.28 (.11)**	**11,760 (.26)** **[5,867 - 18,528]**	-

Table 7 Conventional line transect abundance estimate for common dolphins in block A. Figures in round brackets are coefficients of variation; figures in square brackets are 95% confidence intervals calculated using the log-based method of Burnham *et al.* (1987) rounded to the nearest hundred. Mean school size was calculated using sightings made from the tracking platform only.

Block	School abundance	Mean school size	Animal abundance	Animal density (animals.km^{-2})
A	6,986 (.62) [2,100 - 23,300]	10.8 (.25)	75,449 (.67) [22,900 - 248,900]	0.374 (.67)

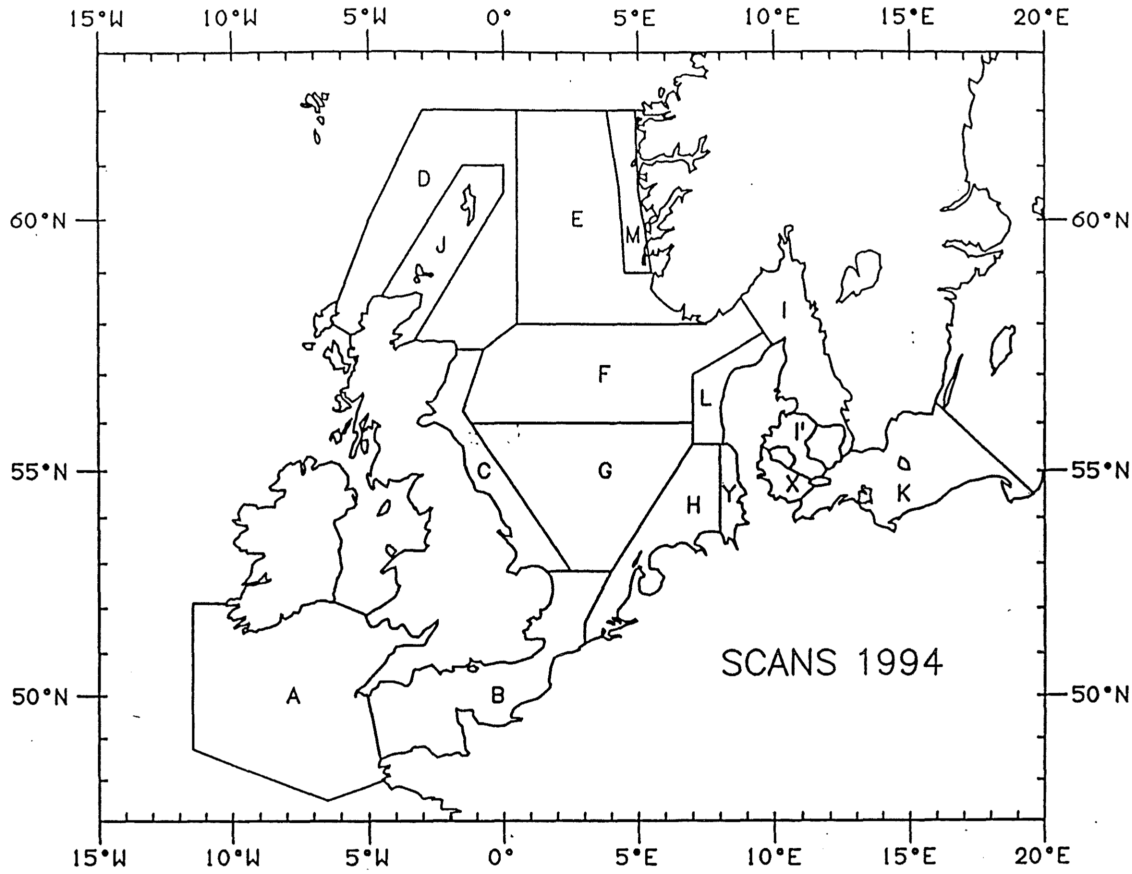

Figure 1 Survey area. Blocks A - I were surveyed by ship. Blocks I', J - M, X and Y were surveyed by aircraft.

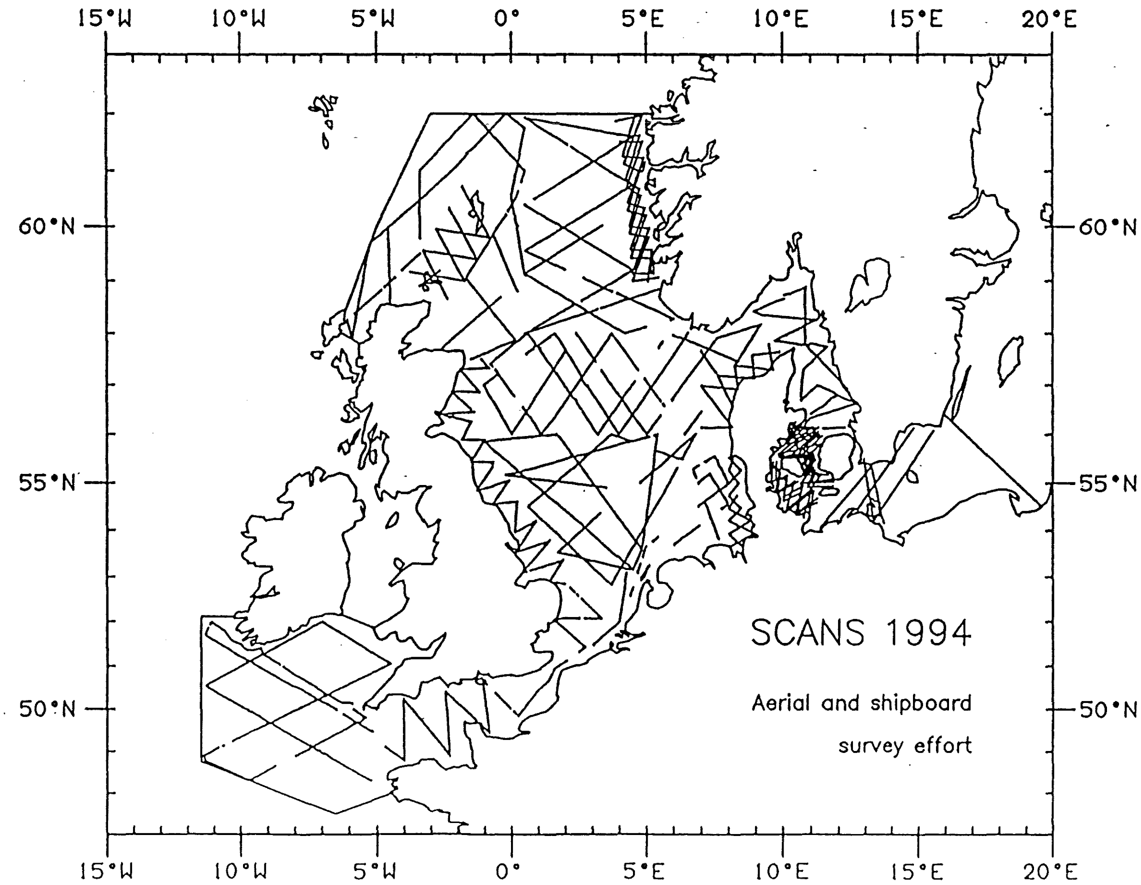

Figure 2 Cruise tracks searched on effort during the shipboard and aerial surveys.

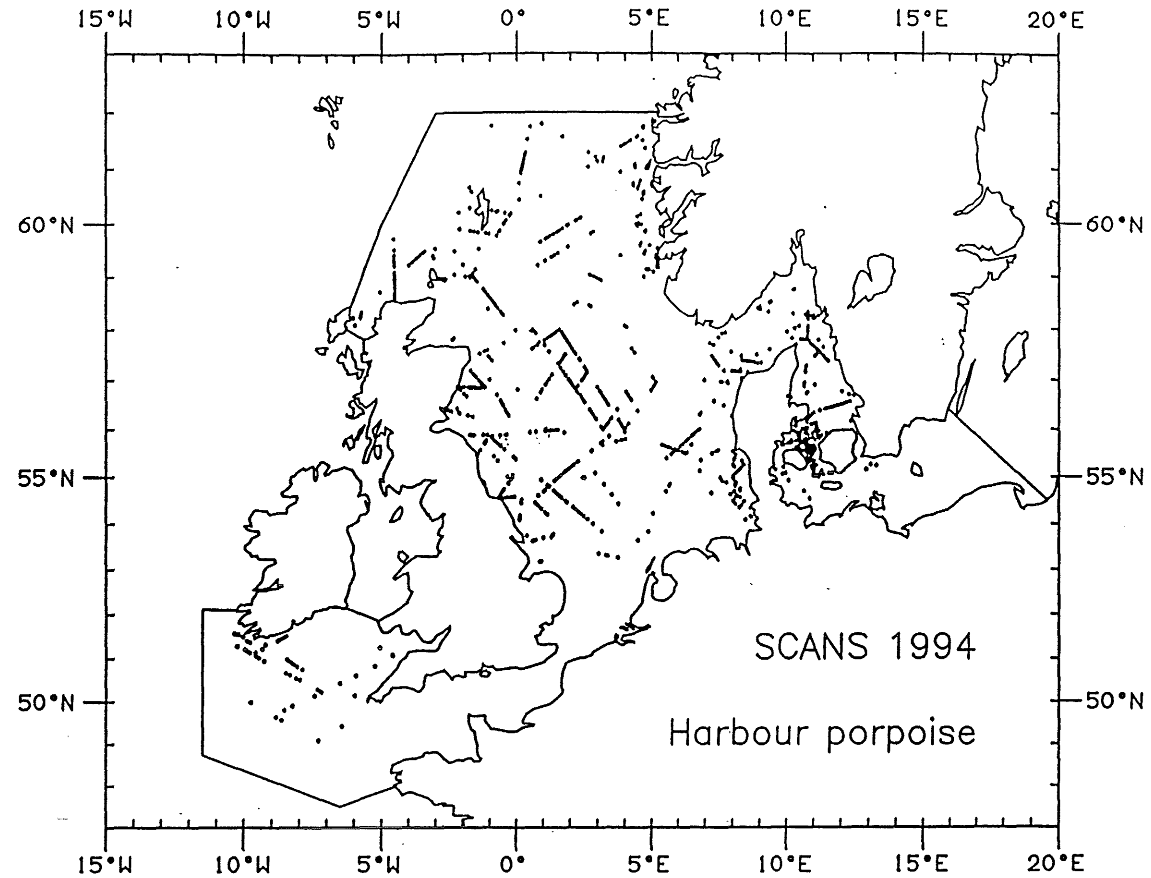

Figure 3 Sightings of harbour porpoises.

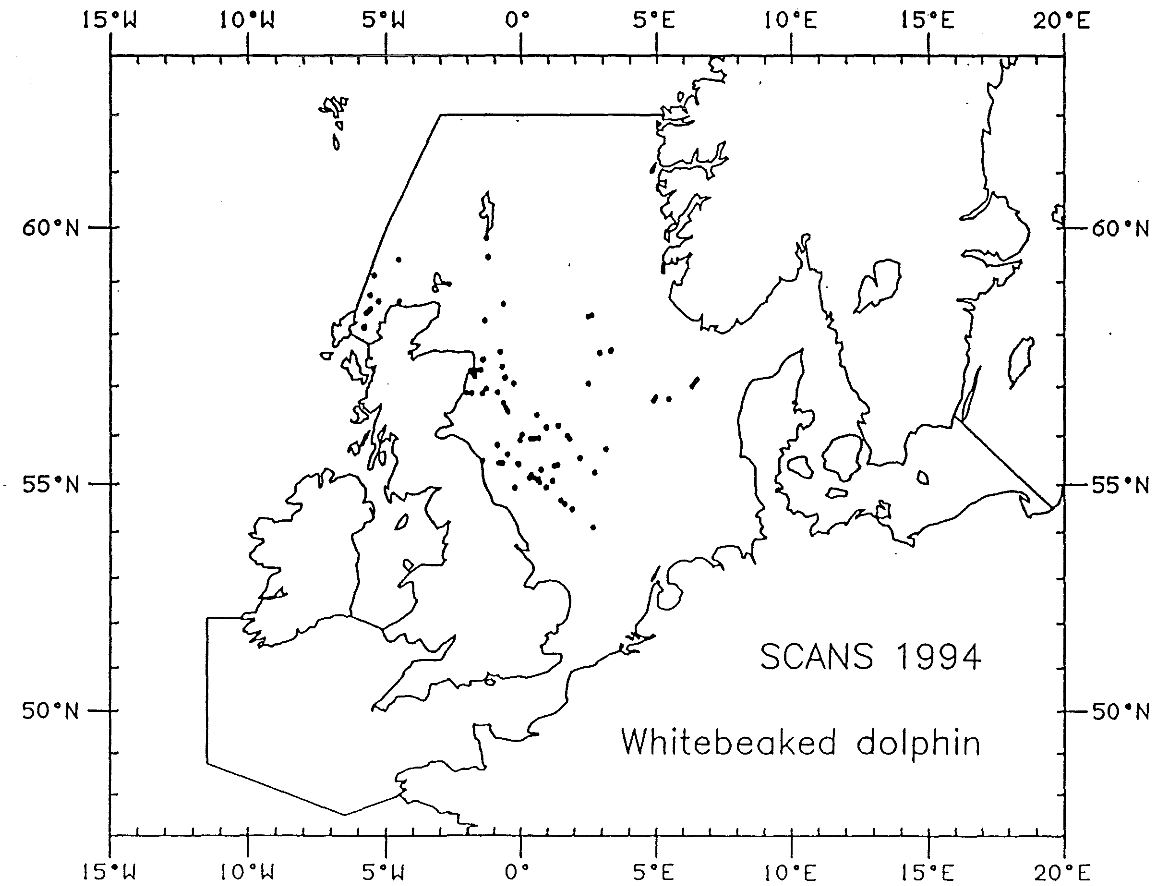

Figure 4 Sightings of whitebeaked dolphins.

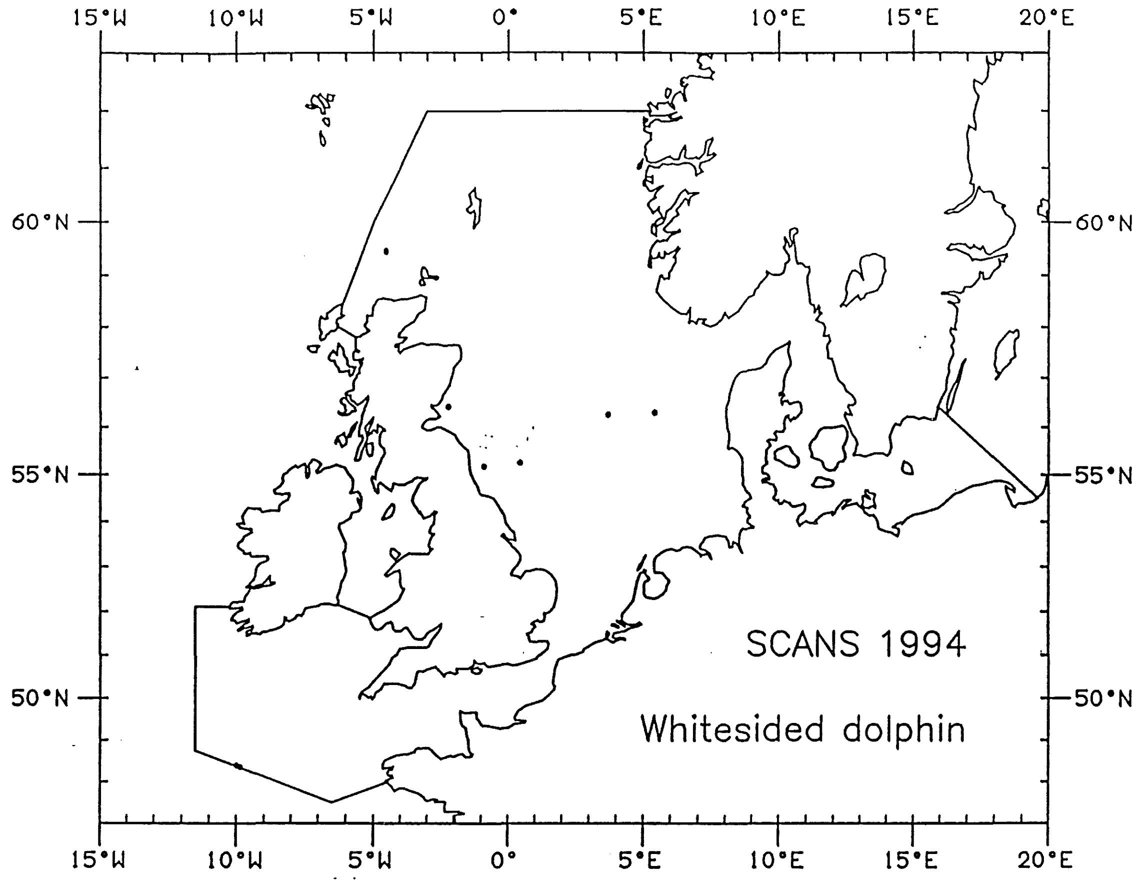

Figure 5 Sightings of whitesided dolphins.

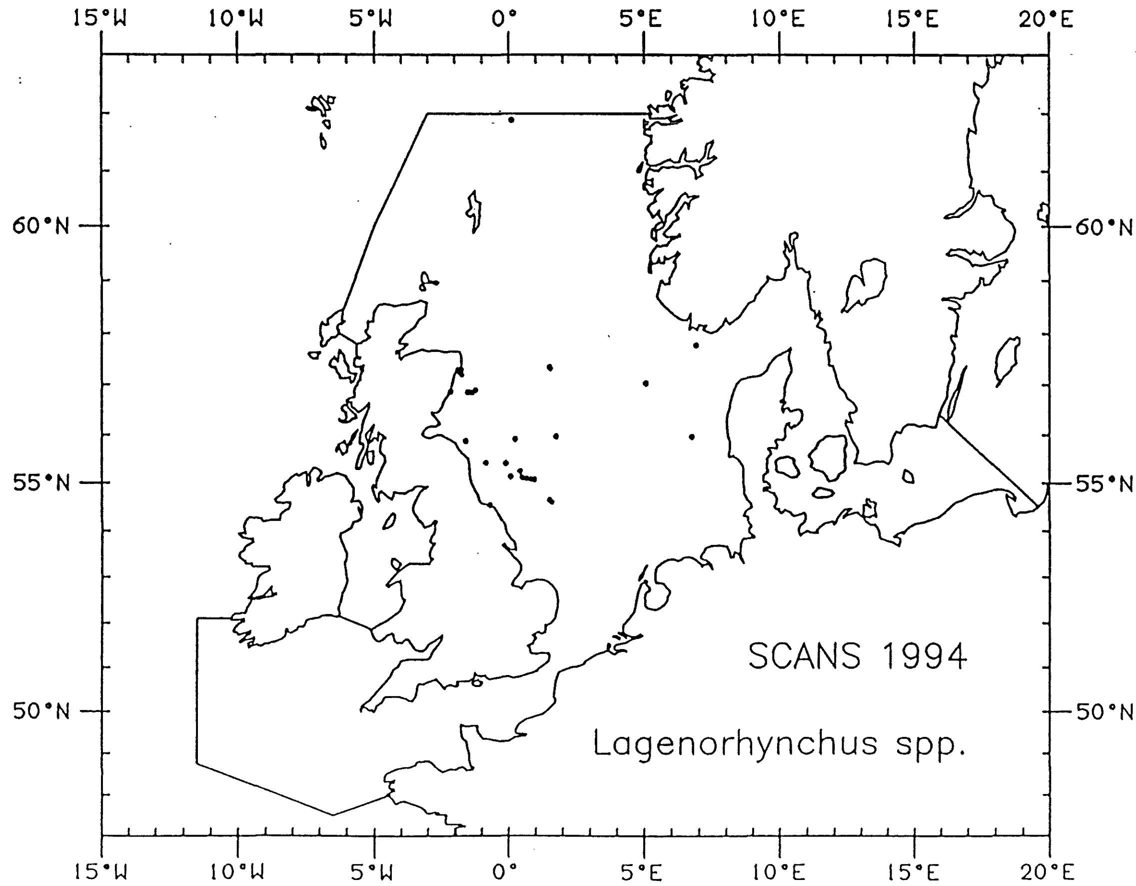

Figure 6 Sightings of *Lagenorhynchus* sp.

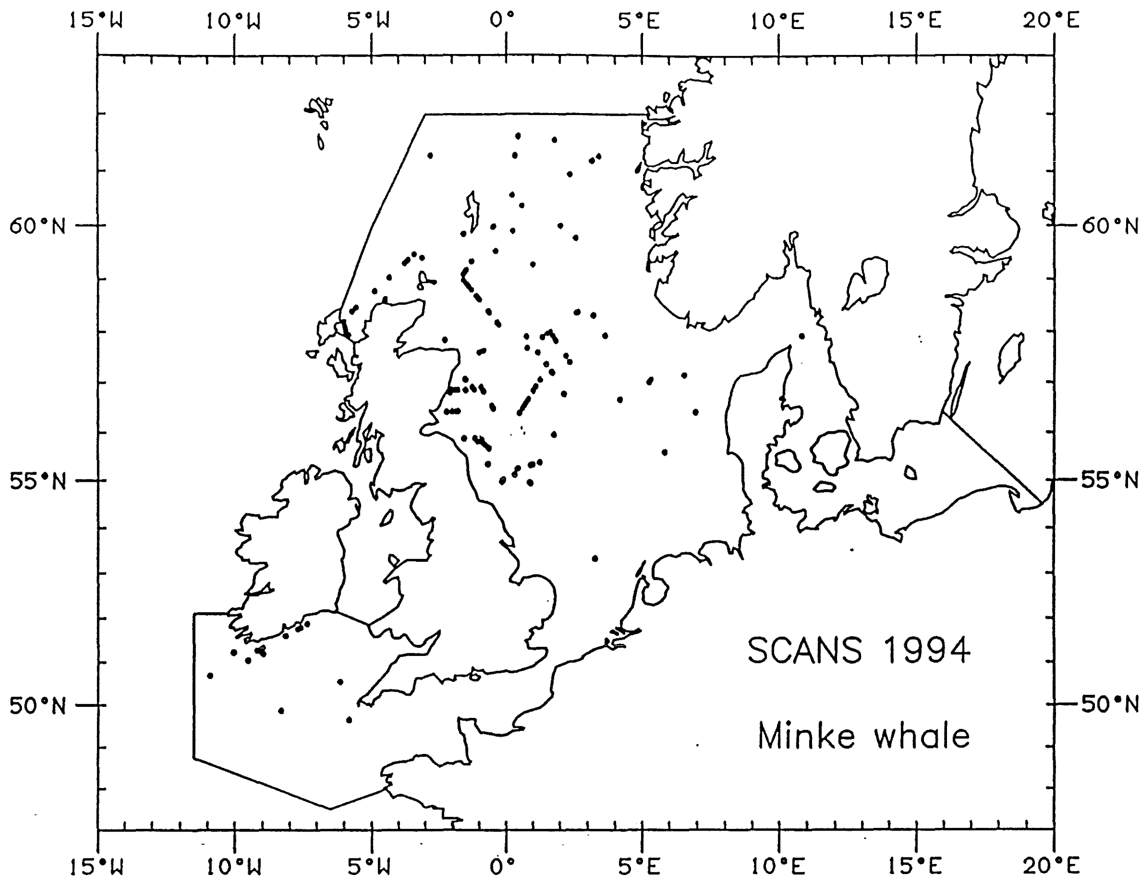

Figure 7 Sightings of minke whales.

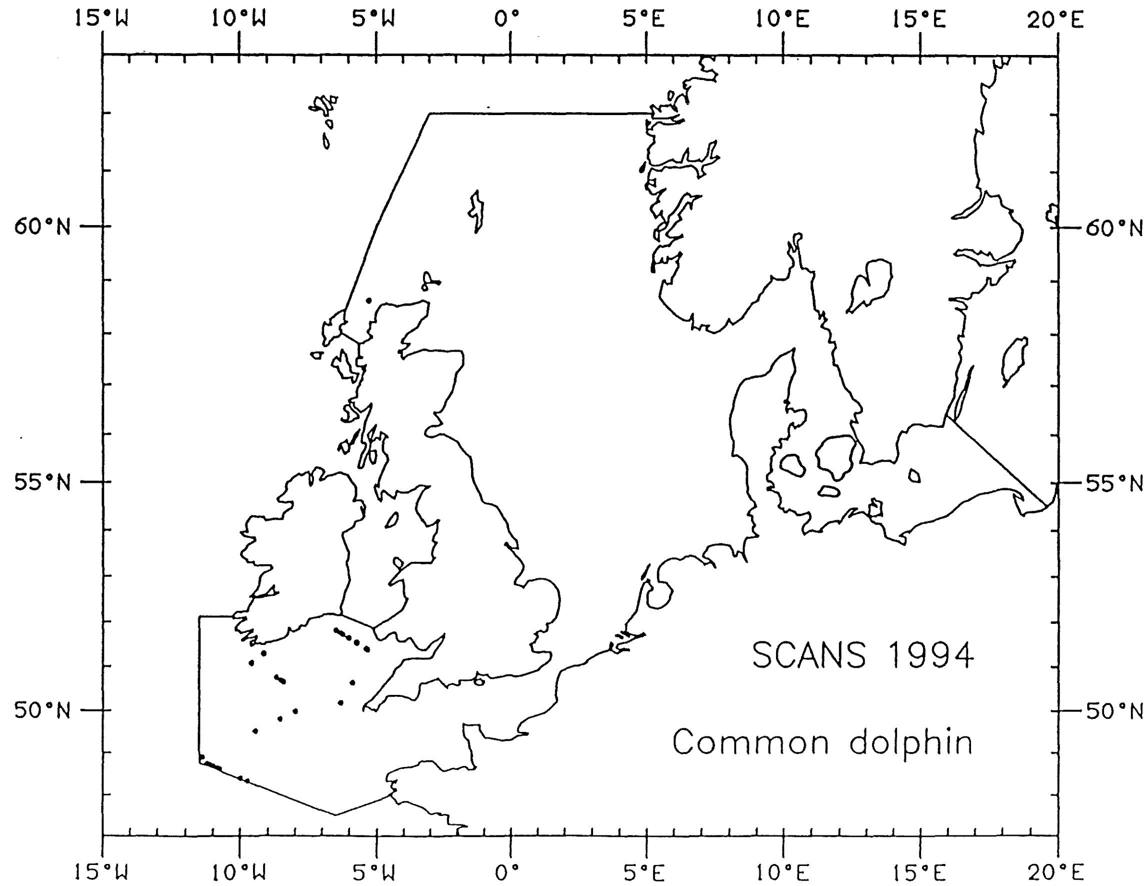

Figure 8 Sightings of common dolphins.

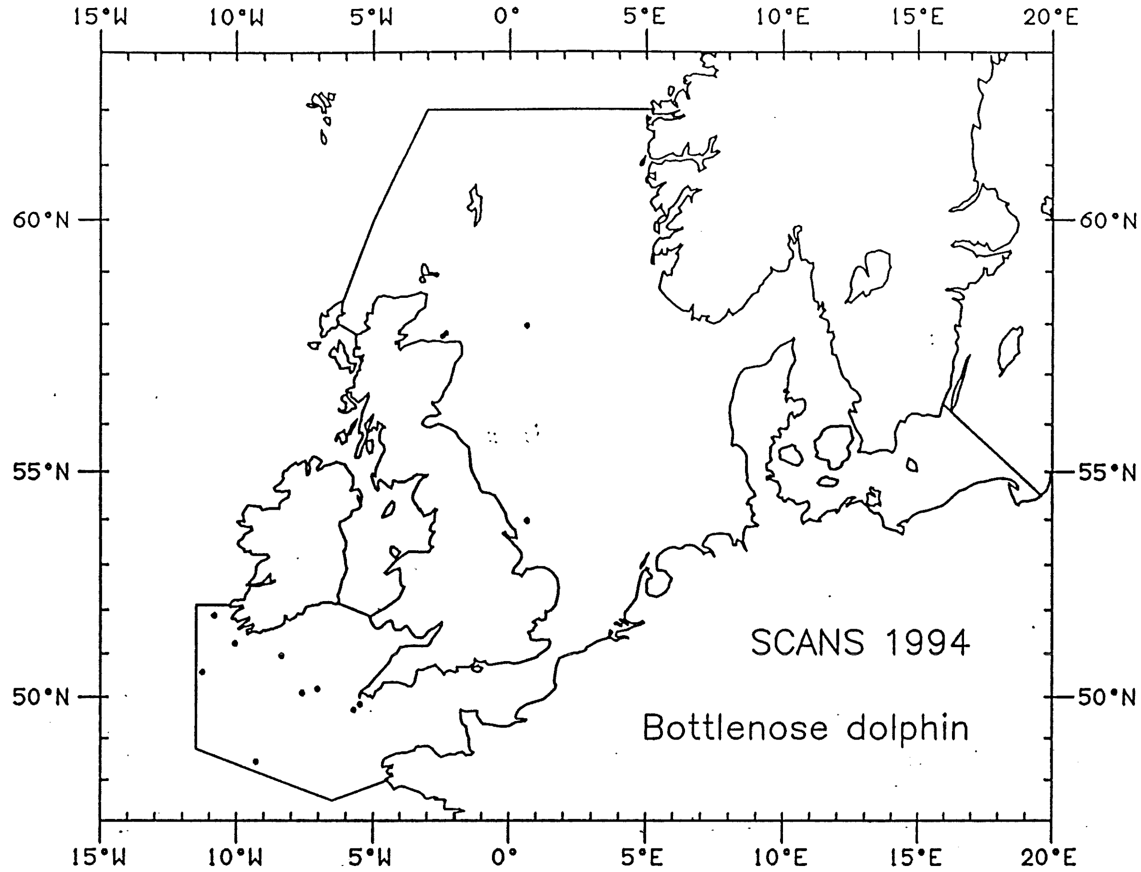

Figure 9 Sightings of bottlenose dolphins

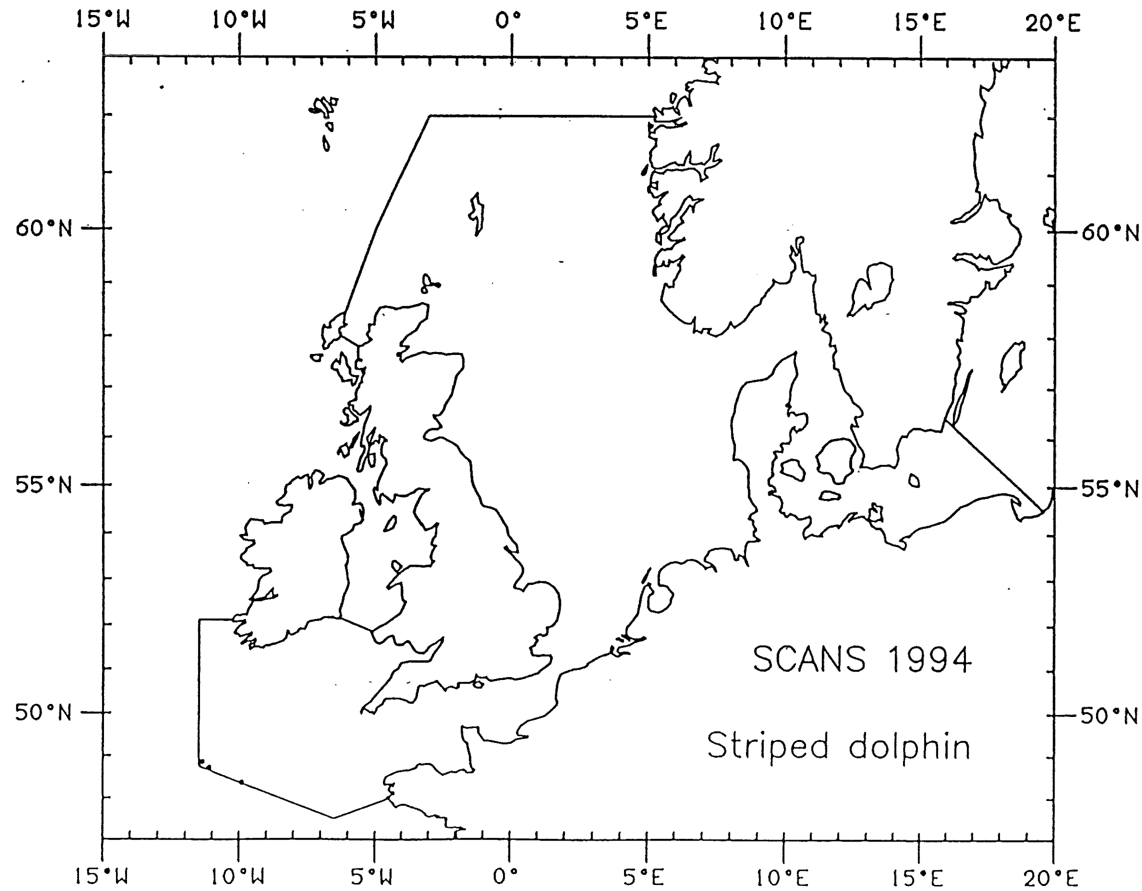

Figure 10 Sightings of striped dolphins.

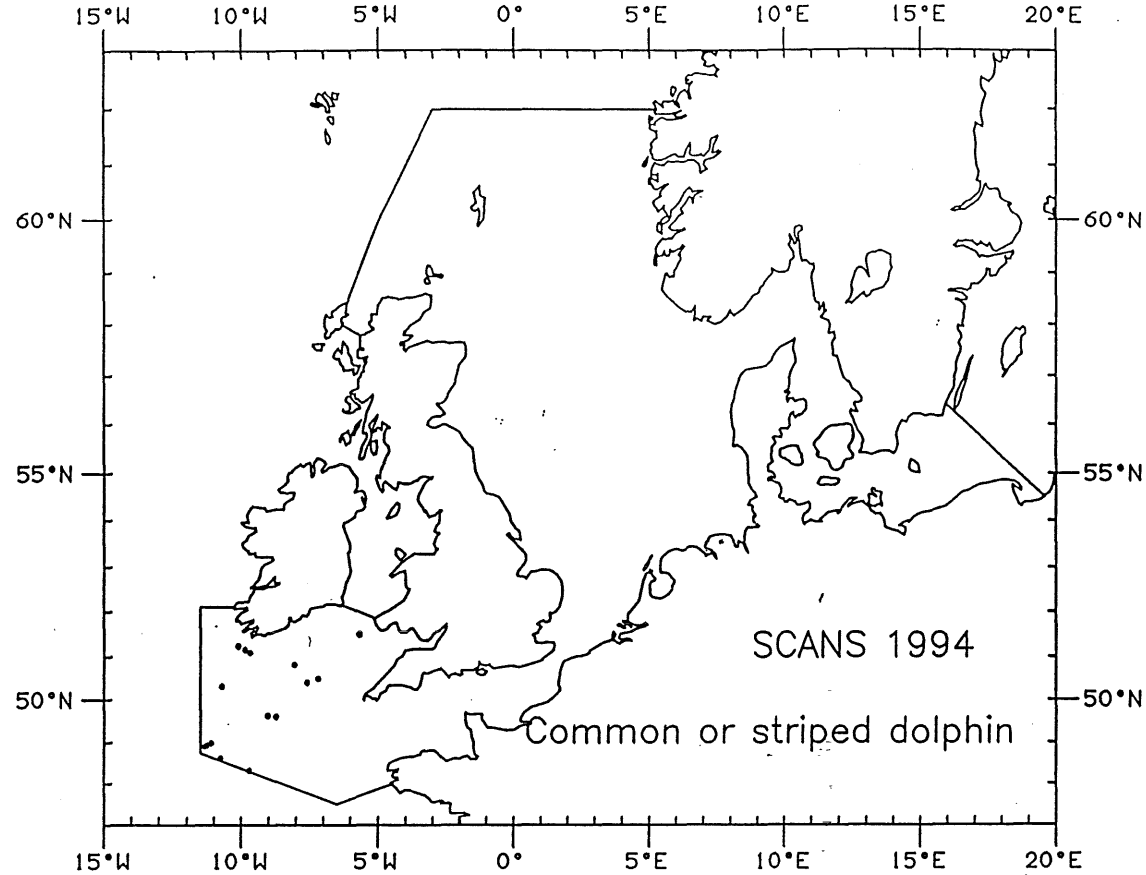

Figure 11 Sightings of striped or common dolphins.

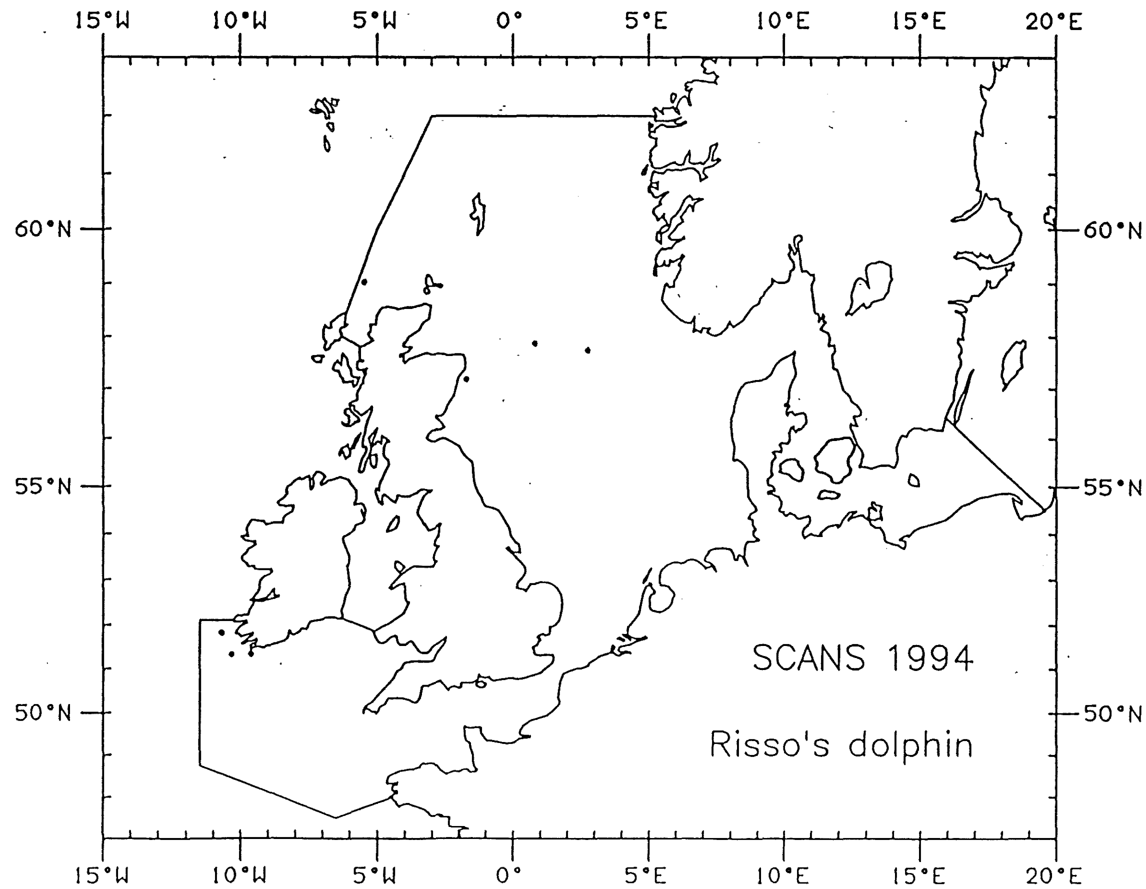

Figure 12 Sightings of Risso's dolphins.

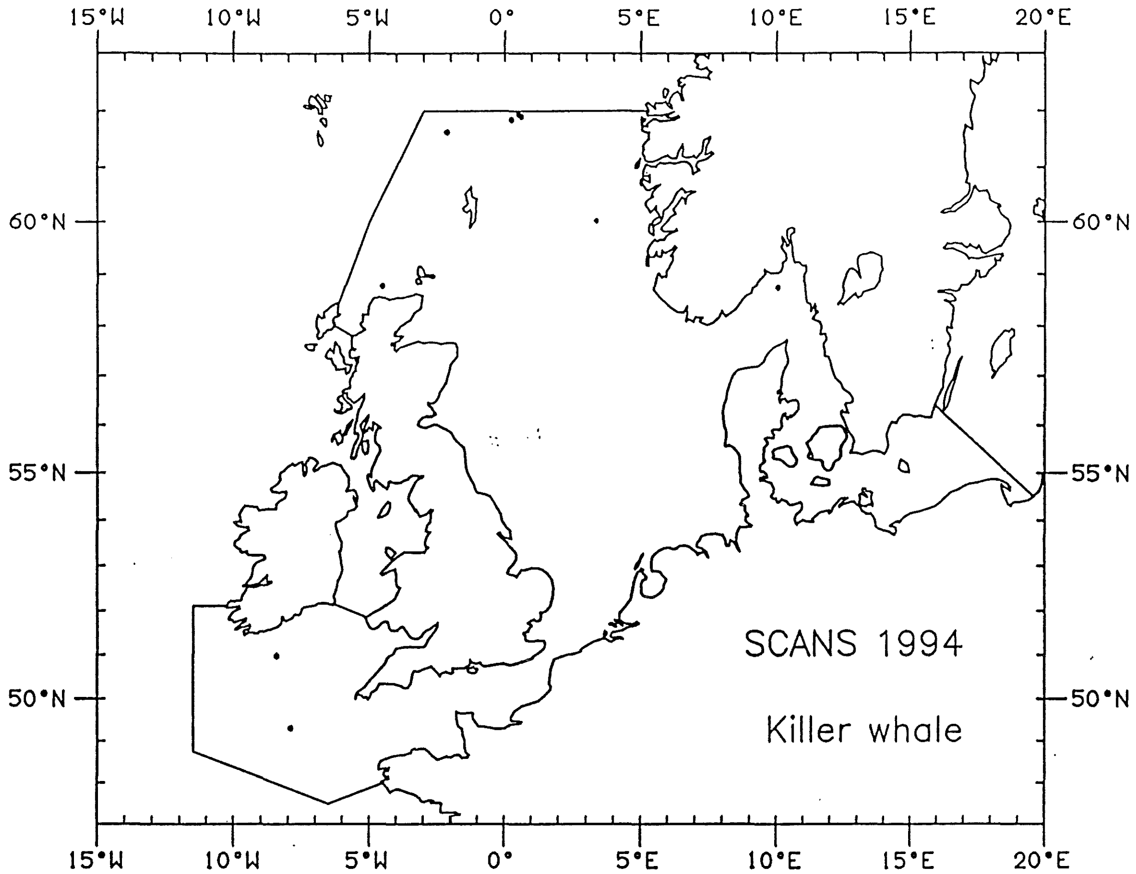

Figure 13 Sightings of killer whales.

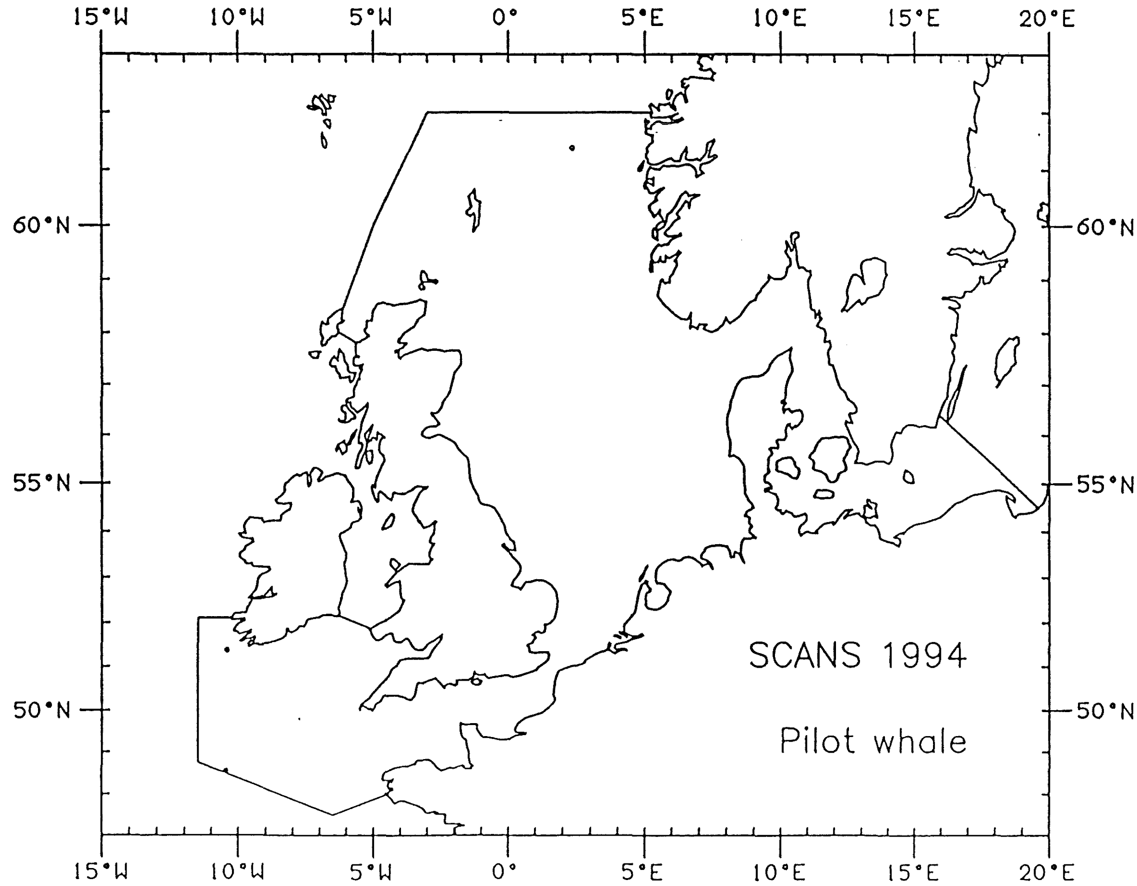

Figure 14 Sightings of pilot whales.