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Cetacean observations during seismic surveys in 1996.

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Contents

1. Summary

1. Cetacean sightings were recorded during seismic surveys in 1996, in compliance with the Department of the Environment's *Guidelines for minimising acoustic disturbance to small cetaceans*. A total of 236 sightings of cetaceans, comprising 1,315 individuals, were reported.

2. The most abundant species were white-sided dolphins, white-beaked dolphins, pilot whales, killer whales and fin whales. Sightings peaked during July and August and were concentrated to the west of Shetland, in the northern North Sea and to the west of Ireland. Large whales and white-sided dolphins were found mainly to the west of Shetland, while white-beaked dolphins were found in the North Sea.

3. After taking account of the proportion of time spent shooting, sightings of fin whales were more frequent when the airguns were firing, while sightings of white-beaked dolphins were less frequent when shooting was taking place. White-sided dolphins were also seen less frequently when the airguns were firing, but this was not significant. More frequent sightings of whales seen when shooting could reflect the greater ease of detecting cetaceans in the calmer weather conditions necessary for shooting.

4. Although numbers of cetaceans declined after August, this was not thought to be a result of prolonged seismic activity. Any disturbance seemed to be only temporary, with cetaceans rapidly appearing in the survey areas between periods of shooting.

5. Nearly all species were found to be further from the airguns when the guns were firing than when they were not, although this was only statistically significant for fin whales and white-sided dolphins.

6. Few cetaceans came towards the ship or crossed its path when the airguns were firing. Cetaceans were observed actively feeding both when the airguns were firing and when they were not, although those seen feeding when the guns were firing were at a greater distance. Positive interactions with the survey vessel were rare when the airguns were firing.

7. Increasing depth may reduce the effect of seismic activity - relatively more fin whales were seen when shooting in waters of greater than 1,000 m depth than in shallower waters.

8. Sample sizes were small, therefore conclusions should be treated with caution.

9. Recommendations are made for revisions to the cetacean recording forms.

2. Introduction

In order to help meet an international obligation under the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS), in February 1995 the Department of the Environment published the *Guidelines for minimising acoustic disturbance to small cetaceans*, aimed primarily at reducing such disturbance from seismic surveys. Most seismic surveys use towed arrays of air-guns to generate a pressure pulse directed at the sea bed. The sound generated is mostly of low frequency. Baleen whales produce a variety of low frequency sounds and are therefore considered to be at risk of disturbance from the low frequencies used for seismic surveys (Moscrop & Simmonds 1994 and references therein). Toothed whales and dolphins use higher frequency sound for communication and echolocation, although there may be some overlap with the frequencies generated during seismic surveys (Goold 1995).

After their first year of operation the guidelines were revised in early 1996. Under the current guidelines (see Appendix 1), operators are required to consult the Joint Nature Conservation Committee (JNCC) when planning seismic surveys and, if necessary, discuss precautions which can be taken to reduce disturbance. When conducting a survey operators are required to check for the presence of cetaceans before starting a survey line, and delay the start of the survey by at least 20 minutes if cetaceans are within 500 metres. Whenever possible, a "slow-start" procedure should be employed, gradually building up the power over 20 minutes from a low energy starting level; in addition, the lowest practicable energy levels should be used throughout the survey. Operators are also required to send a report of the implementation of the guidelines to JNCC after the survey, including details of any sightings.

A review of cetacean sightings during 1995 found that the majority of cetaceans were seen when the airguns were not firing. However, there was no information on the proportion of time spent shooting during surveys, so no conclusions could be drawn on the effects of seismic activity on cetaceans. Consequently, standard recording forms (see Appendix 2) were developed by JNCC to provide information on the length of time spent watching for cetaceans and also the length of time engaged in seismic activity whilst watching, as well as recording details of sightings of cetaceans. These forms were used widely throughout the exploration industry in 1996 and were forwarded to JNCC for analysis. The results of the analysis of 1996 data supplied to JNCC are presented here.

3. Methods

Watches for cetaceans were carried out on seismic survey vessels throughout daylight hours on surveys conducted between January and November 1996. Details of the watch and any sightings were recorded on standard recording forms (see Appendix 2). Data from 30 surveys were forwarded to JNCC, covering 51 quadrants (Figure 1). Species maps were drawn after summing the number of individuals of any given species in a ¼ ICES square (15' latitude x 30' longitude).

Records of sightings included descriptions which were used to assess the accuracy of identifications, particularly when these were tentative i.e. certainty of identification was classed as "probable" or "possible". Other details recorded included the distance of cetaceans from the airguns, their direction of travel (both relative to the survey vessel and in compass points) and behaviour. Feeding was recorded when this was obvious e.g. lunge feeding of baleen whales or active feeding of small cetaceans often associated with flocks of birds.

Some of the analyses involved calculating numbers of sightings per unit effort (i.e. per 100 or 1,000 hours survey). For these analyses, only those sightings from surveys where effort was recorded were used (60% of surveys). Cetacean abundance varied both geographically and seasonally, providing a potential source of bias as the proportion of time spent shooting also varied according to location and time of year. For example, for a species found mainly in an area where little time was spent shooting, including data from another area where sightings were few but a high proportion of time was spent shooting could lead to low numbers seen when shooting, which would in reality reflect a difference in geographical distribution rather than a response to seismic activity. To eliminate such biases due to variations in distribution and/or seasonal abundance of cetaceans, on some occasions subsets of data from selected areas and months were used. Accordingly, each quadrant was assigned to one of six areas (Figure 1). For analyses where calculation of effort was not needed all sightings were used.

Sample sizes were small, even for the more frequently seen species. The non-parametric statistical tests employed were those which are appropriate for small sample sizes e.g. the Fisher exact test (for calculating χ^2 for sample sizes ≤ 20) and the permutation test (Siegel & Castellan 1988).

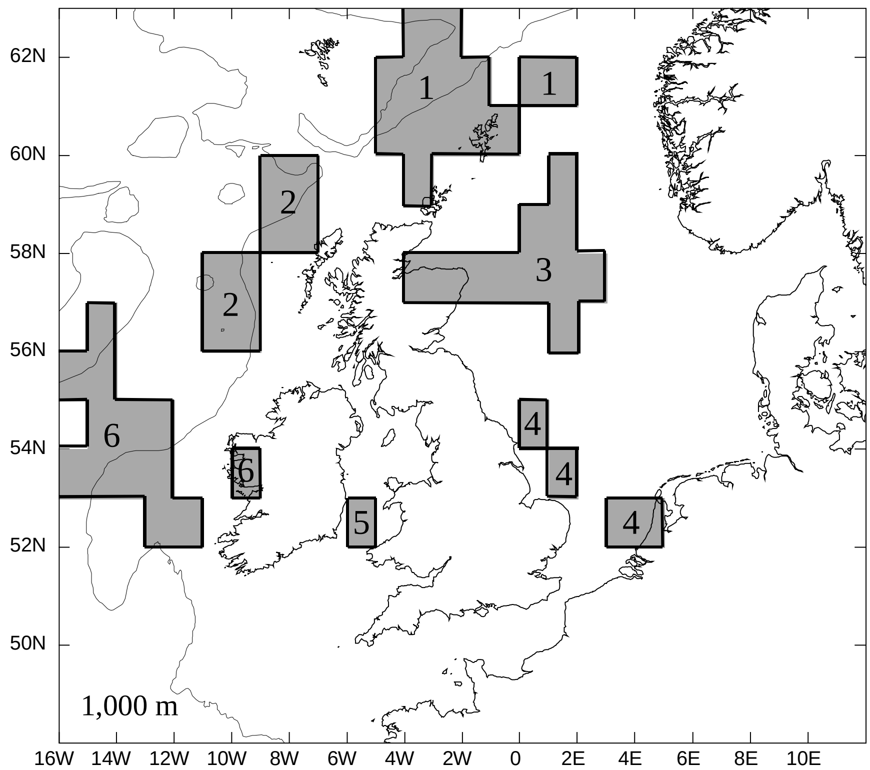

Figure 1 Quadrants surveyed for cetaceans from seismic survey vessels in 1996, and areas used in analysis: 1) West of Shetland; 2) West of Hebrides; 3) Northern North Sea; 4) Southern North Sea; 5) St. George's Channel; 6) West of Ireland.

4. An overview of cetacean sightings and survey effort

Cetaceans were sighted on 236 occasions between January and November 1996. A total of 1,315 individuals was seen, and twelve species were positively identified. The most numerous species were fin whales, killer whales, pilot whales, white-beaked dolphins and white-sided dolphins (Table 1). 63% of sightings were identified to species level, and a further 8% were identified as being one of a pair or group of similar species. Numbers of cetaceans seen peaked during July and August (Figure 2).

"Location and effort" recording forms (see Appendix 2) were completed correctly for 18 of the 30 surveys. During these surveys a total of 7,102 hrs 22 mins were spent watching for cetaceans, of which the airguns were firing for a total of 2,499 hrs 05 mins (35% of time on watch). Time spent watching peaked with increasing daylight in June (Figure 3), although the proportion of time spent shooting peaked in May, August and September. More survey time was spent in the North Sea and to the west of Shetland than in other areas (Figure 4).

Table 1 Summary of cetacean sightings from seismic surveys in 1996.

Species	No. sightings	No. individuals
Cetacean sp.	6	6
Whale sp.	15	24
Large whale sp.	8	12
Sperm whale	16	28
Humpback whale	2	2
Humpback/sperm whale	2	2
Blue whale	2	2
Blue/fin/sei whale	1	2
Fin whale	34	79
Fin/sei whale	9	10
Minke whale	14	20
Minke/northern bottlenose whale	1	1
Pilot whale	11 [a,b]	132
Killer whale	17	120
Dolphin sp.	40[a]	294
Risso's dolphin	1	5
Bottlenose dolphin	1	2
White-beaked dolphin	22	186
White-sided dolphin	24	286
Lagenorhynchus sp.[c]	7[b]	60
Common dolphin	1	6
Striped dolphin	1	18
Harbour porpoise	6	18
Total	**236**	**1,315**

[a] includes one sighting of pilot whales associated with unidentified dolphins
[b] includes four sightings of pilot whales associated with *Lagenorhynchus* sp.
[c] *Lagenorhynchus* sp. = white-beaked or white-sided dolphin

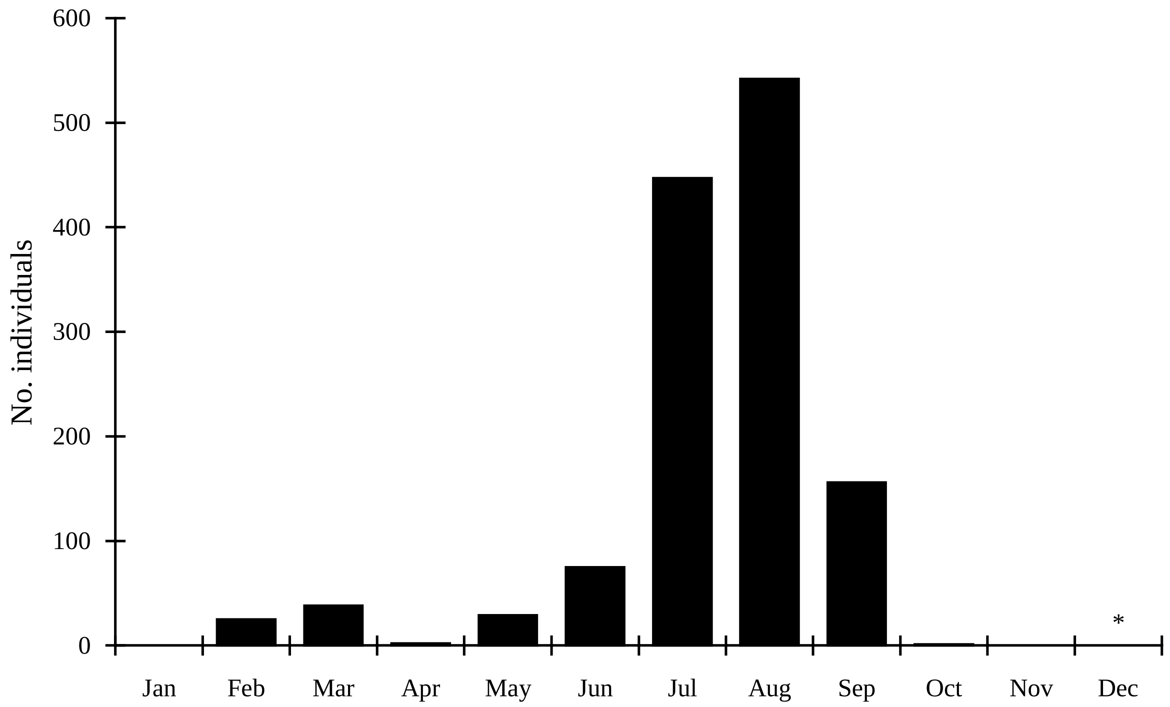

Figure 2 Number of cetaceans seen per month (* = no surveys).

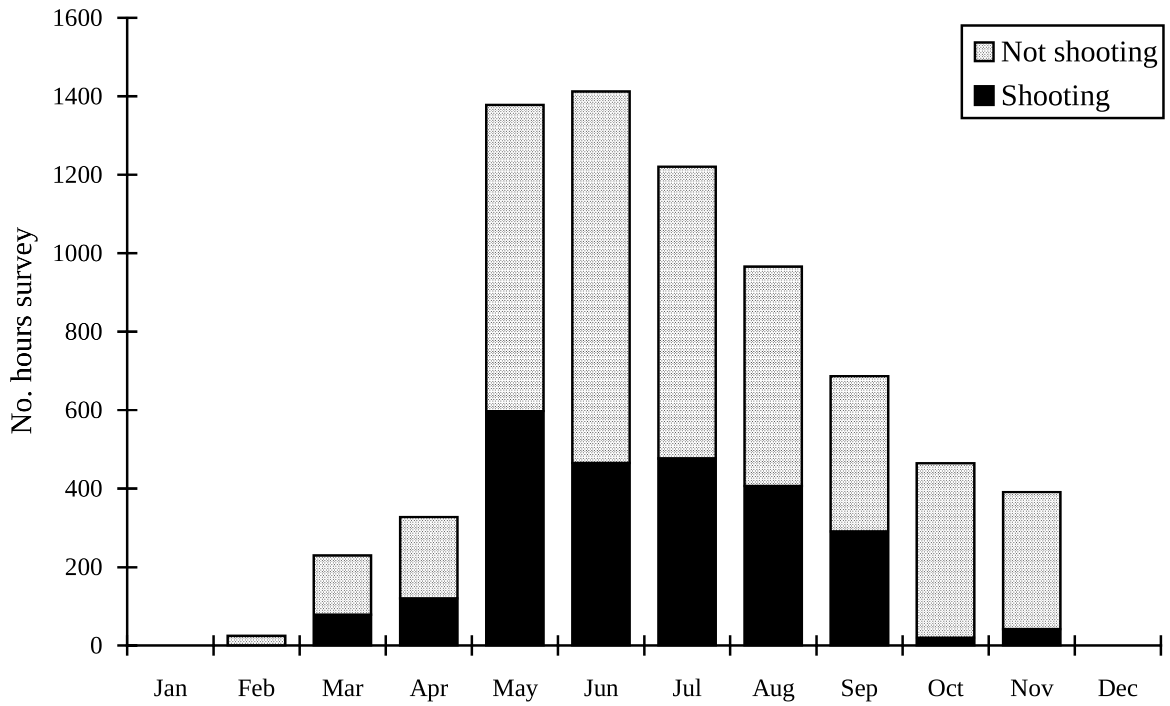

Figure 3 Length of time spent watching for cetaceans throughout 1996, and seismic activity during watches (only includes surveys where effort was recorded).

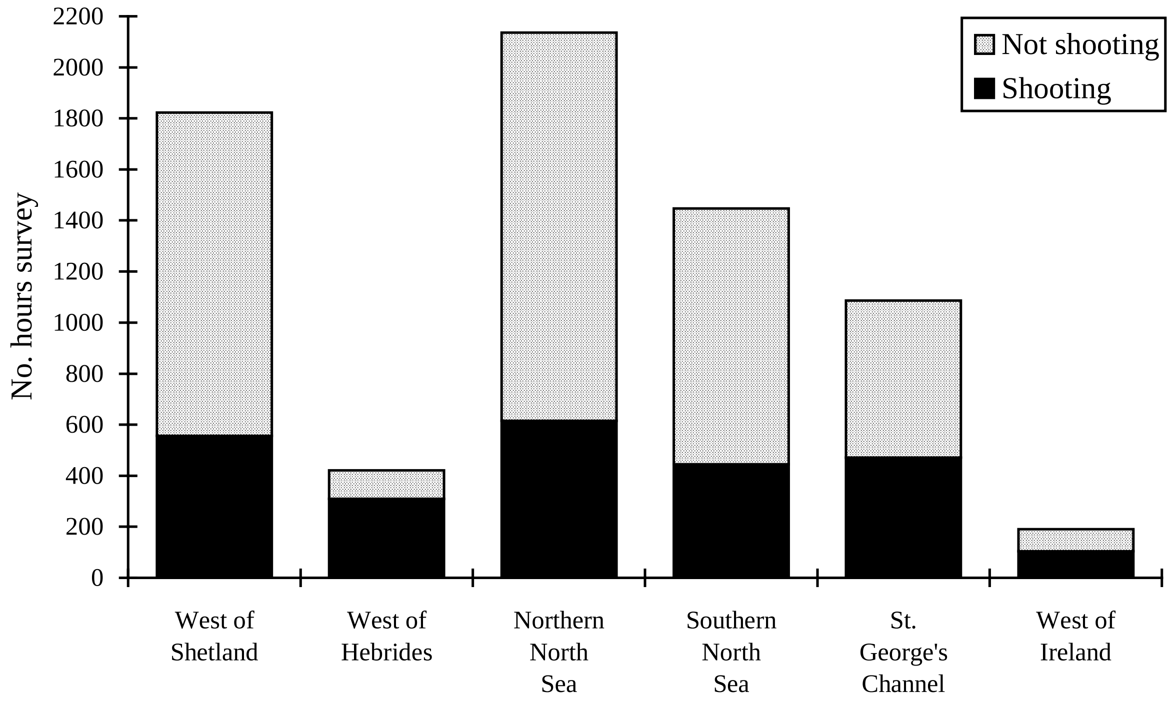

Figure 4 Length of time spent watching for cetaceans in each area, and seismic activity during watches (only includes surveys where effort was recorded).

5. Distribution of cetaceans

Cetacean sightings were concentrated in three main areas - between Shetland and the Faroes, in the northern North Sea and to the west of Ireland (Figure 5). Species maps (Figures 6-21) show that the larger whales (sperm, humpback, blue and fin) were seen mostly to the west of Shetland. One humpback whale was seen to the west of the Hebrides and a number of unidentified whales were seen to the west of Ireland. Fin, blue and sperm whales to the west of Shetland were distributed along the 1,000 m isobath, which corresponds with whaling records for these species which show that most catches occurred in deep waters just off the edge of the continental shelf (Thompson 1928).

Other species seen mainly or exclusively to the west of Shetland were pilot whale, killer whale and white-sided dolphin. White-sided dolphins are known to occur around Orkney and Shetland, particularly between July and September (Evans 1992). The distribution of pilot and killer whales also concurred with that found previously (JNCC 1995). Some killer whales might have been expected to the west of the Hebrides, but survey effort in this area was relatively low. Similarly Risso's dolphins might have been expected to the west of the Hebrides (Evans 1992, JNCC 1995), but the only sighting of this species was to the west of Shetland; as with killer whales, low survey effort probably accounts for the lack of Risso's dolphins to the west of the Hebrides. The sighting of a pod of striped dolphins to the north of Shetland was unusual as the distribution of this species in UK waters is mainly confined to the south and west, although Evans (1992) has suggested that striped dolphins may have been occurring further north in recent years, and reports sightings up to 56^{o}N.

Minke whales were seen both to the west of Shetland and in the North Sea - it is perhaps surprising that more were not seen in the North Sea as they are known to occur regularly in this area (JNCC 1995, Northridge *et al.* 1995). Harbour porpoises were also seen less often than might have been expected in the North Sea. Harbour porpoises are widespread in the North Sea (JNCC 1995, Northridge *et al.* 1995), but are often difficult to detect due to their small size and shy nature. White-beaked dolphins were seen only in the North Sea, where they are known to occur regularly (JNCC 1995, Northridge *et al.* 1995). The sighting of common dolphins in the North Sea was unusual as this species has a south-westerly distribution in UK waters (Evans 1992, JNCC 1995).

Bottlenose dolphins around the UK are mostly found in inshore waters (JNCC 1995), so it is not too surprising that there was only one positive sighting of this species, although this sighting occurred away from known resident populations. There is a resident population of bottlenose dolphins in Cardigan Bay, which were not encountered during seismic surveys in the St. George's Channel. That there were no sightings of any cetaceans in St. George's Channel is surprising as common dolphins occur regularly there (JNCC 1995). It is probable that many of the unidentified dolphins seen to the west of Ireland were common dolphins as this is the most frequently encountered species in this area (Evans 1992, JNCC 1995).

Cetacean distribution may be influenced by variable natural factors such as water masses, fronts, eddies, upwellings, currents, water temperature, salinity and length of day. A major factor likely to influence cetacean distribution is the availability of prey, mainly fish, plankton and cephalopods. Distribution and abundance of prey species in UK waters during 1996 is not yet known, so the influence of this factor on the results presented here cannot be assessed.

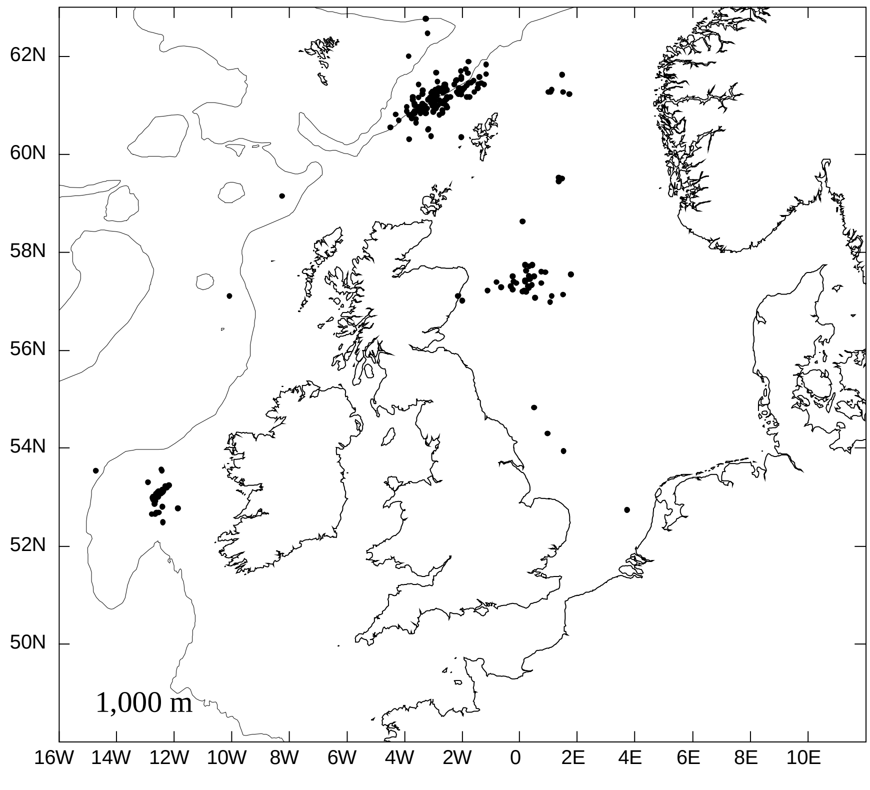

Figure 5 Cetacean sightings (all species) from seismic survey vessels during 1996.

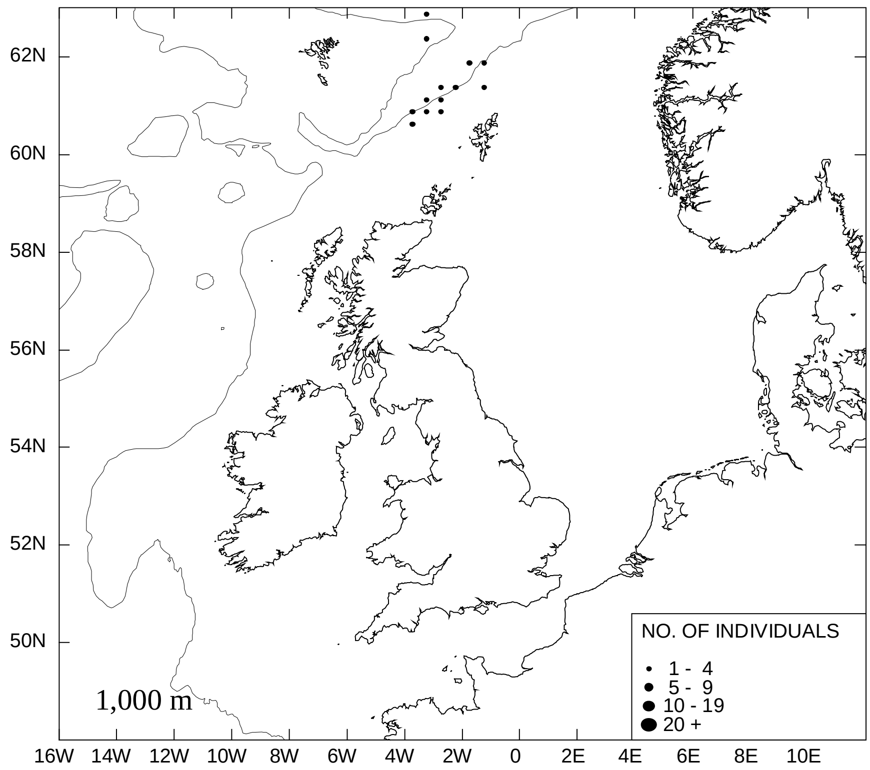

Figure 6 Distribution of sperm whales observed during seismic surveys in 1996.

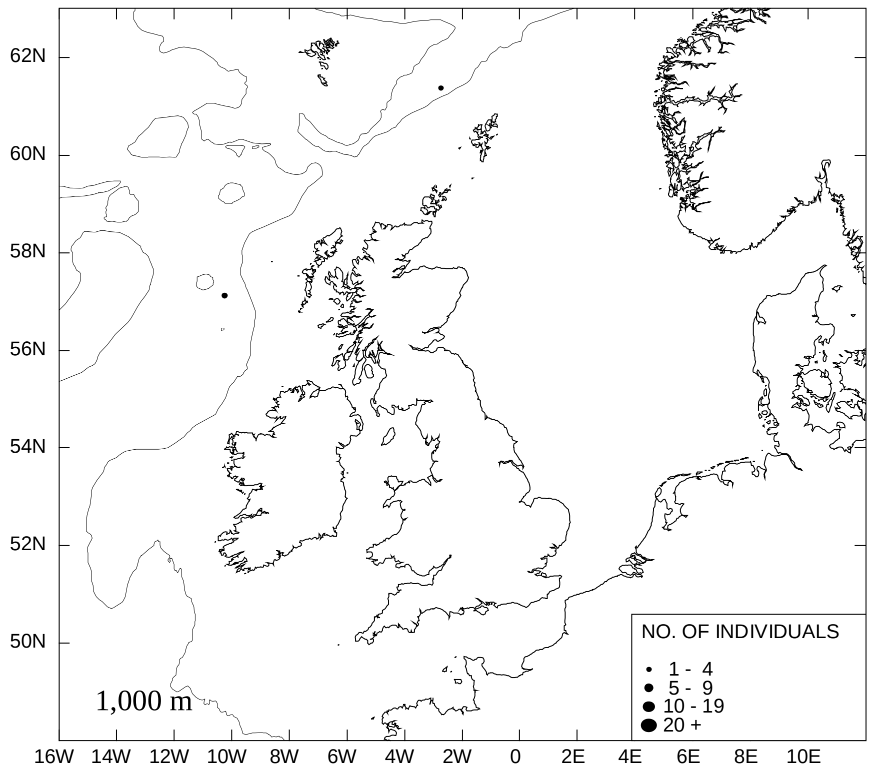

Figure 7 Distribution of humpback whales observed during seismic surveys in 1996.

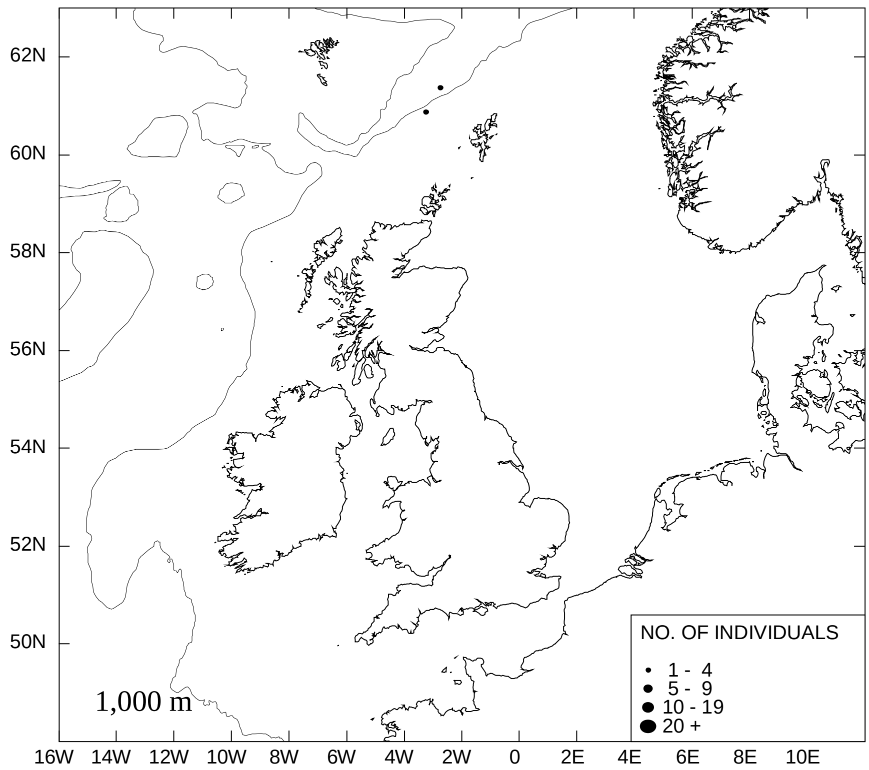

Figure 8 Distribution of blue whales observed during seismic surveys in 1996.

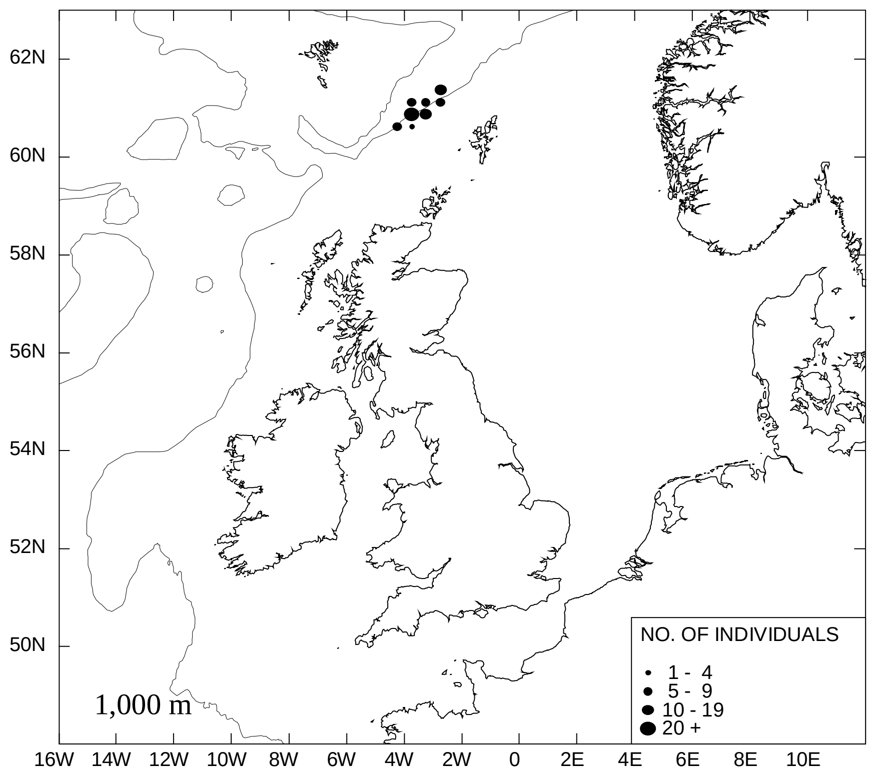

Figure 9 Distribution of fin whales observed during seismic surveys in 1996.

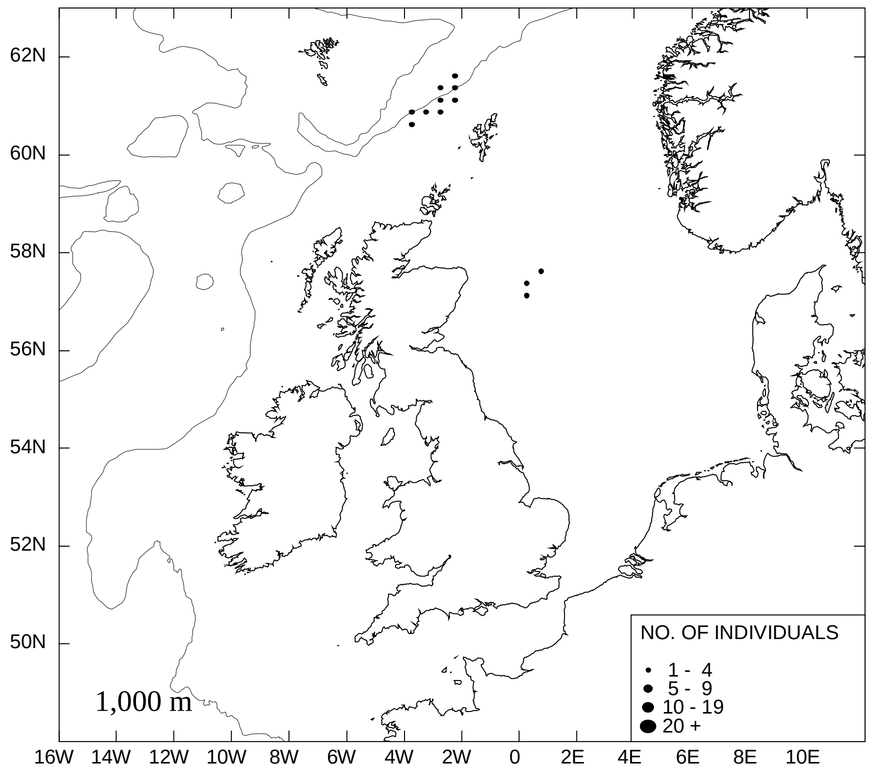

Figure 10 Distribution of minke whales observed during seismic surveys in 1996.

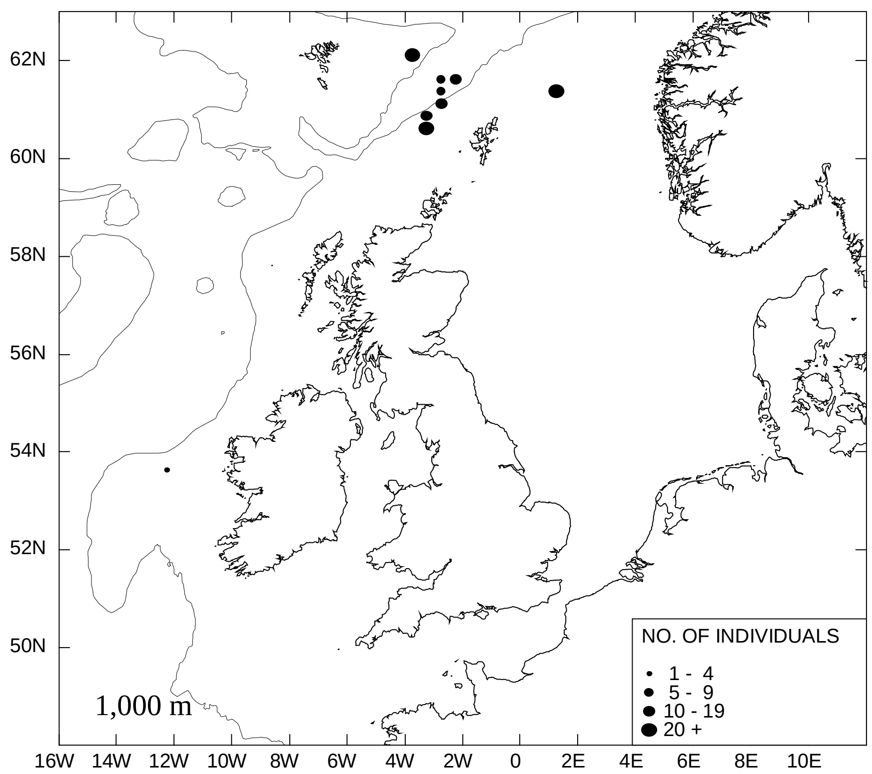

Figure 11 Distribution of pilot whales observed during seismic surveys in 1996.

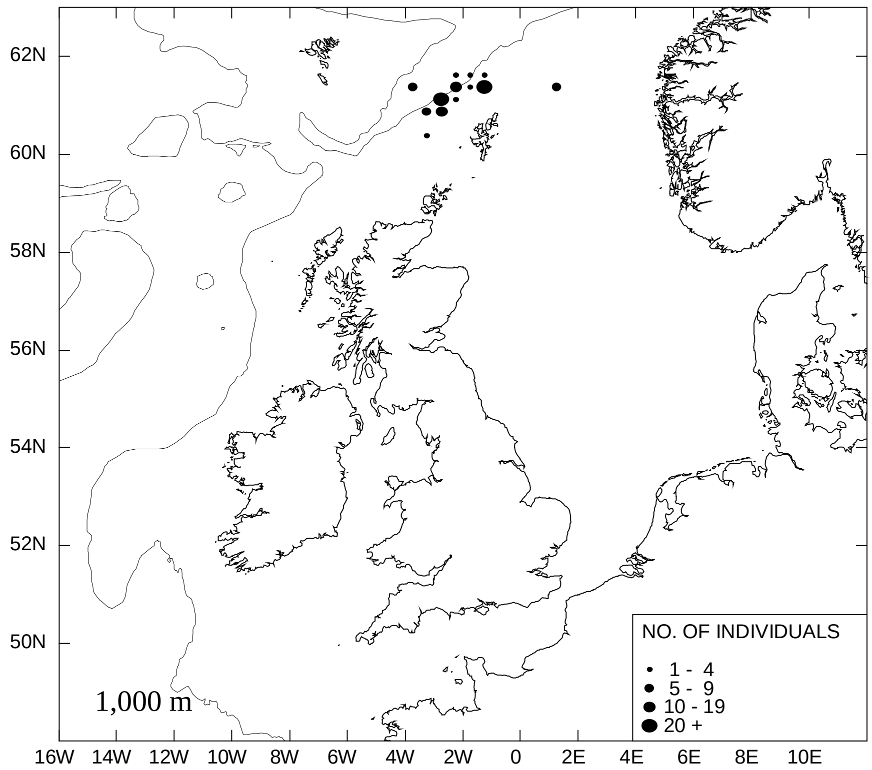

Figure 12 Distribution of killer whales observed during seismic surveys in 1996.

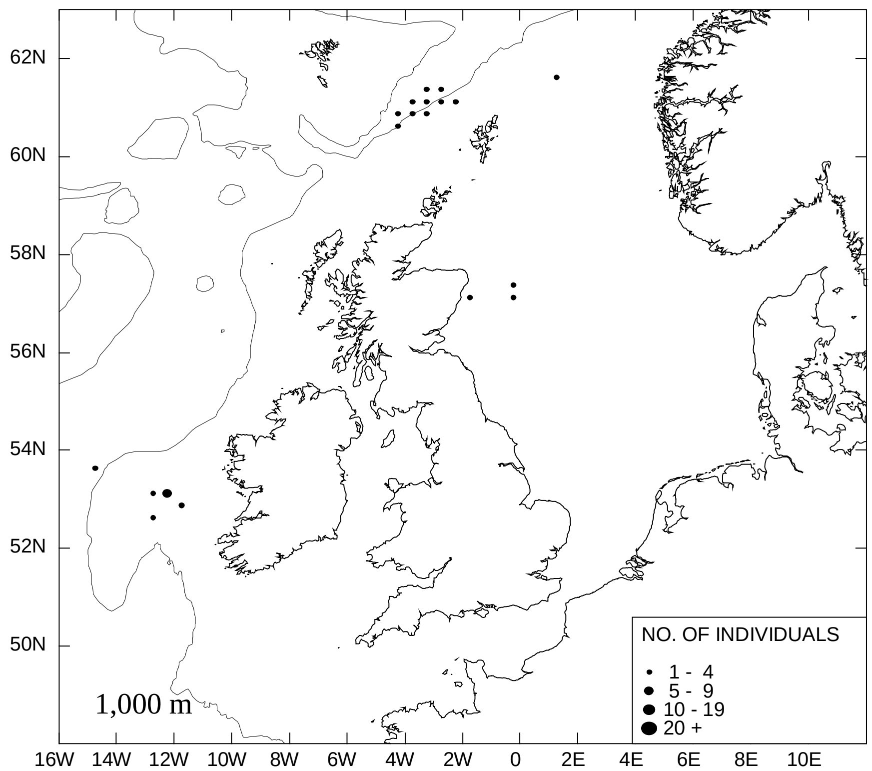

Figure 13 Distribution of unidentified whales observed during seismic surveys in 1996.

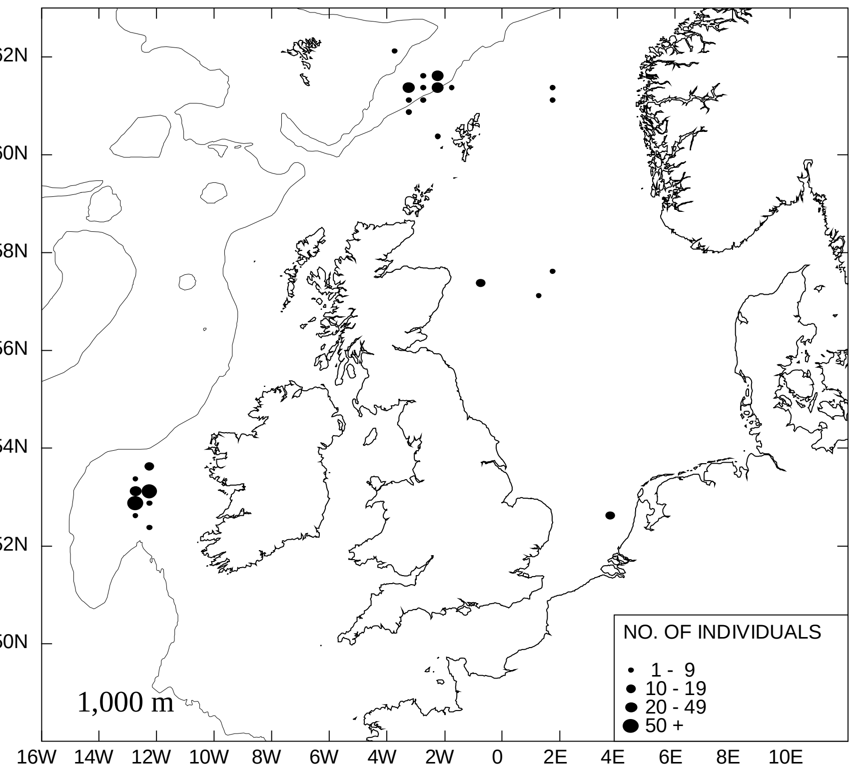

Figure 14 Distribution of unidentified dolphins observed during seismic surveys in 1996.

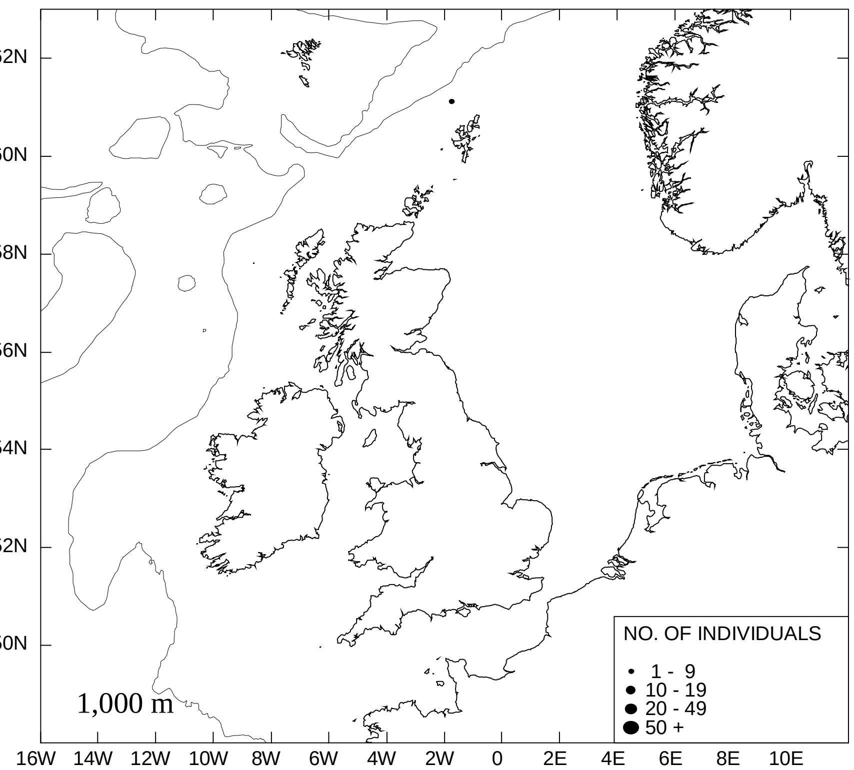

Figure 15 Distribution of Risso's dolphins observed during seismic surveys in 1996.

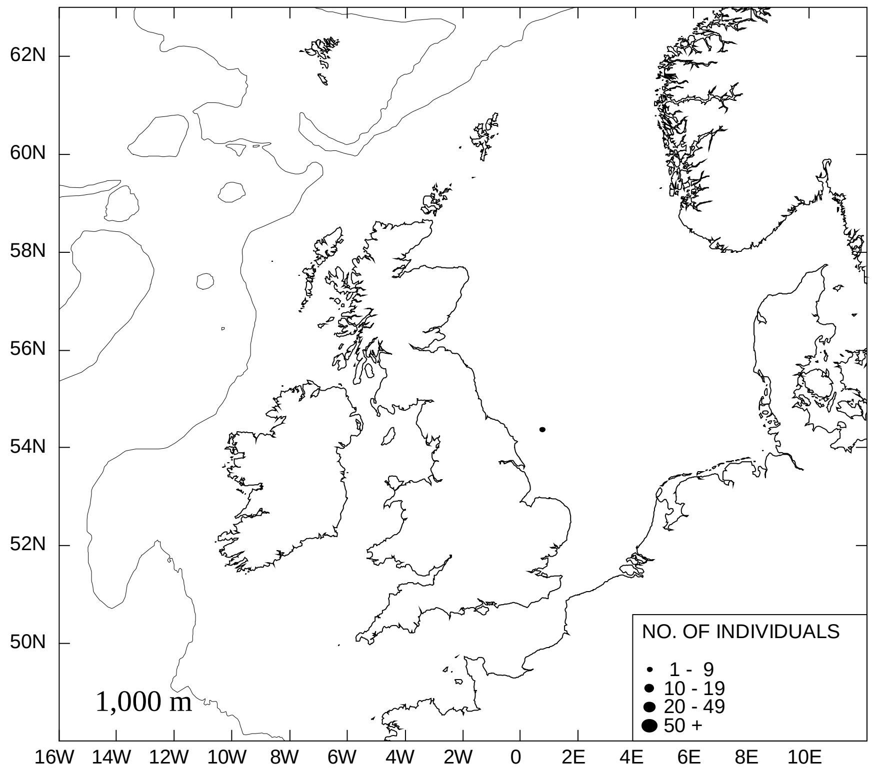

Figure 16 Distribution of bottlenose dolphins observed during seismic surveys in 1996.

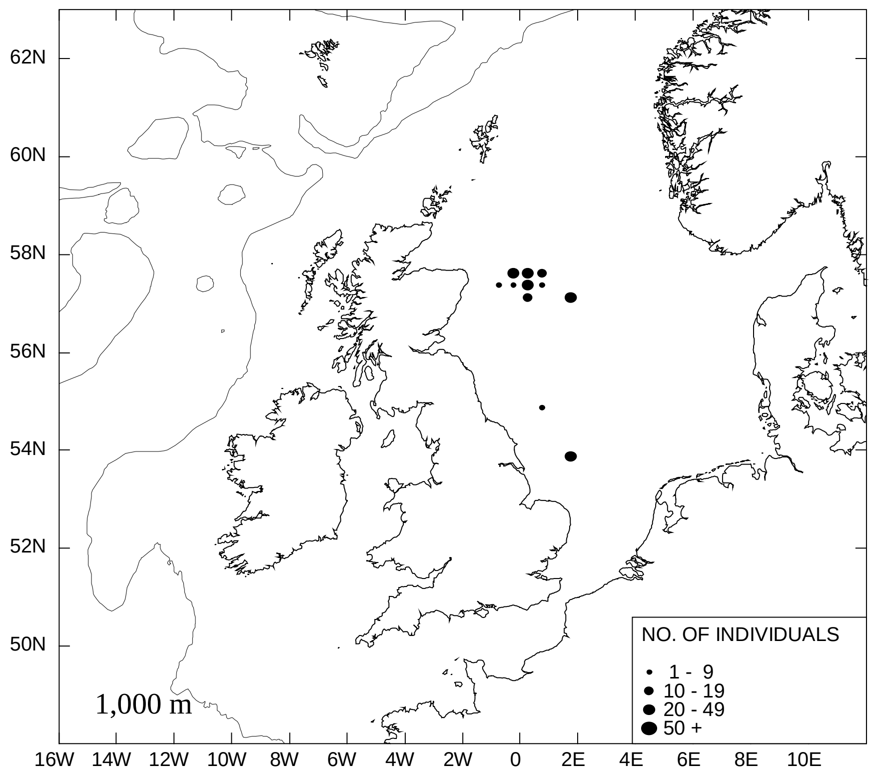

Figure 17 Distribution of white-beaked dolphins observed during seismic surveys in 1996.

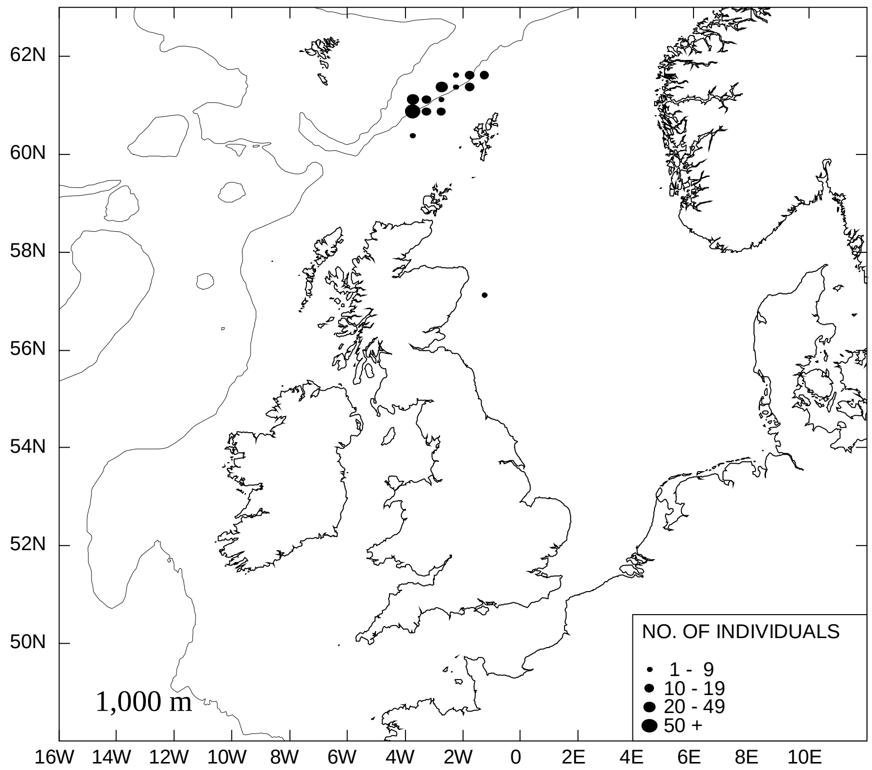

Figure 18 Distribution of white-sided dolphins observed during seismic surveys in 1996.

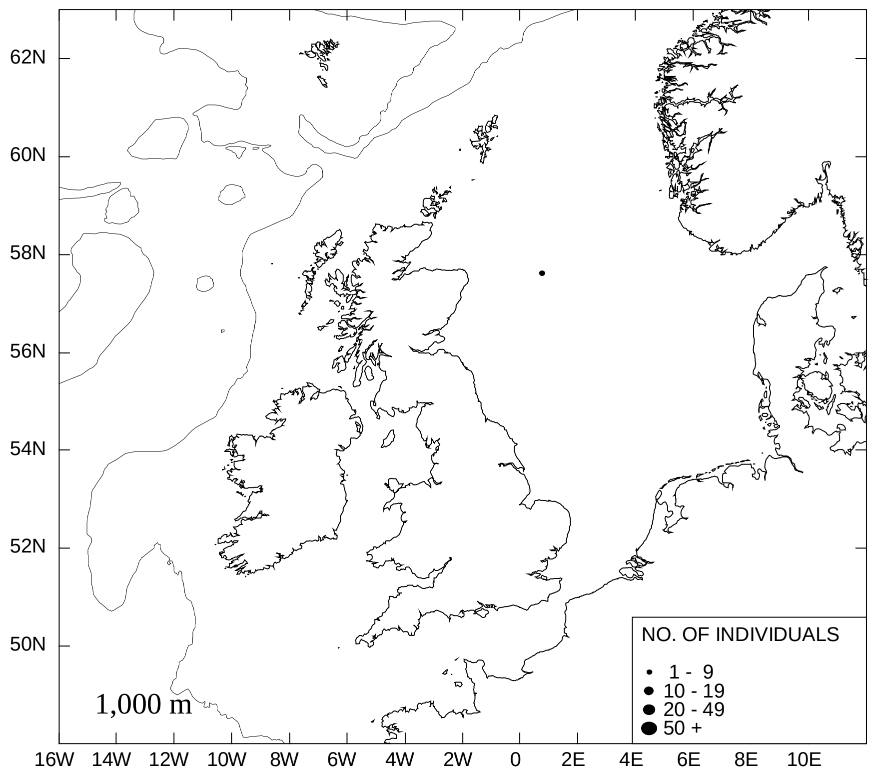

Figure 19 Distribution of common dolphins observed during seismic surveys in 1996.

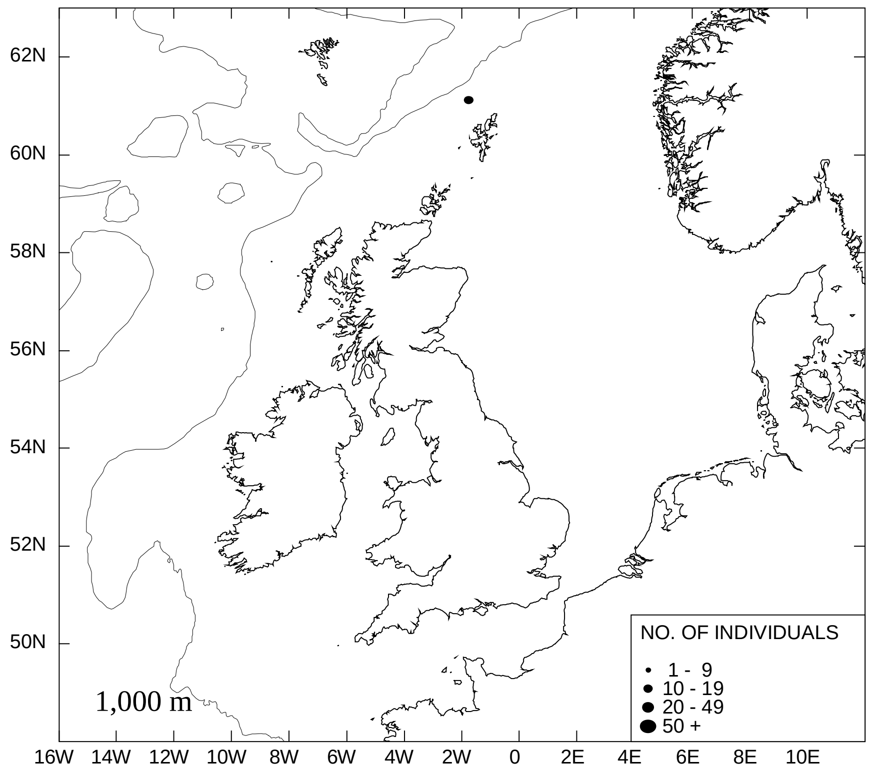

Figure 20 Distribution of striped dolphins observed during seismic surveys in 1996.

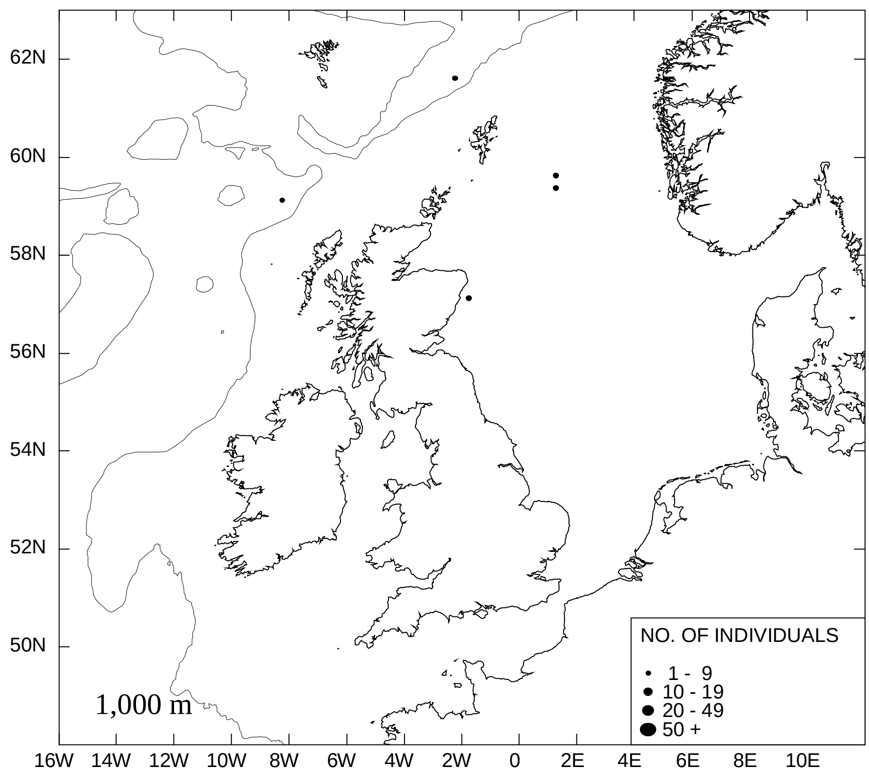

Figure 21 Distribution of harbour porpoises observed during seismic surveys in 1996.

6. Effects of seismic activity on cetaceans

6.1 Numbers of cetaceans

Most cetaceans (80%) were seen when the airguns were not firing. However, the airguns were firing for only 35% of the time on watch. After correcting for the amount of time spent at each activity, sightings of baleen whales were found to be more frequent when shooting (Figure 22), while sightings of odontocetes (toothed whales and dolphins) were more frequent when not shooting (Figure 23).

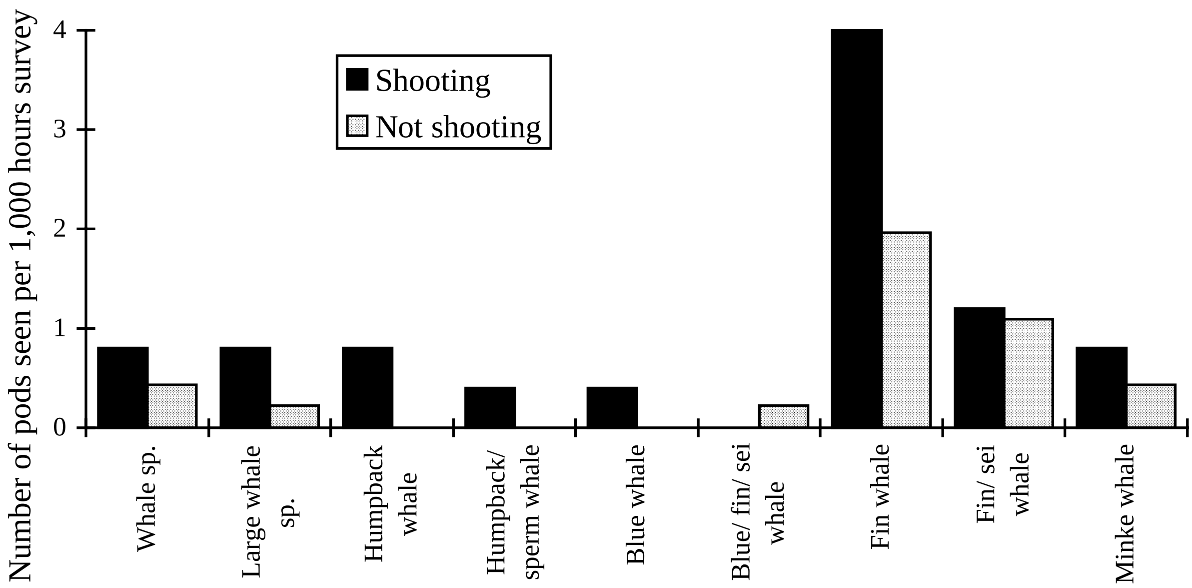

Figure 22 Sightings of baleen whales in relation to seismic activity.

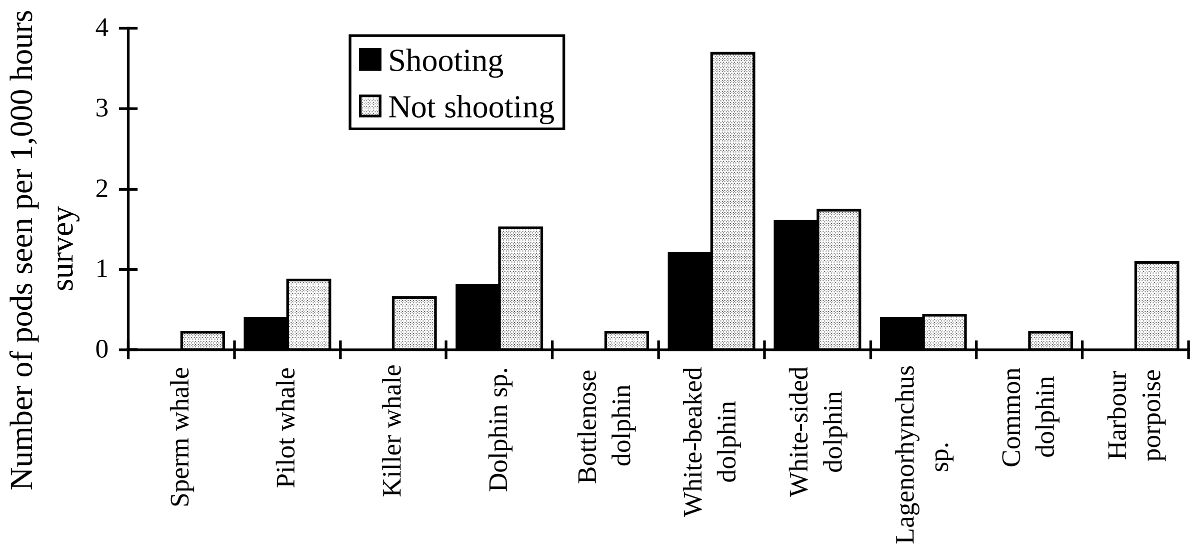

Figure 23 Sightings of odontocetes in relation to seismic activity.

Most species were seen in low numbers, so any conclusions drawn for those species must be regarded as tentative. Species seen more frequently tended to be concentrated in one area and have seasonal peaks in abundance. This could lead to bias in the results if effort for all areas and months are included in the analysis, due to an imbalance in the proportion of time spent shooting in different areas and months. For example, most white-beaked dolphins were seen in the northern North Sea from July to September - including effort from, say, the west of Ireland in May, when more time was spent shooting and no white-beaked dolphins were seen, could lead to a tendency for numbers to be lower when shooting. To counter this potential bias, for the five most frequently occurring species subsets of data comprising the areas and months of greatest abundance were selected (Table 2). Analysis of these subsets revealed that significantly more fin whales were seen when the airguns were firing, while significantly more white-beaked dolphins were seen when the airguns were not firing (Figure 24, Table 2).

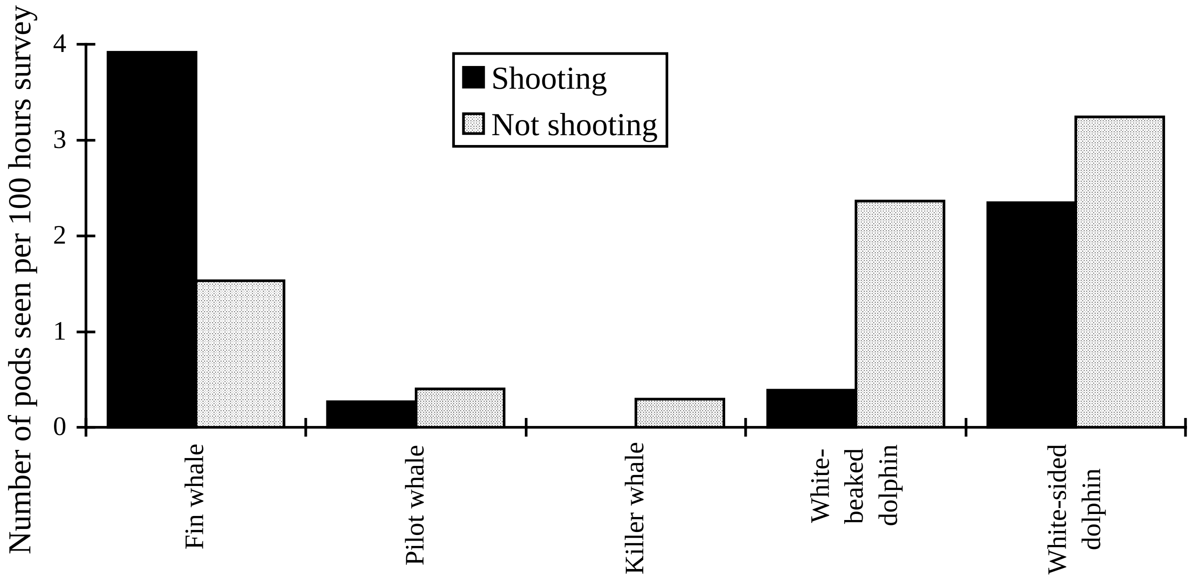

Figure 24 Sightings of five species of cetacean in relation to seismic activity, using only data from locations and seasons of peak abundance (see Table 2).

Table 2 Location and season of peak abundance for the five most frequently sighted species of cetacean, and statistical significance of difference in numbers seen when shooting or not shooting (n.s. = not significant).

Species	**Month(s)**	**Area**	χ^2	**d.f.**	**P**
Fin whale	July & August	West of Shetland	4.505	1	<0.05
Pilot whale	March - August	West of Shetland	0.138	1	n.s.
Killer whale	June - September	West of Shetland	1.369	1	n.s.
White-beaked dolphin	July - September	Northern North Sea	7.487	1	<0.01
White-sided dolphin	August	West of Shetland	0.285	1	n.s.

It is easier to detect cetaceans in calmer seas when there is little swell and spray. Coincidentally, shooting is also restricted to calmer sea states. Higher numbers of fin whales seen when shooting could reflect the greater ease of detecting them in calmer weather. Weather conditions were generally only recorded when cetaceans were sighted, and not at other times. It is therefore not possible to make allowances for weather when analysing the numbers of cetaceans seen in relation to seismic activity. However, in one survey, reported previously, weather was recorded continuously; it was found that when weather was taken into account numbers of fin whales ceased to be significantly different between periods of shooting and periods of not shooting, while the difference in numbers of white-sided dolphins at each activity increased, resulting in significantly more being seen when not shooting (Stone 1996).

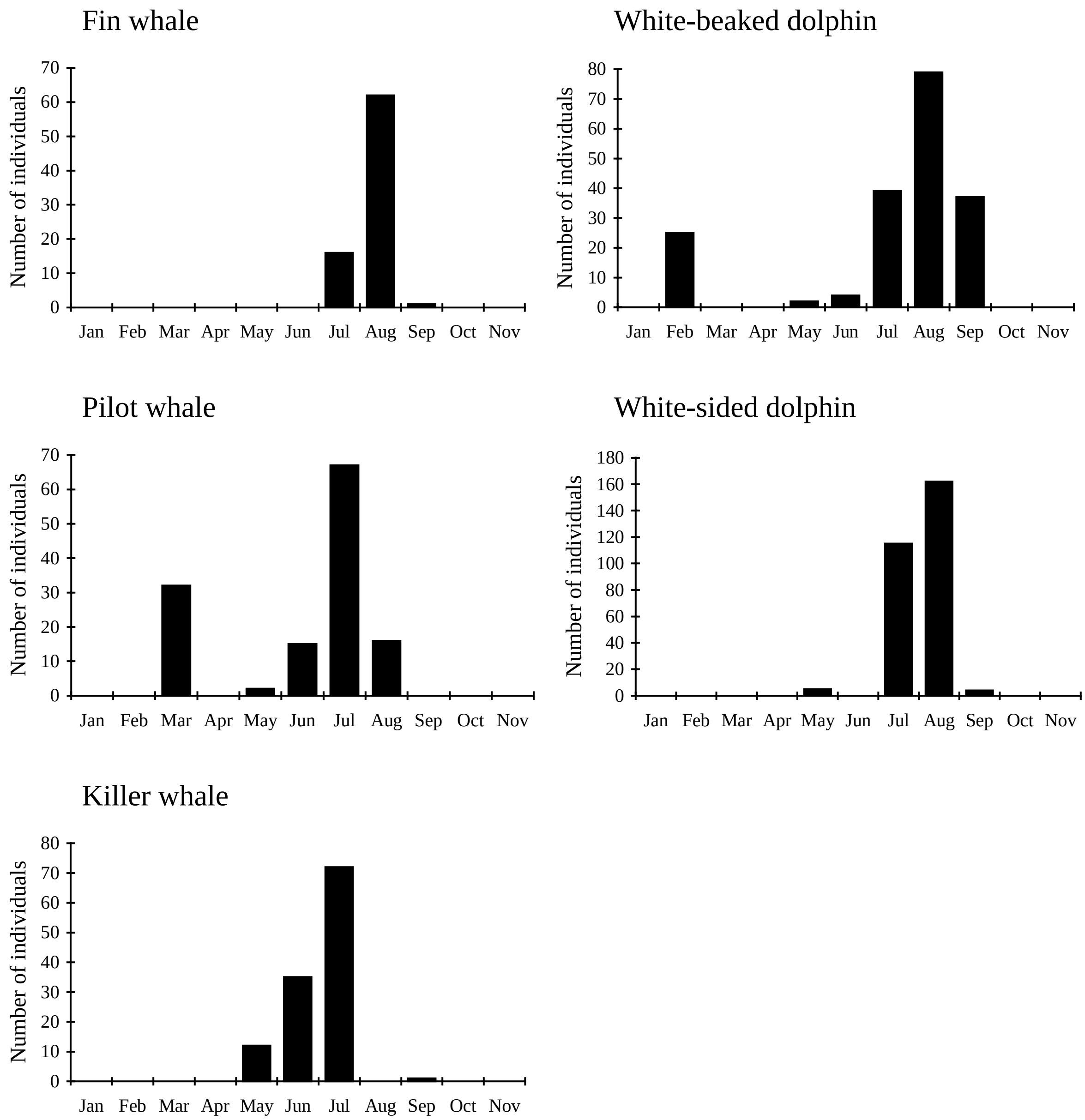

Figure 25 Seasonal abundance of cetaceans observed from seismic survey vessels.

Numbers of cetaceans peaked in July and August (Figure 2). Seasonal abundance of the five most frequently seen species (Figure 25) corresponds with previous records of sightings in UK waters (Evans 1992), with the exception of fin whale. Fin whale sightings have been recorded throughout June to December, with most December sightings off southern Ireland or south-west England (Evans 1992). Evans (1980) suggests that at least some fin whales undergo a latitudinal migration moving south in autumn, which would account for the decrease in numbers of fin whales seen during seismic surveys to the west of Shetland after August. Although there was no evidence of migration of any species from their direction of travel, it seems more likely that the decrease in cetacean sightings at the end of the summer represents normal seasonal movements rather than a response to seismic activity. This is supported by the continued presence of cetaceans in some areas after several months of seismic activity e.g. in the northern North Sea white-beaked dolphins were present from June to September, despite continued seismic activity throughout this period (Figure 26).

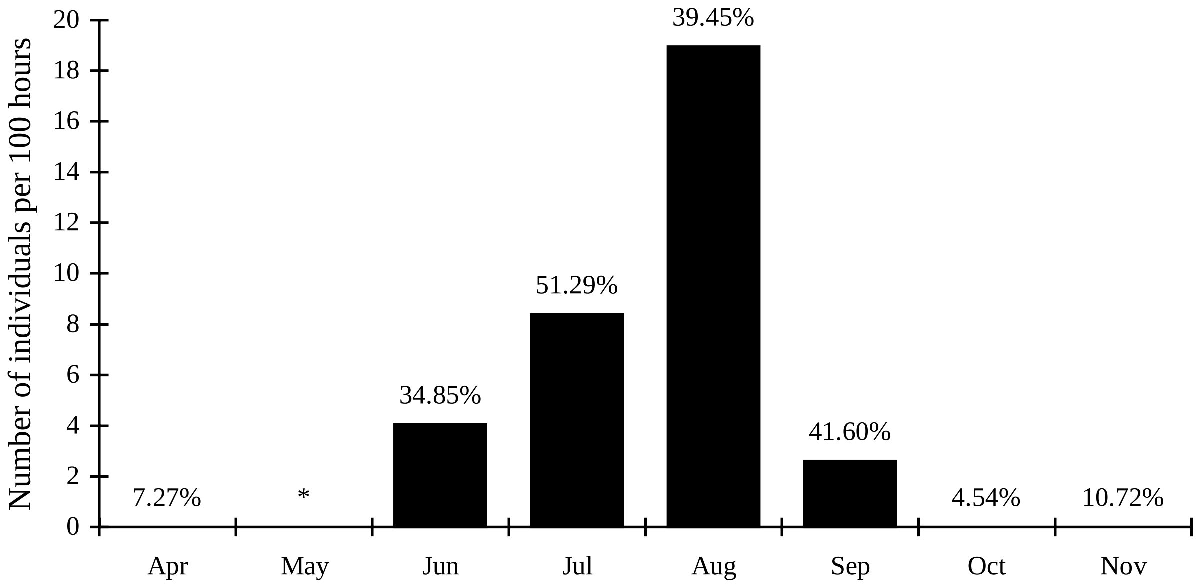

Figure 26 Relative numbers of white-beaked dolphins per month during seismic surveys in the northern North Sea, with proportion of time on watch spent shooting in this area (* = effort not recorded).

It appears that any reduction in the numbers of dolphins due to seismic activity was only temporary, with animals rapidly appearing in the survey area between periods of shooting. Of the white-beaked dolphins seen when the airguns were not firing, 88% were seen within 48 hours of firing stopping. For white-sided dolphins, 80% of those seen when not shooting were seen within 48 hours of firing stopping, with 61% being seen on the same day that firing stopped.

6.2 Distance of cetaceans from airguns

There were thirteen species or groups of species where the distance from the airguns was recorded during both periods of shooting and not shooting. In nearly all cases, the mean distance of pods from the airguns was greater when the guns were firing than when they were not firing (Figure 27). However, permutation tests showed that the increase in distance of pods when the airguns were firing was significant only for fin whales and white-sided dolphins (at 1% and 5% significance levels respectively) (Table 3). However, these were the only two species where distance was recorded on more than ten occasions, so the lack of significant differences for other species may be due to small sample sizes.

The operation of the guidelines, where firing was delayed if cetaceans were sighted within 500 m before the start of a survey line, may have led to bias in these results. The level of potential bias is uncertain as no delays were reported. However, as sightings were infrequent it seems unlikely that sightings within 500 m just prior to starting a survey line would have occurred often, therefore any bias due to delays is probably small. For one survey it was reported that no delays were necessary, hence eliminating any bias, yet cetaceans were still found to be further from the airguns when the guns were firing (Stone 1996).

Although these results indicate that cetaceans were remaining further from the guns when they were firing, the mean distances do not necessarily represent distances at which cetaceans are tolerant of airguns.

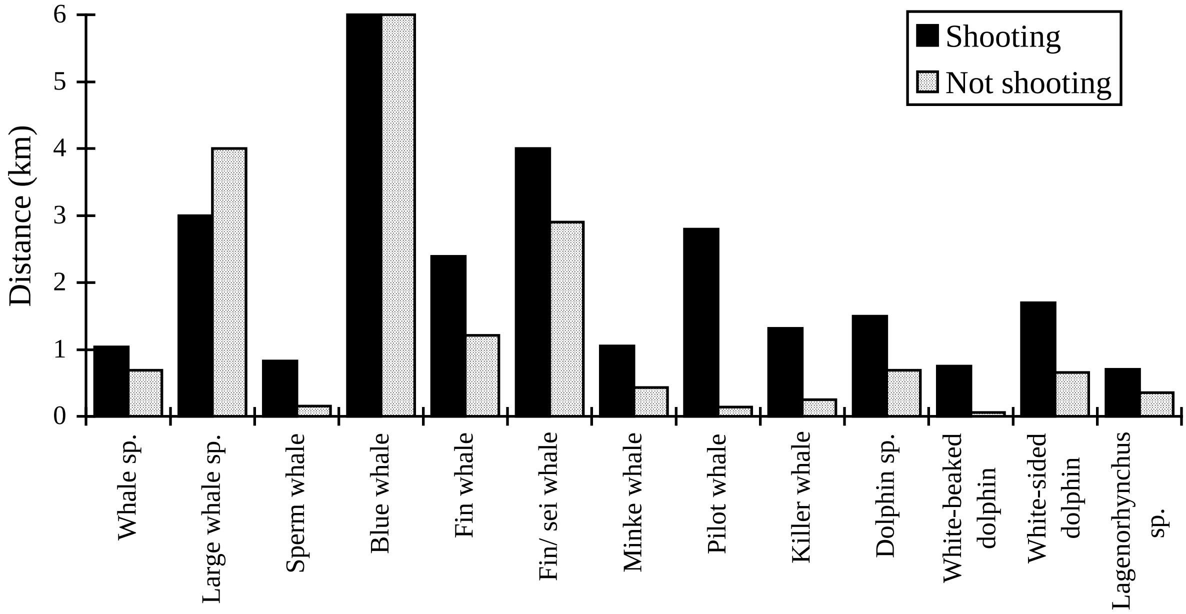

Figure 27 Mean distance of cetacean pods from the airguns in relation to seismic activity (only includes species where distances were recorded during periods of both shooting and not shooting).

Table 3 Statistical significance using the permutation test of the differences in distance of cetacean pods from the airguns in relation to seismic activity (n.s. = not significant).

Species	**Number of pods**	**Statistical significance**
Whale sp.	9	n.s.
Large whale sp.	3	n.s.
Sperm whale	5	n.s.
Blue whale	2	n.s.
Fin whale	34	p = 0.004
Fin/sei whale	8	n.s.
Minke whale	7	n.s.
Pilot whale	4	n.s.
Killer whale	8	n.s.
Dolphin sp.	5	n.s.
White-beaked dolphin	5	n.s.
White-sided dolphin	15	p = 0.015
Lagenorhynchus sp.	3	n.s.

6.3 Behaviour of cetaceans

The main effect of seismic activity on cetacean behaviour was on the direction of travel of pods in relation to the survey vessel. The direction of travel of cetaceans relative to the ship was divided into six categories: 1) travelling towards the ship; 2) travelling ahead of the ship and crossing its path; 3) travelling away from the ship; 4) travelling parallel to the ship in the same direction as the ship; 5) travelling parallel to the ship in the opposite direction to the ship; and 6) milling or circling. Each pod was assigned to one of these categories based on diagrammatic representations of their direction of travel recorded by the observers. Few pods came towards the ship or crossed its path when the airguns were firing, although these were the most frequent directions recorded when the airguns were not firing (Table 4). The total number of pods travelling in each of the six directions differed significantly with seismic activity ($\chi^2 = 16.904$, d.f. = 5, $p<0.01$). Partitioning showed that the number of pods heading towards or across the path of the ship when the airguns were firing was significantly lower than the number of pods in the four other categories.

Fourteen pods were observed actively feeding, five pods (32 individuals) when the airguns were firing and nine pods (64 individuals) when the airguns were not firing. The ratio of the numbers of pods seen feeding at each activity was in accordance with the proportion of time spent at each activity (35% of time spent shooting). The mean distance from the airguns of pods feeding when the guns were firing was 3.3 km, while those observed feeding when the airguns were not firing were at a mean distance of 363 m from the guns. The closest distance to the airguns at which cetaceans were observed actively feeding was 3 km when shooting and 50 m when not shooting. It is possible that other pods were also feeding but that this was not apparent to the observers.

Table 4 Direction of travel of cetacean pods relative to the ship in relation to seismic activity.

Species	**Seismic activity**	**Towards ship**	**Crossing path of ship**	**Away from ship**	**Parallel to ship in same direction**	**Parallel to ship in opposite direction**	**Milling**
Cetacean sp.	Shooting						
	Not shooting			2		4	
Whale sp.	Shooting			1	1	1	
	Not shooting		3		2	1	
Large whale sp.	Shooting			1			1
	Not shooting				1		
Sperm whale	Shooting				2	2	
	Not shooting	1	1			1	
Humpback whale	Shooting		1			1	
	Not shooting						
Humpback/sperm whale	Shooting				1		
	Not shooting				1		
Blue whale	Shooting						1
	Not shooting						
Blue/fin/sei whale	Shooting						
	Not shooting					1	
Fin whale	Shooting	1		4	2	4	
	Not shooting	5	10	2	4	2	
Fin/sei whale	Shooting					2	1
	Not shooting			1	2	2	
Minke whale	Shooting		2		1		
	Not shooting		1	2		3	
Pilot whale	Shooting		1				
	Not shooting	4	1		1		
Killer whale	Shooting		1		1		
	Not shooting	2	7	1			
Dolphin sp.	Shooting		2				
	Not shooting	3	4			2	
Bottlenose dolphin	Shooting						
	Not shooting				1		
White-beaked dolphin	Shooting	1			2		
	Not shooting	6	4	2	3	2	1
White-sided dolphin	Shooting	1		1		1	1
	Not shooting	1	5	1	1	3	
Lagenorhynchus sp.	Shooting			1			
	Not shooting	2					
Common dolphin	Shooting						
	Not shooting	1					
Harbour porpoise	Shooting						
	Not shooting	1		2	1	2	
Total	**Shooting**	**3**	**7**	**8**	**10**	**11**	**4**
	Not shooting	**26**	**36**	**13**	**17**	**23**	**1**

Positive interactions of cetaceans with the survey vessel included bow-riding, swimming alongside the paravanes and approaching the ship. Positive interactions were rare during periods of shooting. Bow-riding was observed eight times, mostly involving white-beaked dolphins. Only one pod of four white-beaked dolphins was observed to bow-ride whilst shooting. Cetaceans were seen swimming by the paravanes on four occasions, all when the airguns were not firing. A total of nineteen individuals (in five pods) were recorded as approaching the ship (but not bow-riding); of these, only one individual (a minke whale) approached the ship while the airguns were firing.

Cetaceans were observed avoiding the survey vessel on five occasions, three times when the airguns were not firing and twice when they were. One pod of fin whales which showed a clear avoidance reaction during a period of shooting possibly included a calf, which may have increased the wariness of the pod. It is impossible to say whether the cetaceans recorded as avoiding the ship whilst shooting were responding to the seismic activity or merely to the presence of the ship. As 35% of the time was spent shooting, it might be expected that two of the five occasions when an avoidance reaction was recorded would occur during a period of shooting.

"Playful" behaviour was recorded on ten occasions, mostly involving white-beaked dolphins, and all during periods when the airguns were not firing. Breaching and jumping were recorded on twenty four occasions, of which four were when the airguns were firing - the closest distance to the airguns at which breaching or jumping was observed during periods of shooting was 800 m. Similar numbers of cetaceans were recorded as embarking on a prolonged dive whether the airguns were firing or not.

6.4 Influence of depth on the level of disturbance of cetaceans

Depth of water was routinely recorded when cetaceans were sighted. The mean, minimum and maximum depth for each species is presented in Table 5. Whales were found mainly over the shelf edge. Minke whales, killer whales and pilot whales were the only whale species which were also seen over the continental shelf, while the larger whales showed a preference for deeper waters over the outer regions of the shelf edge or beyond. White-sided dolphins also occurred mainly in deeper waters, while bottlenose dolphins, white-beaked dolphins and common dolphins were only found in shallower areas.

Some of the survey areas, particularly those to the west of Shetland, were in deep water, often over 1,000 m in depth. Depth can influence the propagation of sound underwater, and thus may influence the response of cetaceans to seismic activity. Fin whales and white-sided dolphins were the most common species seen in deep waters to the west of Shetland. Fin whales were evenly dispersed either side of the 1,000 m isobath. They appeared to be more tolerant of seismic activity in waters of greater than 1,000 m depth - a greater proportion of pods were seen when the airguns were firing in waters over 1,000 m deep than in shallower waters (Table 6). The difference in numbers of fin whale pods seen at different seismic activities and different depths was statistically significant ($\chi^2 = 7.291$, d.f. = 1, $p<0.01$). Similarly, relatively more white-sided dolphins were seen when the airguns were firing in waters over 1,000 m deep, although this difference was not significant ($\chi^2 = 0.011$, d.f. = 1) (Table 7).

Table 5 Mean and range of depth of cetaceans encountered during seismic surveys.

Species	Mean depth of pods (m)	Minimum depth (m)	Maximum depth (m)	Number of pods
Cetacean sp.	459.20	83	1,000	5
Whale sp.	485.88	72	1,193	8
Large whale sp.	1,094.25	642	1,400	4
Sperm whale	830.85	300	1,400	13
Humpback whale	1,639.00	1,169	2,109	2
Humpback/sperm whale	918.00	785	1,051	2
Blue whale	1,107.50	1,000	1,215	2
Blue/fin/sei whale	1,234.00	1,234	1,234	1
Fin whale	1,007.44	750	1,319	34
Fin/sei whale	1,118.00	914	1,228	8
Minke whale	674.62	72	1,309	13
Minke/northern bottlenose whale	675.00	675	675	1
Pilot whale	724.70	160	1,536	10
Killer whale	543.93	143	1,295	14
Dolphin sp.	637.27	29	1,250	15
Risso's dolphin	386.00	386	386	1
Bottlenose dolphin	53.00	53	53	1
White-beaked dolphin	84.10	63	106	21
White-sided dolphin	874.96	60	1,292	23
Lagenorhynchus sp.	865.71	70	1,536	7
Common dolphin	86.00	86	86	1
Striped dolphin	300.00	300	300	1
Harbour porpoise	600.00	107	1,407	5

Table 6 Number of pods of fin whales in relation to depth and seismic activity.

Seismic activity	Numbers in waters <1,000 m	Numbers in waters >1,000 m
Shooting	1	10
Not shooting	15	8
Total	16	18

Table 7 Number of pods of white-sided dolphins in relation to depth and seismic activity.

Seismic activity	Numbers in waters <1,000 m	Numbers in waters >1,000 m
Shooting	3	3
Not shooting	10	7
Total	13	10

The higher proportion of fin whales seen whilst shooting in deep waters was not due to varying amounts of seismic activity at different depths; the proportion of time spent shooting was similar over the continental slope (200-1,000 m) and deep waters (>1,000 m) (Table 8).

Table 8 Proportion of time spent shooting at various depths.

Depth	Proportion of time spent shooting
0-50 m	25.58%
50-100 m	41.83%
100-200 m	11.22%
200-1,000 m	48.46%
>1,000 m	45.65%

During these surveys no species was seen in sufficient numbers in both shallow shelf waters and deeper waters to enable a comparison of the effects of seismic activity over a greater range of depth. The only species to show a marked reduction in abundance during periods of shooting was the white-beaked dolphin (see section 6.1), and this was also the only species regularly seen in shallow waters. White-beaked dolphins were found mainly in the 50-100 m depth range; a similar proportion of survey time was spent shooting at this depth range as in deeper waters where white-sided dolphins were found (Table 8), although these showed no reduction in abundance. It is possible that the greater sensitivity of white-beaked dolphins to seismic activity was due partly to their shallow-water distribution.

7. Discussion and recommendations for the future

7.1 Effects of seismic activity on cetaceans

Dolphins were apparently more strongly affected by the seismic activity than the larger whales were. Numbers of sightings of white-beaked dolphins and white-sided dolphins decreased during periods of shooting. Although this result was only statistically significant for white-beaked dolphins, reference to previous analysis of a subset of the data suggests that the lack of significance for white-sided dolphins may be attributable to poor weather conditions, and therefore poor observation conditions, sometimes experienced during periods when not shooting (Stone 1996). Fin whale abundance, on the other hand, was not adversely affected by seismic activity. This situation is perhaps surprising as large whales use low frequency sounds for communication which overlap with the frequencies produced by the airguns, while dolphins use much higher frequencies. Fin whales use frequencies from 10-750 Hz with dominant frequencies for moans at 20 Hz, as well as higher frequency chirps, clicks and whistles ranging up to 31 kHz; white-beaked dolphins and white-sided dolphins whistle at dominant frequencies of 8-12 and 6-15 kHz respectively (Evans & Nice 1996, from various sources). Airguns generally produce frequencies of 1-200 Hz, well below the frequencies used by dolphins, although it is recognised that they also emit higher frequencies. Goold (1995) found that airgun acoustic emissions contain high frequency components which are probably audible to dolphins several kilometres away from the source. Reports of dolphins being disturbed by seismic activity are rare but not unknown - Goold (1996) found that populations of common dolphins in St. George's Channel were temporarily disturbed by seismic activity.

Pilot whales and killer whales are, like the dolphins, odontocetes; they use frequencies which are higher than those of baleen whales, but also lower than those of dolphins. Dominant frequencies are 1.6-6.7 kHz for pilot whales and 1-25 kHz for killer whales (Evans & Nice 1996, from various sources). Neither species suffered lowered abundance as a result of seismic activity.

The fact that fin whale sightings were significantly more frequent when the airguns were firing may lead to speculation that they were attracted by the seismic activity. However, such speculation would be premature while the possibility remains that the higher numbers recorded during periods of shooting reflect calmer weather conditions then. Daily recording of weather conditions on future surveys (see section 7.3) would allow this possibility to be either eliminated or confirmed.

It is a natural assumption that if cetaceans are disturbed they will move away, resulting in decreased abundance. However, disturbance may be manifested in other, more subtle, ways. Studies of baleen whales, mainly bowhead whales and gray whales, have demonstrated subtle responses to seismic activity, such as changes in their blow intervals or dive times (e.g. Richardson *et al.* 1985). Responses other than decreased abundance were also found in the 1996 seismic surveys. Both fin whales and white-sided dolphins were seen at greater distances from the airguns during periods of shooting. This may indicate that seismic activity was indeed having some effect on these species, even though abundance was not significantly lowered. The relative reluctance of cetaceans to swim towards the ship or to cross its path, and the scarcity of positive interactions with survey vessels when shooting as compared with not shooting, also indicates that the seismic activity caused some disturbance to cetaceans.

It is not clear what may represent a distance at which cetaceans are tolerant of seismic activity. That two pods of fin whales and one humpback whale were seen feeding during a period of shooting at distances of 3 km and 4 km from the airguns may indicate that disturbance of baleen whales is negligible at such distances. The distance at which dolphins are tolerant of seismic activity may be closer than for baleen whales, as high frequency sounds attenuate more rapidly with distance from the source than low frequency sounds. Goold (1996) found some evidence that common dolphins were tolerant of seismic emissions outside a 1 km radius. The distance at which cetaceans are tolerant of seismic activity is likely to vary depending on factors such as water depth and sea floor topography, which affect the propagation of seismic emissions.

It is difficult to assess the level of disturbance caused by seismic activity. There were some indications that cetaceans may have been tolerant of seismic activity at greater distances from the source, and there were some indications that disturbance may have been reduced in deep water. The rapid appearance of dolphins in survey areas in between periods of shooting indicates that disturbance to dolphins was only temporary.

Many species were seen in numbers too low to assess the effects of seismic activity on them. Continued collection of data during seismic surveys is necessary to increase sample sizes and further our understanding of the effects of seismic activity on cetaceans. Until the effects of seismic activity on different species and the influence of factors such as depth are better understood it is important that the *Guidelines for minimising acoustic disturbance to small cetaceans* are followed.

7.2 Recommendations for further training of observers

As with all cetacean surveys, positive identification proved difficult at times. However, following a training seminar early in 1996 identification ability was improved from 1995 levels; 57.1% of sightings were identified to species level in 1996, compared to 42.8% in 1995 (1996 figure excludes experienced cetacean observers on board two survey vessels). There is still room for further improvement, particularly in identifying difficult cases as far as a pair or group of similar species e.g. humpback or sperm whale, white-beaked or white-sided dolphin. Further training should aim to improve this particular identification skill, as well as providing a refresher course in characteristic features of the individual species.

Further training should also stress the importance of completing the "Location and effort" forms. These forms were completed correctly for 60% of the surveys, which is pleasing for their first year of use. "Location and effort" forms were not used for most of the remaining surveys (some of these surveys were prior to the main distribution of forms in March), and were completed incorrectly for a small number of surveys. The most usual error was that effort was only recorded for days when cetaceans were seen, and not for other days of the survey. Further training and clearer instructions on the form (see section 7.3) should clarify this misunderstanding.

7.3 Recommendations for revisions to recording forms

Proposed revised recording forms are presented in Appendix 3. The main revision proposed is to move weather details from the "Record of sighting" form to the "Location and effort form". A simple assessment of the weather for each day should enable the influence of weather on the number of sightings in relation to seismic activity to be assessed (see section 6.1). As fishery liaison officers, who usually also act as cetacean observers, regularly record weather details it is envisaged that this will not create an undue burden.

Other proposed revisions to the recording forms are minor, and are concerned with clarifying the forms. There is a need for clearer instruction on the "Location and effort" form to complete this form each day, regardless of whether cetaceans are seen or not. This is particularly important in ensuring that these forms are completed correctly by observers who have been unable to attend a training seminar. "Record of sighting" forms were generally completed correctly. One common omission was that some observers did not record the distance of cetaceans from the airguns when the guns were not firing, presumably believing this information to be irrelevant. There were sufficient observers who did record this information to enable comparisons of distance in relation to seismic activity to be made, but clarification on the form should increase the number of observers reporting this information.

It is hoped that the revisions to the recording forms, in the light of one year's experience of using them, will make them as self-explanatory as possible, thereby further increasing the quality of data recorded.

7.4 Compliance with guidelines

The conditions and restrictions attached to blocks licensed in the 16th round of offshore licensing require that seismic exploration shall be conducted in accordance with the *Guidelines for minimising acoustic disturbance to small cetaceans*. In addition to operating in a way that will minimise disturbance, the guidelines require operators to contact JNCC when planning a seismic survey to determine the likelihood that cetaceans will be encountered, and to send a report to JNCC after the survey. There were a total of 29 seismic surveys in blocks licensed in the 16th round for which JNCC received notifications and/or reports during 1996. Of these, 11 surveys were both notified and reported to JNCC, five surveys were notified to JNCC but reports were not forwarded, and 13 surveys were reported with no prior notification (Figure 28).

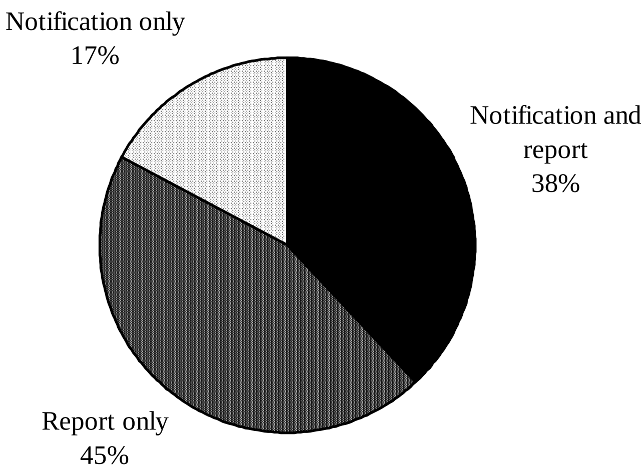

Figure 28 Proportion of seismic surveys being notified and/or reported to JNCC.

At present JNCC receives most notifications as copies of form CSON35 or PON14 and/or as letters, usually from the operator but occasionally from the contractor. Reports arrive from a variety of sources: from operators (either environmental or geophysics departments), contractors, environmental consultants, fishery liaison officers or faxed direct from the ship. Clearly there is a need to improve the notification and reporting procedures, particularly the notification of surveys.

No comments were received about the ease of use, or otherwise, of the guidelines in their current form. It is assumed, therefore, that no problems have been encountered whilst complying with the guidelines.

7.5 Considerations for future revisions to guidelines

It is proposed that the *Guidelines for minimising acoustic disturbance to small cetaceans* should remain as they are for 1997. Further data collected during future seismic surveys and from other projects may add to the present knowledge of the effects of seismic activity on cetaceans, enabling appropriate revisions to be made.

There are some points in the current version of the guidelines that are potentially ambiguous and require clarification in future versions. In their current form the guidelines state that a visual check should be made for cetaceans "before starting a survey line", and if cetaceans are present "the start of the survey" should be delayed. This should be revised to ensure that a check for cetaceans is made "at any time when the airguns are about to be fired", whether at the start of a survey line or not, and that "firing" should be delayed if cetaceans are present. The visual check for cetaceans is based on a radius of 500 metres - for this to be effective it is necessary for observers to be on board the seismic survey vessel rather than on the chase boat, and this point should also be addressed in future revisions to the guidelines.

At present the guidelines are aimed primarily at small cetaceans; it is likely that in future reduction of disturbance to larger whales will need to be considered. It is difficult to assess the level of disturbance to larger whales - abundance does not appear to be adversely affected, but there are some indications of more subtle responses (see section 7.1). The practical operation of the guidelines currently centres around a visual check for cetaceans within a 500 m radius. This may be insufficient for large whales, which can remain submerged for long periods and may be affected by low frequency seismic emissions propagating over considerable distances.

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10. Appendices

Appendix 1	Guidelines for minimising acoustic disturbance to small cetaceans
Appendix 2	Cetacean recording forms used in 1996
Appendix 3	Proposed revised recording forms for 1997 and guide to using recording forms
Appendix 4	Scientific names of species mentioned in text

Appendix 1

Guidelines for minimising acoustic disturbance to small cetaceans

GUIDELINES FOR MINIMISING ACOUSTIC DISTURBANCE TO SMALL CETACEANS

Precautions to reduce the disturbance caused by seismic surveys

Seismic surveys at sea do not necessarily constitute a threat to cetaceans, if care is taken to avoid contact with the animals.

When a seismic survey is being planned, operators should:

- Contact the Joint Nature Conservation Committee (see Annex for address) to determine the likelihood that cetaceans will be encountered. In sensitive areas, the JNCC may request precautions in addition to those outlined below (for example, the special conditions attached to some oil and gas licences). If recommended or requested, operators are encouraged to allow observers to be placed on board vessels involved in surveys.

- If advised to do so by the Joint Nature Conservation Committee, discuss the precautions which can be taken to reduce disturbance, and the design of any scientific studies with the Sea Mammal Research Unit (see Annex for address). In areas where cetaceans are abundant, properly conducted observation and recordings carried out before, during and after the seismic survey can provide valuable information on its effect.

- Operators should plan surveys so that the timing of such surveys will reduce the likelihood of encounters with cetaceans, although at present there is limited information on cetacean distribution in some areas.

- Operators should seek to reduce and/or baffle unnecessary high frequency noise produced by air-guns.

When conducting a seismic survey, the following guidelines should be followed:

- Before starting a survey line, operator and observers should carefully make a visual check to see if there are any cetaceans within 500 metres, using the cues mentioned later in these guidelines to detect their presence. Hydrophones and other listening equipment may provide additional information on the presence of inconspicuous species, such as harbour porpoises or submerged animals and should be used whenever possible. This will be particularly appropriate in poor weather, when visual evidence of cetacean presence cannot be obtained.

- If cetaceans are present, the start of the survey should be delayed until the cetaceans have moved away, allowing adequate time after the last sighting (20 minutes) for the animals to move well out of range. Hydrophones may also be useful in determining when cetaceans have moved out of range i.e. when they can no longer be heard.

- Where equipment allows, power should be built up slowly from a low energy start-up over 20 minutes to give adequate time for cetaceans to leave the vicinity.

- Throughout the survey, the lowest practicable energy levels should be used.

Report after the survey

A report detailing cetaceans sighted (standard forms are available from JNCC), the methods used to detect and deter cetaceans, problems encountered, and any other comments will help increase our knowledge and allow us to improve these guidelines in the light of experience.

Reports should be sent to the JNCC (see Annex for address). It would be helpful if reports include the following information:

- Date and location of survey

- Nature of air-gun discharge frequency and intensity

- Number and types of vessels involved in the survey

- Details of any problems encountered during cetacean detection/deterrence procedures, or during the survey

- Cetacean sightings (using standard forms)

- Details of watches made for cetaceans and the seismic activity during watches (using standard forms)

- Reports from any observers on board

Background to the guidelines

These guidelines reflect principles which could be used by anyone planning marine operations that could cause acoustic and physical disturbance to cetaceans. The recommendations contained in the guidelines should assist in ensuring that all cetaceans in areas of proposed seismic survey activity are protected against possible injury, and disturbance to small cetaceans is minimised.

The guidelines were originally prepared by a Working Group convened at the request of the Department of the Environment, developed from a draft prepared by the Sea Mammal Research Unit for a scientific survey conducted by the British Geological Survey in Cardigan Bay in 1992. The Group was chaired by the head of the Sea Mammal Research Unit and included representatives of the Joint Nature Conservation Committee, Department of Trade and Industry, Fisheries Departments, Ministry of Defence and the British Geological Survey.

Further consultation involved other Government departments: English Nature, the Countryside Council for Wales, Scottish Natural Heritage and the oil and gas industry, through the UK Offshore Operators' Association. Voluntary conservation organisations were also consulted. The guidelines have been reviewed by the Joint Nature Conservation Committee in the light of experience after their use in the 1994/95 round of surveys.

Please note: As these guidelines are concerned with reducing risks to cetaceans, all other notifications should be given as normal.

Existing protection

Section 9 of the Wildlife and Countryside Act 1981 prohibits deliberate killing, injuring or disturbance of any cetacean. This reflects the requirements of the Convention on the Conservation of European Wildlife and Habitats (the Bern Convention) and Article 12 of the EC Habitats and Species Directive (92/43/EEC), implemented by The Conservation (Natural Habitats, &c.) Regulations 1994.

In addition, the UK is a signatory to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas and has applied its provisions in all British waters. Amongst other actions required to conserve and manage populations of small cetaceans, the Agreement requires range states to "work towards....the prevention of ...disturbance, especially of an acoustic nature".

Cetacean presence in British waters

Records indicate there may be 22 species of cetacean either resident in, or passing through, Britain's waters. There are 9 regular visitors seen in coastal waters, the most common species of which are harbour porpoise, white-beaked dolphin, bottlenose dolphin and common dolphin; the most common seen in deeper offshore seas are the long-finned pilot whale, common dolphin, harbour porpoise and killer whale.

Cues for detecting the presence of cetaceans

Even when quite close to vessels, cetaceans are often difficult to detect. The following points should help in ensuring that an adequate search has been made.

- Seismic operators should allow adequate time for sightings to be made once vessels have arrived in an area where testing is to take place.

- The ease of detecting cetaceans declines with increasing sea state, so care should be taken to ensure an adequate search has been made in the prevailing conditions.

- Searches should be made from a high vantage point with a clear all-round view, e.g. the bridge roof or crow's nest. If necessary use two or more vantage points to give an all-round view.

- The sea should first be scanned slowly with the naked eye and then scanned slowly with binoculars.

- Hydrophones are a useful aid to detecting cetaceans. Cetaceans communicate with each other using whistles, creaks, chirps and moans which may be heard over considerable distances. Trains of clicks are used for echolocation and while foraging. They may be heard with a hydrophone at distances of several kilometres. In areas which are known to be frequented by small cetaceans, any hydrophones used should be capable of receiving the high frequency sounds used by these animals.

- Submerged cetaceans are much more at risk than those on the surface. This makes it particularly important to use a hydrophone whenever possible to detect animals that may be invisible from the surface.

- Dolphins and porpoises generally surface 2-3 times per minute in order to breathe. Dive times and surfacing behaviour are more erratic when they are feeding, but most dives are unlikely to exceed 5 minutes.

- Splashes may be a cue to the presence of cetaceans, although in seas rougher than sea state 2 cetacean splashes may be difficult to detect and distinguish from wave splashes.

- Blows of larger whales may be more obvious, but still may be difficult to detect in strong winds.

- Some species may be attracted to boats from some distance away, probably by engine noise. They may accompany a vessel for a considerable period and even bowride if it is fast-moving. If possible, look over the bow of the ship to check for cetaceans close in to the ship which may be hidden from view from the normal vantage points. The arrays of hydrophones which are towed by survey vessels may also be attractive to dolphins.

- Feeding seabirds can sometimes be evidence of the presence of cetaceans. Species which are likely to associate with cetaceans include gannets, kittiwakes and Manx shearwaters, although any flock of birds should be checked for the possible presence of cetaceans.

- An oily slick at the sea surface may signify the presence of cetaceans. These slicks may also be attractive to birds such as fulmars and storm petrels.

Cetaceans are capable of brief swimming speeds of 30 knots (34 mph), and sustained movement at 8 knots (10 mph). If disturbed, they may alter their heading rapidly.

Seismic surveys

Modern large-scale surveys are conducted using towed arrays of "air-guns" - cylinders of compressed air. Each cylinder contains a small volume (typically between 10 and 100 cubic inches) at a pressure of about 2000 psi. The array, typically containing some tens of such cylinders, is discharged simultaneously, to generate a pressure pulse which travels downwards into the sea bed. Some of this acoustic energy is emitted into the wider marine environment; however, the designers of air-gun arrays seek to maximise the transmission of energy into the sea bed, with the result that the energy dissipated into the wider environment is minimal. As a survey proceeds, the air-gun array is recharged with air from a compressor on board the towing vessel. The process is repeated at intervals of a few seconds - the timing dependent on the depth of the subsurface structures being investigated.

Potential effects of acoustic disturbance on cetaceans

The most prevalent form of acoustic disturbance in British waters is probably the noise generated by boats; however, the noise caused by boat traffic is so widespread that many cetacean populations may have become used to it. The limited research on the effects of disturbance due to the passage of vessels shows there is some evidence that cetaceans will avoid approaching ships and alter migration routes in response to marine traffic.

Effects of seismic surveys

The extent to which seismic disturbance affects cetaceans is not known for certain, since only a limited amount of research has been done (see Annex for further details). Most published research relates to the effect on large whales of older air-gun arrays, which were different from those currently in use.

Seismic air-guns are designed to produce low frequency noise used to build up a picture of the seabed. However, recent research has shown that high frequency noise is also produced (Goold 1996a). Low frequency noise is more likely to disturb baleen whales than toothed dolphins; baleen whales communicate at frequencies mostly below 3kHz, which are likely to overlap with the dominant frequencies used by seismic air-guns. The sensitivity of toothed dolphins to sound falls sharply below 1kHz, and sounds below 0.2kHz are probably inaudible to them. The sounds used by dolphins for communication are above 4.8kHz, and echolocation sounds can occur up to 200kHz. Goold (1996a) found significant levels of energy across the recorded bandwidth up to 22 kHz. This high frequency noise, incidental to seismic operations, will overlap with the frequencies used by toothed dolphins, and could potentially cause disturbance. There is some evidence of dolphins temporarily avoiding areas where seismic testing is taking place (Goold 1996b).

Seismic testing could have a number of different effects on small cetaceans: it may interfere with communication or alter behaviour. In the worst case, there is some risk of physical damage in the immediate vicinity of air-guns, although there is no evidence to suggest that injury has occurred to any cetacean in British waters as a result of seismic testing. Seismic surveys may have indirect effects on local cetacean populations because of changes they may cause in the distribution of prey species.

The risk to cetaceans is increased by their natural inquisitiveness, and the fact that they may be attracted to areas of human activity where seismic testing is about to take place.

Further information and comments on these guidelines

If you have any comments or questions on these guidelines, or suggestions on how they may be improved, please contact:

Mark Tasker
Joint Nature Conservation Committee
Seabirds and Cetaceans Branch
Dunnet House
7, Thistle Place
ABERDEEN
AB10 1UZ

Telephone 01224 655701
Fax 01224 621488

ANNEX

CONTACT NAMES AND ADDRESSES

Trevor Salmon
Department of the Environment
European Wildlife Division (TG 9/02)
Tollgate House
Houlton Street
BRISTOL BS2 9DJ

Telephone 0117-987 8854
Fax 0117-987 8642

(And, if requested to contact the Sea Mammal Research Unit)

Dr John Harwood
Sea Mammal Research Unit
Gatty Marine Laboratory
University of St. Andrews
St. Andrews
FIFE
KY16 8LB

Telephone 01334-462630
Fax 01334-462632

FURTHER INFORMATION

Davis *et al.* (1990: State of the Arctic Environment, Report on Underwater Noise. Prepared by LGL Ltd, PO Box 280, King City, Ontario, Canada L0G 1K0 for the Finnish Initiative on Underwater Noise) provides a useful summary of the available scientific information of the possible effects of acoustic disturbance on cetaceans.

Environmental Guidelines for Exploration Operations in Nearshore and Sensitive Areas, published by the UK Offshore Operators Association, 3 Hans Crescent, London SW1X 0LN.

Goold, J.C. 1996a. Broadband characteristics and propagation of air gun acoustic emissions in the southern Irish Sea. Journal of the Marine Biological Association (in press).

Goold, J.C. 1996b. Acoustic assessment of populations of common dolphin *Delphinus delphis* in conjunction with seismic surveying. Journal of the Marine Biological Association (in press).

Moscrop, A. & Simmonds, M. 1994. The threats posed by noise pollution and other disturbances to the health and integrity of cetacean populations around the UK. A report for the Whale and Dolphin Conservation Society, pp. 1-8. (Includes a review of work on acoustic disturbance of cetaceans). Available from the Whale and Dolphin Conservation Society, Alexander House, James Street West, Bath, Avon, BA1 2BT.

Richardson, W.J., Fraker, M.A., Würsig, B. & Wells, R. 1985. Behaviour of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: reactions to industrial activities. Biological Conservation 32: 195-230.

Turnpenny, A.W.H. & Nedwell, J.R. 1994. The Effects on Marine Fish, Diving Mammals and Birds of Underwater Sound Generated by Seismic Surveys, Fawley Aquatic Research Laboratories Ltd, Fawley, Southampton SO45 1TW. (This includes an extensive further bibliography). Available from United Kingdom Offshore Operators Association, 3 Hans Crescent, London, SW1X 0LN.

USEFUL CETACEAN IDENTIFICATION GUIDES:

Cawardine, M. 1995. Eyewitness handbooks - Whales, dolphins and porpoises. Dorling Kindersley. ISBN 0-7513-1030-1. Price £14.99. Available from bookshops.

Evans, P.G.H. 1995. Guide to the identification of whales, dolphins and porpoises in European seas. Sea Watch Foundation Publication, Oxford. Available from Sea Watch Foundation, Unit 29, Southwater Industrial Estate, Station Road, Southwater, West Sussex RH13 7UD. Price £5.00 + 50p p&p.

Leatherwood, S. & Reeves, R.R. 1983. The Sierra Club handbook of whales and dolphins. Sierra Club Books, San Francisco. ISBN 0-87156-341-X (hardback) ISBN 0-87156-340-1 (paperback). Available from some bookshops.

Sea Watch Foundation / BBC Wildlife 1994. Identification guide to whales and dolphins of the British Isles. Laminated wall chart available from Sea Watch Foundation Publication, Oxford. Available from Sea Watch Foundation, Unit 29, Southwater Industrial Estate, Station Road, Southwater, West Sussex RH13 7UD. Price £2.95 + £1.00 p&p.

Appendix 2

Cetacean recording forms used in 1996

CETACEAN RECORDING FORM - LOCATION AND EFFORT DATA

Ship .... Ship type (seismic/guard etc.) ....

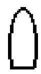
Please record the following information for each day.

Date	Observer	Block number	Number of daylight hours during which a watch for cetaceans was kept	Length of time seismic guns were shooting during the day

Return to: JNCC, Thistle House, 7, Thistle Place, Aberdeen, AB1 1UZ.

CETACEAN RECORDING FORM - RECORD OF SIGHTING

Options in italics should be circled or underlined as appropriate

<table>
<tr><td colspan="2">Date</td><td colspan="2">Time</td></tr>
<tr><td colspan="2">Ship</td><td colspan="2">Observer</td></tr>
<tr><td colspan="3">Position</td><td>Depth (if known)</td></tr>
<tr><td colspan="2">Species</td><td colspan="2">Certainty of identification
Definite / probable / possible</td></tr>
<tr><td colspan="2">Total number</td><td colspan="2">Number of adults
Number of juveniles</td></tr>
<tr><td colspan="3" rowspan="2">Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow)</td><td>Photograph or video taken
Yes / No</td></tr>
<tr><td>Direction of travel of cetaceans in relation to ship (draw arrow)
</td></tr>
<tr><td colspan="3">Behaviour</td><td>Direction of travel of cetaceans (compass points)</td></tr>
<tr><td>Activity of ship</td><td colspan="2">Airguns firing
Yes / No</td><td>Distance of cetaceans from airguns (metres)</td></tr>
<tr><td>Wind direction and force</td><td colspan="2">Sea state
Calm / Rippled / Slight / Choppy / Rough</td><td>Visibility
Poor / Moderate / Good</td></tr>
</table>

Please continue overleaf or on a separate sheet if necessary

Return to: JNCC, Thistle House, 7, Thistle Place, Aberdeen, AB1 1UZ.

Appendix 3

Proposed revised recording forms for 1997 and guide to using recording forms

CETACEAN RECORDING FORM - LOCATION AND EFFORT DATA

Ship .... Ship type (seismic/guard etc.) ....

Please record the following information every day, regardless of whether cetaceans are seen or not.

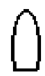
Date	Observer	Block number	Number of daylight hours during which a watch for cetaceans was kept	Length of time seismic guns were shooting during the watch	Wind force (Beaufort) and direction	Sea state Choose from: G = glassy S = slight C = choppy R = rough	Visibility Choose from: P = poor M = moderate G = good

Return to: JNCC, Dunnet House, 7 Thistle Place, Aberdeen, AB10 1UZ (Fax. 01224 621488).

CETACEAN RECORDING FORM - RECORD OF SIGHTING

Options in italics should be circled or underlined as appropriate

<table>
<tr><td colspan="2">Date</td><td colspan="2">Time (GMT)</td></tr>
<tr><td colspan="2">Ship</td><td colspan="2">Observer</td></tr>
<tr><td colspan="3">Position</td><td>Depth (metres)</td></tr>
<tr><td colspan="2">Species</td><td colspan="2">Certainty of identification
Definite / probable / possible</td></tr>
<tr><td colspan="2">Total number</td><td colspan="2">Number of adults

Number of juveniles</td></tr>
<tr><td colspan="3" rowspan="2">Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow)</td><td>Photograph or video taken
Yes / No</td></tr>
<tr><td>Direction of travel of cetaceans in relation to ship (draw arrow)
</td></tr>
<tr><td colspan="3">Behaviour</td><td>Direction of travel of cetaceans (compass points)</td></tr>
<tr><td>Activity of ship</td><td colspan="2">Airguns firing
Yes / No</td><td>Closest distance of cetaceans from airguns (metres)
(Record even if not firing)</td></tr>
</table>

Please continue overleaf or on a separate sheet if necessary

Return to: JNCC, Dunnet House, 7 Thistle Place, Aberdeen, AB10 1UZ (Fax. 01224 621488).

GUIDE TO USING CETACEAN RECORDING FORMS

There are two forms to be completed: one contains basic information on where you looked for cetaceans and how long you looked for ("Location and Effort Data"), the other contains information on each sighting of cetaceans ("Record of Sighting").

Location and Effort Data

One line on the "Location and Effort" form should be filled out for each day, regardless of whether you actually see any cetaceans or not. This form includes basic information e.g. date, observer's name, block number and weather. You will need to note the number of daylight hours over which a watch was kept and how long the airguns were firing during the watch (this should include any times when the guns were firing e.g. during the run-in to a line or when being tested, as well as the time spent shooting a line). This information is important to assess the effects of seismic activity on cetaceans without bias. Wind force should be on the Beaufort scale (1-12), e.g. W 5. If you record it as speed in knots please make this clear, e.g. W 19 knots, so that we can convert it to Beaufort later. Visibility should be recorded as poor, moderate or good (poor = less than 1 km [½ mile]; moderate = 1-5 km [½ - 3 miles]; good = more than 5 km [3 miles]).

Record of Sighting

The sighting form need only be filled out when you see cetaceans. Most of the details you are asked to record are self-explanatory, but notes on some items are given below for clarification.

Position This is the position at the time of the sighting.

Depth This should be in metres - if it is in any other unit e.g. fathoms, please specify this.

Species Identify cetaceans as far as possible - if you cannot identify it to species level then put down what you can. For example, if you know it's a whale not a dolphin, but you can't tell what sort of whale, put down "whale". Useful categories are "whale", "large whale", "medium whale", "small whale", "dolphin", "patterned dolphin", "unpatterned dolphin" or groups of species of similar appearance e.g. "blue/fin/sei whale", "white-beaked/white-sided dolphin", "common/striped/white-sided dolphin" etc. It can also be useful to eliminate species that you know it definitely isn't e.g. "medium-sized whale but not killer whale".

Total number If it is difficult to tell exactly how many cetaceans there are this can be an estimate of the minimum and maximum number, e.g. 5 - 8.

Number of adults / Number of juveniles If it is difficult to tell how many of each age there are this can be an estimate of the minimum e.g. at least 3 adults, at least 2 juveniles.

Description It is useful to include a description of the animal, even if you are certain which species it is. If you are certain which species it is, describe the characteristic features you used to identify it e.g. "hourglass pattern on flanks" for common dolphin. If you are uncertain, then the more details you give, the better. Features to describe are suggested on the form. A rough sketch may be useful (e.g. of the shape of fin, or pattern of colour); this could be drawn on the back of the form if more space is needed.

Photograph or video taken If you have the opportunity to photograph or video the animal this may be used later to help in identification.

Direction of travel of cetaceans The direction of travel should be given in two ways - in relation to the boat, and in points of the compass.

Behaviour If there is more than one sort of behaviour then record all behaviours seen. Examples of behaviour are:

- normal swimming
- fast swimming
- porpoising
- breaching (animal launches itself out of the water and falls back in)
- tail-slapping (animal slaps tail on the water surface)
- sky-pointing (animal almost vertical in the sea with its head pointing towards the sky)
- feeding
- resting
- avoiding the ship
- approaching the ship
- bow-riding
- or any other behaviour you see.

Activity of ship e.g. steaming, on standby, deploying streamers, shooting a line, etc.

Airguns firing This is important information - even if you think it's obvious from the activity of the ship, please fill in whether the airguns were firing or not when the cetaceans were seen.

Closest distance of cetaceans from airguns This should be filled in whether or not the airguns are firing when cetaceans are seen. If the airguns are not out, then use the closest distance to the ship instead.

If you have any queries regarding the use of these forms, please contact the JNCC (address below).

The forms should be returned to:

[*Oil company name*]
[*Oil company address*]

or if unsure to:

Joint Nature Conservation Committee,
Seabirds and Cetaceans Team,
Dunnet House,
7 Thistle Place,
Aberdeen,
AB10 1UZ.

Tel.	01224 655704
Fax.	01224 621488

Appendix 4

Scientific names of species mentioned in text

Bowhead whale	*Balaena mysticetus*
Gray whale	*Eschrichtius robustus*
Minke whale	*Balaenoptera acutorostrata*
Fin whale	*Balaenoptera physalus*
Sei whale	*Balaenoptera borealis*
Blue whale	*Balaenoptera musculus*
Humpback whale	*Megaptera novaeangliae*
Sperm whale	*Physeter macrocephalus*
Northern bottlenose whale	*Hyperoodon ampullatus*
Killer whale	*Orcinus orca*
Pilot whale	*Globicephala melas*
Risso's dolphin	*Grampus griseus*
Bottlenose dolphin	*Tursiops truncatus*
White-beaked dolphin	*Lagenorhynchus albirostris*
White-sided dolphin	*Lagenorhynchus acutus*
Common dolphin	*Delphinus delphis*
Striped dolphin	*Stenella coeruleoalba*
Harbour porpoise	*Phocoena phocoena*