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Marine mammal observations during seismic surveys in 2000

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Comments: Observations of marine mammals seen during seismic surveys carried out in accordance with the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys (April 1998)* were forwarded to JNCC. This report presents an analysis of the data gathered.

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Contents

1. Summary

1. There were 467 sightings of marine mammals (9,258 individuals) during seismic surveys in UK waters and some adjacent areas in 2000. 12,069 hrs 40 mins were spent watching for marine mammals during seismic surveys in 2000.

2. The most frequently seen species were white-sided and white-beaked dolphins. Sperm whales, fin whales and minke whales were also seen with moderate frequency, with lower numbers of sightings of other species. Sightings of marine mammals peaked in August, with most occurring to the west of Shetland and in the northern North Sea, which reflected the location and timing of surveys.

3. After controlling for potential sources of bias (location, season, weather conditions) the sighting rate of white-sided dolphins was found to be significantly lower during periods of shooting (excluding during low power site surveys). Sighting rates of fin whales, sperm whales, white-beaked dolphins, all baleen whales combined and all dolphins combined did not differ significantly with seismic activity.

4. After controlling for weather conditions at the time of the sighting, white-beaked dolphins, white-sided dolphins and all dolphins combined were found to be significantly further from the airguns when they were firing than when they were silent (excluding site surveys).

5. Some effects of seismic activity on the behaviour of marine mammals were evident during seismic surveys (excluding site surveys). There was a decreased tendency for cetaceans to engage in feeding activity during periods of shooting. Positive interactions of cetaceans with the survey vessel or its equipment occurred significantly more often when the airguns were not firing. When all baleen whales, all dolphins or all cetaceans were combined, significantly fewer were found to be heading towards the vessel during periods of shooting. Similarly, significantly more dolphins were observed to be heading away from the vessel during periods of shooting.

6. Sample sizes were lower for site surveys than for surveys with larger airgun arrays. Where sample sizes were sufficient to permit statistical testing for site surveys, no effects of seismic activity on sighting rates of marine mammals or the distance they remained from the airguns were found. However, some low level disturbance was indicated on site surveys, as significantly fewer animals were observed heading towards the vessel during periods of shooting when all dolphins or all cetaceans were combined.

7. Sample sizes were low for many species, therefore the results should be treated with caution.

8. Both notification and a report were received by JNCC for 76% of seismic surveys taking place during 2000 (in blocks licensed in the 16th, 17th and 18th rounds of offshore licensing).

9. The use of dedicated marine mammal observers had increased slightly from previous years, but such observers were still only used on a minority of surveys. Where JNCC requested specific types of observers on surveys, these requests were complied with on 62% of occasions for the primary observer, but on only 41% of occasions for the secondary observer.

10. The duration of pre-shooting searches for marine mammals met or exceeded the required minimum of 30 minutes for 79% of occasions when the airguns were used during daylight hours in blocks where compliance with the guidelines was a licence condition (16th, 17th and 18th round blocks), which represents a decline in standards from previous years. This decline was mainly due to inadequate pre-shooting searches on site surveys, particularly where members of ships' crews were responsible for marine mammal observations.

11. Excluding site surveys, 95% of soft-starts met or exceeded the required minimum duration of 20 minutes in blocks where compliance with the guidelines was a licence condition. This represents an increase in standards from previous years.

12. For site surveys, soft-starts were mostly inadequate. Only 37% of soft-starts were of acceptable duration for site surveys in blocks where compliance with the guidelines was a licence condition.

13. Marine mammals were seen within 500 m of the airguns shortly before shooting was due to commence on seven occasions in blocks where compliance with the guidelines was a licence condition. The guidelines require that in such circumstances shooting should be delayed for a minimum of 20 minutes

after the animals are last seen; the subsequent soft-start should also last for a minimum of 20 minutes. On all seven occasions shooting was delayed for at least 20 minutes, but on one occasion the subsequent soft-start was too short. The proportion of delay situations where correct procedures were followed had increased from previous years.

14. For surveys with large airgun arrays, the guidelines were applied throughout all UK waters, not just in those blocks (16th, 17th and 18th round) where compliance with the guidelines is a licence condition. There was little difference in the standard of pre-shooting searches and soft-starts between blocks, and there was one instance of shooting being delayed outside 16th, 17th and 18th round blocks.

15. For site surveys there was a difference in the level of compliance with the guidelines according to the location of the survey. The standard of pre-shooting searches and soft-starts was lower outside 16th, 17th and 18th round blocks.

16. The main area of concern regarding compliance with the guidelines was site surveys. Standards of pre-shooting searches and soft-starts were low, and reports from site surveys were often missing or incomplete.

17. Differences were found in the level of compliance with the guidelines according to the type of observer used. Dedicated marine mammal observers provided the highest standard of pre-shooting searches, while fishery liaison officers showed a gradual improvement in the standard of their pre-shooting searches. Members of ships' crews were the least likely to perform an adequate pre-shooting search. There was considerable variation in the standard of soft-starts on site surveys according to the type of observer used; very few soft-starts were of adequate duration when either fishery liaison officers or members of ships' crews were acting as marine mammal observers.

18. There were also variations in the quality of observations according to the type of observer used. Dedicated marine mammal observers were more efficient at detecting marine mammals than other personnel. Dedicated marine mammal observers also made fewer errors when completing the recording forms, and their identification skills were better than those of other personnel. However, fishery liaison officers had improved both their ability to detect marine mammals and their identification skills from previous years. The ability of ships' crew members to detect marine mammals was very low.

19. The use of trained, dedicated marine mammal observers is recommended, both in terms of compliance with the requirements of the guidelines and the provision of high quality data. Sole reliance on members of ships' crews to carry out observations of marine mammals is the least effective alternative.

20. A number of items for consideration when the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* are next revised are noted.

2. Introduction

Marine mammals use sound to communicate and, in some cases, echolocate. The ability to detect calls from conspecifics, echolocation signals and other natural sounds is of paramount importance to them. Man-made sounds thus have the potential to interfere with their natural functions, such as feeding, social interactions (including breeding) and navigation, as well as having the potential to cause physical harm. Concern over the issue of acoustic disturbance to marine mammals has led to attention being focussed on seismic surveys as one of a number of potential sources of such disturbance. Seismic surveys use airguns to generate sound at low frequencies that overlap with those used by baleen whales; these species are therefore considered to be vulnerable to disturbance from seismic surveys. Although toothed whales and dolphins use higher frequency sounds for communication and echolocation, seismic operations incidentally emit high frequency sounds (Goold and Fish 1998), so these species may also be vulnerable to disturbance.

The Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) requires range states to work towards "the prevention of ... disturbance, especially of an acoustic nature". As part of the UK's response to ASCOBANS, in February 1995 the *Guidelines for minimising acoustic disturbance to small cetaceans* were published by the then Department of the Environment, following development work by the Joint Nature Conservation Committee (JNCC). These guidelines aimed to reduce disturbance to cetaceans from seismic surveys. Since their original publication, the guidelines have twice been revised by JNCC, with the latest revision (April 1998) applying precautionary measures to all marine mammals. This revision has been renamed the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* (Appendix 1). In March 2000 JNCC produced a *Guidance note on the implementation of the guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* (Appendix 1) to clarify some of the requirements of the guidelines.

The guidelines require operators to consult JNCC when planning a seismic survey (including site surveys) in UK waters and, if necessary, discuss precautions that can be taken to reduce disturbance. The timing of surveys should be planned to reduce the likelihood of encounters with marine mammals. Operators should provide appropriately qualified and experienced personnel to act as marine mammal observers on surveys in areas of importance for marine mammals. Prior to commencing any use of the seismic sources observers should make a careful check for the presence of marine mammals within 500 m. If any marine mammals are detected then shooting must be delayed until at least 20 minutes have elapsed since the last sighting. Whether marine mammals are detected or not, a soft-start procedure should be employed whenever possible, gradually building up the airgun power over at least 20 minutes from a low energy starting level. In addition, the lowest practicable energy levels should be used throughout the survey. Following the survey a report should be forwarded to JNCC, including details of the implementation of the guidelines, the time spent watching for marine mammals and any sightings that occurred. Standard forms designed and periodically revised by JNCC are available for this purpose (current versions of these are in Appendix 3). The results of the analysis of such data recorded during 2000 are presented here.

3. Methods

Watches for marine mammals were carried out throughout daylight hours on seismic survey vessels operating during 2000. Details of seismic (= airgun) activity, the watch for marine mammals and any sightings were recorded on standard recording forms (Appendix 2). Data were collected from 75 surveys within 103 quadrants (1^o x 1^o rectangle; Figure 1). 43 of these surveys were rig site surveys or similar surveys (pipeline, cable route, debris or anchor search surveys) using low power equipment; these surveys are hereafter collectively termed site surveys. Where airguns were used on site surveys the total volume was typically 140 cu. in. or less. The remaining 32 surveys were 2D, 3D, 4D and 4C surveys, where the total airgun volume often exceeded 3000 cu. in.

Observers were asked to provide descriptions of marine mammals to support their identification. Where descriptions were missing or inadequate, or did not correspond with the identification given, identifications were amended. This usually involved downgrading of identifications from one species to a group of similar species which the animal could have been. For example, if an observer identified a white-sided dolphin, but the description was of a "small animal with a sickle shaped fin", then this record would have been downgraded to dolphin sp., i.e. an unidentified dolphin.

Some of the analyses involved calculating numbers of sightings per unit effort (i.e. per 1,000 hours survey). For these analyses, only sightings from surveys where effort was correctly recorded were used (69% of surveys). There were several potential sources of variation in sighting rate: 1) geographical variation in abundance of marine mammals; 2) seasonal variation in abundance of marine mammals; 3) the influence of weather on the ability to detect marine mammals. The proportion of time spent shooting also varied according to location, season and weather conditions, so it was important to control for these potential sources of bias when assessing the effects of seismic activity. Therefore, for some aspects of the analysis, subsets of data from selected areas and months were used, and periods of poor weather were disregarded. Each quadrant was assigned to one of eight geographical areas (Figure 1). Weather conditions were recorded daily (or occasionally more frequently) by observers. Sea state was classed as 'glassy', 'slight', 'choppy' or 'rough', or defined according to the Sea Criteria of the World Meteorological Organisation (HMSO 1983). Swell was classed as 'low' (< 2 m), 'medium' (2-4 m) or 'large' (> 4 m), and visibility categorised as 'poor' (< 1 km), 'moderate' (1-5 km) or 'good' (> 5 km).

Sample sizes were small for many species. The extraction of subsets of data to eliminate bias further reduced sample sizes, so this was done only for species seen more frequently. Non-parametric statistical tests appropriate for small sample sizes were used (Siegel and Castellan 1988).

Species maps were drawn after summing the number of individuals of a species in each ¼ ICES square (15' latitude x 30' longitude). All maps were plotted using DMAP for Windows, and show the 1,000 m isobath (dashed line).

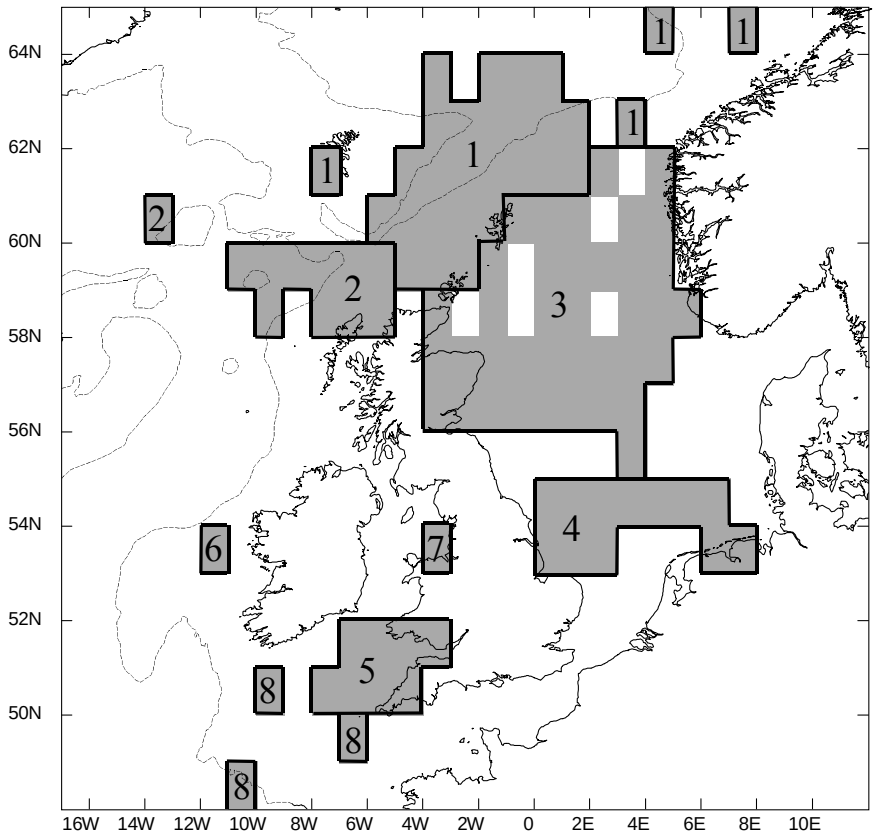


Figure 1 Quadrants surveyed for marine mammals from seismic survey vessels in 2000, and areas used in analysis: 1) West of Shetland; 2) Rockall; 3) Northern North Sea; 4) Southern North Sea; 5) St. George's Channel and Bristol Channel; 6) West of Ireland; 7) Irish Sea; 8) South-West Approaches.

4. An overview of marine mammal sightings and survey effort

There were 465 sightings of cetaceans (9,256 individuals) and two sightings of seals (two individuals) during 2000 seismic surveys (Table 1). 70% of sightings were identified to species level, and a further 14% were identified as being one of a pair or group of similar species.

Table 1 Summary of marine mammal sightings from seismic survey vessels in 2000

Species	*Number of sightings*	*Number of individuals*
Grey seal	2	2
Cetacean sp.	8	29
Whale sp.	20	21
Large whale sp.	2	2
Northern right whale (probable)	1	1
Humpback whale	1	1
Fin whale	33 [a]	89
Sei whale	5	5
Fin/ sei whale	2 [b]	4
Fin/ sei/ humpback whale	5	9
Fin/ sei/ blue/ humpback whale	8	24
Minke whale	21	21
Sperm whale	38 [c]	47
Humpback/ sperm whale	1	3
Medium whale sp.	5	6
Northern bottlenose whale	2	11
Pilot whale	13 [d,e]	1,146
Killer whale	12	78
Dolphin sp.	49 [d]	763
Dolphin sp. not porpoise	25	405
Risso's dolphin	5	14
Bottlenose dolphin	8	65
Unpatterned dolphin sp.*[1]	1	10
White-beaked dolphin	86 [f]	552
White-sided dolphin	94 [a,b,c,e,f,g]	5,277
Lagenorhynchus sp.*[2]	12	190
Common dolphin	2	12
Striped dolphin (possible)	3 [e,g]	224
Common/ white-sided dolphin	1	108
Common/ striped dolphin	2	22
Common/ white-sided/ striped dolphin	1	65
Patterned dolphin sp.*[3]	3	12
Harbour porpoise	9	40
Total	**467**	**9,258**

*[1] unpatterned dolphin = Risso's/ bottlenose dolphin

*[2] *Lagenorhynchus* sp. = white-beaked/ white-sided dolphin

*[3] patterned dolphin = white-beaked/ white-sided/ common/ striped dolphin

a includes 4 sightings of fin whales associated with white-sided dolphins

b includes 1 sighting of fin/ sei whales associated with white-sided dolphins

c includes 1 sighting of sperm whales associated with white-sided dolphins

d includes 3 sightings of pilot whales associated with dolphin sp.

e includes 1 sighting of pilot whales associated with white-sided dolphins and striped dolphins

f includes 1 sighting of white-beaked dolphins associated with white-sided dolphins

g includes 1 sighting of white-sided dolphins associated with striped dolphins

The most frequently seen species were white-sided and white-beaked dolphins. Sperm whales, fin whales and minke whales were seen with moderate frequency, with lower numbers of sightings of other species. Dolphins, pilot whales and killer whales usually occurred in groups (mean pod size = 88.15 for pilot whales, 6.50 for killer whales, 6.42 for white-beaked dolphins, 56.14 for white-sided dolphins). Baleen whales and sperm whales tended to occur either singly or in small groups (mean pod size = 2.70 for fin whales, 1.00 for

minke whales, 1.24 for sperm whales). Sightings of marine mammals peaked during the month of August (Figure 2).

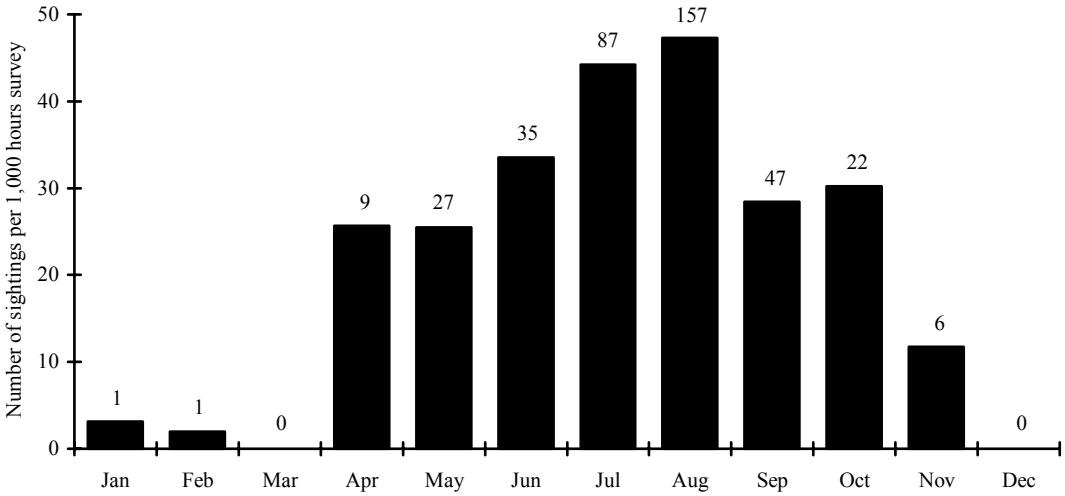


Figure 2 Sighting rates of marine mammals per month, with number of sightings (only includes surveys where effort was correctly recorded).

The length of time spent watching for marine mammals was summed for surveys where 'Location and Effort' recording forms were completed correctly (51.5 of the 75 surveys). Excluding site surveys, 8,424 hrs 01 min were spent watching for marine mammals, of which the airguns were firing for 3,008 hrs 45 mins (36% of the time on watch). During site surveys 3,645 hrs 39 mins were recorded as watching for marine mammals, of which the airguns were firing for 496 hrs 56 mins (14% of the time on watch). Although the majority of surveys during 2000 were site surveys, the time spent watching for marine mammals during site surveys equated to only 30% of the total time spent watching during all surveys (12,069 hrs 40 mins), reflecting the short duration of most site surveys. When the airguns were not firing the survey vessels were engaged in a variety of activities e.g. turning between survey lines, deploying, retrieving or carrying out maintenance on the airguns and streamers, waiting for weather conditions to improve, time-sharing with other seismic survey vessels, and steaming between survey areas and ports. In the case of site surveys, some of the periods when the airguns were not firing were occupied by analogue surveys for which airguns were not used, although various other items of equipment (e.g. side scan sonar, boomers and pingers) were used.

The time spent watching for marine mammals peaked in August, although the proportion of time spent shooting peaked in May and March (Figure 3). Most survey effort was concentrated in areas Northern North Sea and West of Shetland (Figure 4); in these areas and West of Ireland approximately one third of the time was spent shooting, while in other areas the proportion of time spent shooting was lower.

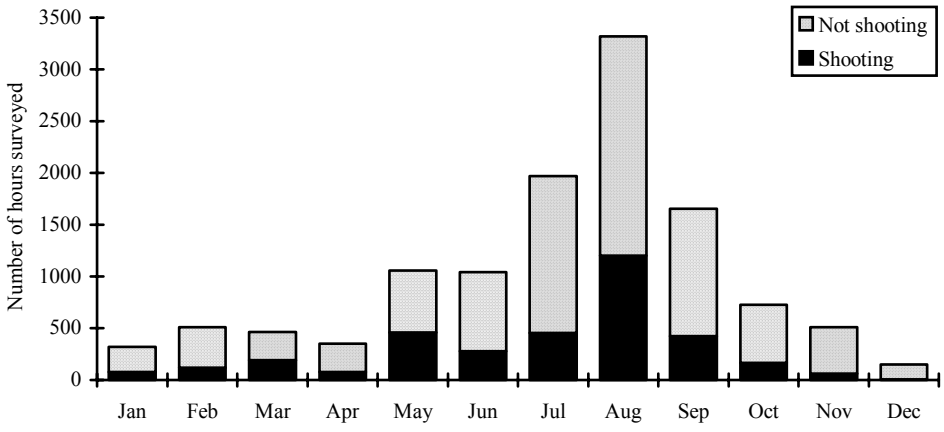


Figure 3 Length of time spent watching for marine mammals throughout 2000, and seismic activity during watches (all areas combined; only includes surveys where effort was correctly recorded).

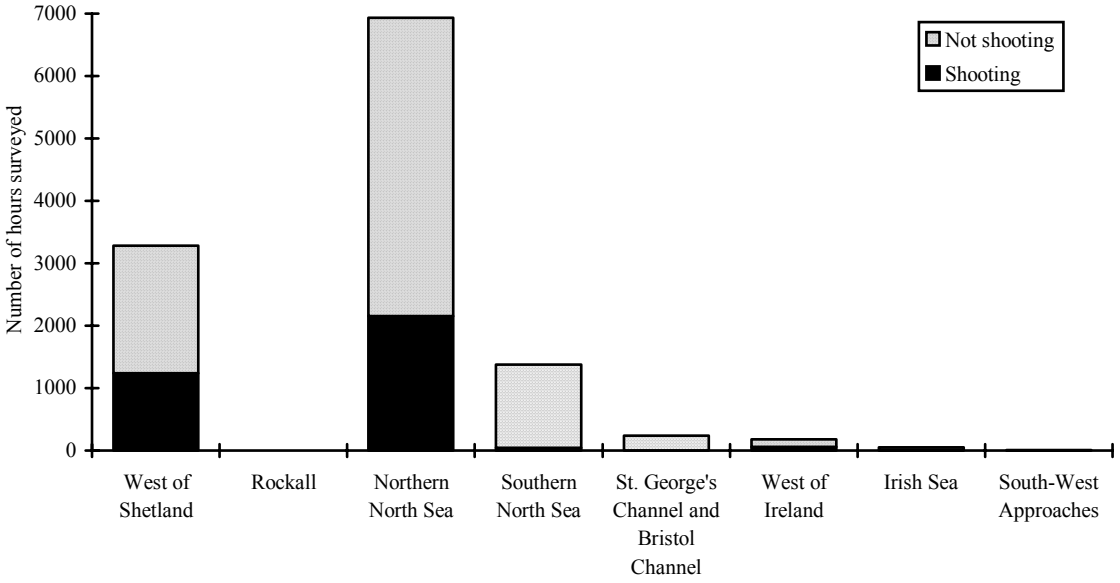


Figure 4 Length of time spent watching for marine mammals in each area, and seismic activity during watches (all months combined; only includes surveys where effort was correctly recorded).

Survey effort in the different areas varied throughout the year (Figure 5). Surveys in area West of Shetland did not commence until April and there were none after October, while those in the Northern North Sea were spread throughout the year. In the Southern North Sea there was no survey effort prior to May. In all three areas there was a peak in the proportion of time spent shooting in May, with additional peaks in October to the West of Shetland and in August in the Northern North Sea. In all other areas survey effort was low; effort was restricted to the summer months in the exposed areas of Rockall, West of Ireland and the South-West Approaches, while in the St. George's and Bristol Channels there were surveys in spring as well as summer. In contrast, the only survey reported from the Irish Sea took place in January.

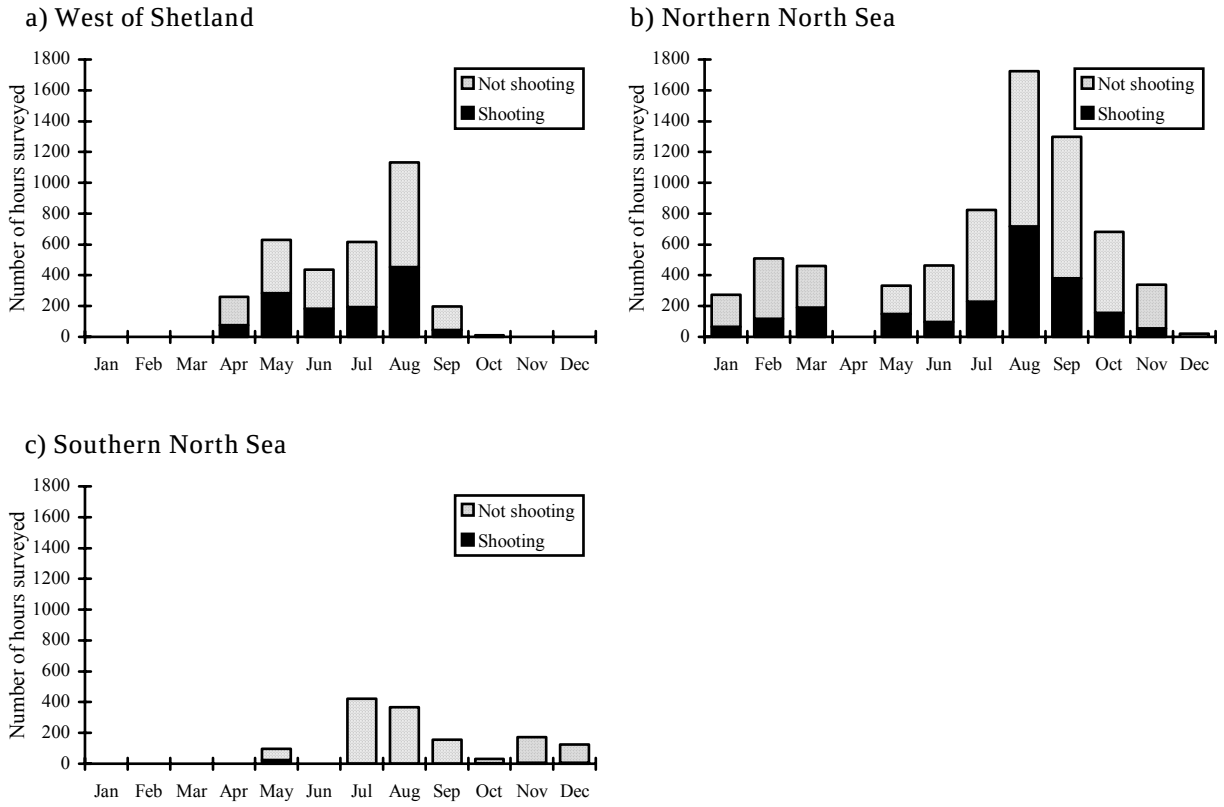


Figure 5 Comparison of survey effort throughout the year for the more frequently surveyed areas (only includes surveys where effort was correctly recorded).

Weather conditions varied considerably, ranging from calm conditions to winds of force 11 on the Beaufort scale. Most of the time spent watching for marine mammals was when sea states were categorised as 'slight', but the proportion of time spent shooting was greatest in 'glassy' sea states (Figure 6). The amount of time spent watching for marine mammals and the proportion of time spent shooting both peaked in conditions of 'low' swell and 'good' visibility.

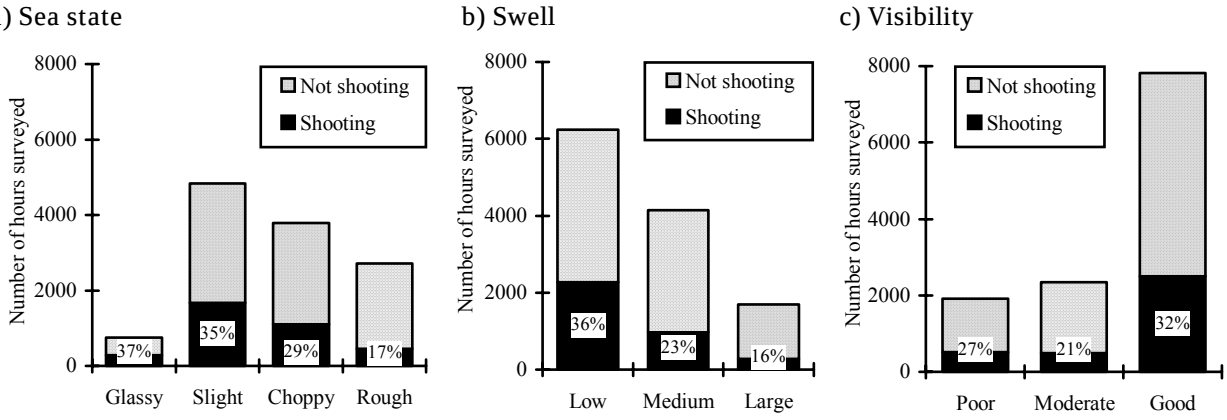


Figure 6 Length of time spent watching for marine mammals in different weather conditions in relation to seismic activity, with percentage of time spent shooting (only includes surveys where effort was correctly recorded).

5. Distribution of marine mammals

Sightings of marine mammals were concentrated in northern UK waters, in the northern North Sea and to the north and west of Shetland (Figure 7). Many sightings occurred in the deep waters of the Faroe-Shetland Channel, but there were also numerous sightings over the continental shelf slope and at the outer edges of the continental shelf. In the northern North Sea, the main cluster of sightings occurred to the east of Aberdeen.

Species maps for cetaceans (Figures 8 - 25) show some interspecific variations in distribution. The large whales (humpback, fin, sei, sperm, and a probable northern right whale; Figures 10, 11, 12, 14 & 9 respectively) were seen over deep water and the shelf slope to the north and west of Shetland, the only exception being one sighting of a fin whale in the northern North Sea. Sightings of northern bottlenose whales, pilot whales and possible striped dolphins (Figures 15, 16 & 24) also occurred in deep waters in the Faroe-Shetland Channel, although there was also one sighting each of pilot whales and striped dolphins in shelf waters to the west and east of Shetland respectively.

Of the three sightings of striped dolphins, one was recorded as 'possible', although a reasonable description was given. The other two sightings were recorded as 'definite' striped dolphins but the descriptions were rather more vague; whilst not being sufficiently poor to merit downgrading of the species identity, the certainty of the identification was nevertheless amended to 'possible'. The certainty of identification of the northern right whale was recorded as 'probable' by the observer, who was a fishery liaison officer with experience of marine mammal observations during seismic surveys. He provided a detailed description of the animal, describing a twin blow with the left part highest, and recording that no fin was visible. However, although the head was apparently seen, the observer did not mention any callosities, even though the animal was close (200 m from the airguns) and the sea state was 'glassy', with a swell of 0.5m. Although the pattern of callosities is variable between individual right whales, it is unusual that none were seen in these conditions. No photographs or video were taken, so confirmation of the identity was not possible.

Sightings of killer whales were restricted to more northern waters, although this species showed no preference for waters of a particular depth. Killer whales were seen from relatively shallow coastal waters of Norway and Shetland out to the deep waters of the Faroe-Shetland Channel (Figure 17). White-sided dolphins also demonstrated an adaptability to various habitats; whilst there were large concentrations of this species in the deep waters of the Faroe-Shetland Channel, there were also many sightings in the shallower waters of the northern North Sea (Figure 22).

Some species did not extend into deep waters. Risso's dolphins and harbour porpoises did not extend beyond the shelf slope (Figures 19 & 25), while bottlenose dolphins and common dolphins were not seen beyond the continental shelf (Figures 20 & 23). White-beaked dolphins were also mainly seen in shelf waters, with a concentration in the northern North Sea and scattered sightings close to Shetland and Orkney, with only one sighting in deep water (Figure 21).

The common dolphin was the only species seen exclusively in southern UK waters. There were two sightings of common dolphins, both occurring in the St. George's Channel (Figure 23).

Two species had a distribution that was more geographically widespread. Minke whales and bottlenose dolphins were seen in various locations around the UK (Figures 13 & 20). Although bottlenose dolphins did not extend beyond shelf waters, minke whales were cosmopolitan, being seen in waters of all depths.

The only pinniped species seen was the grey seal, with both sightings of this species occurring off the east coast of Scotland (Figure 26).

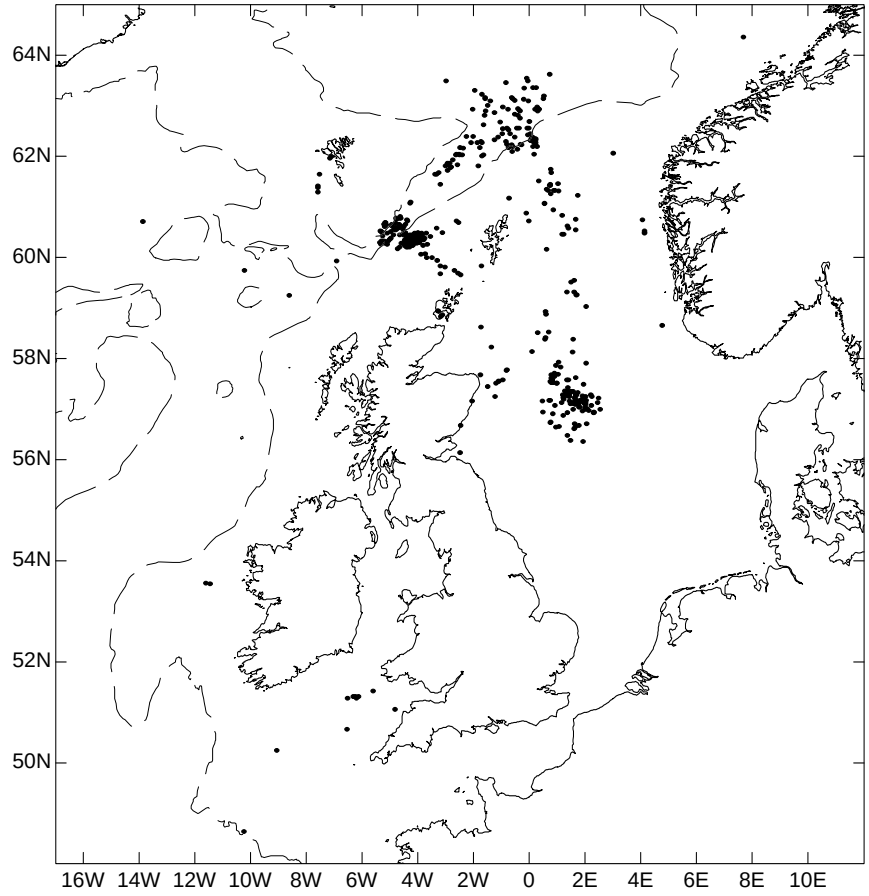


Figure 7 Marine mammal sightings (all species) from seismic survey vessels during 2000

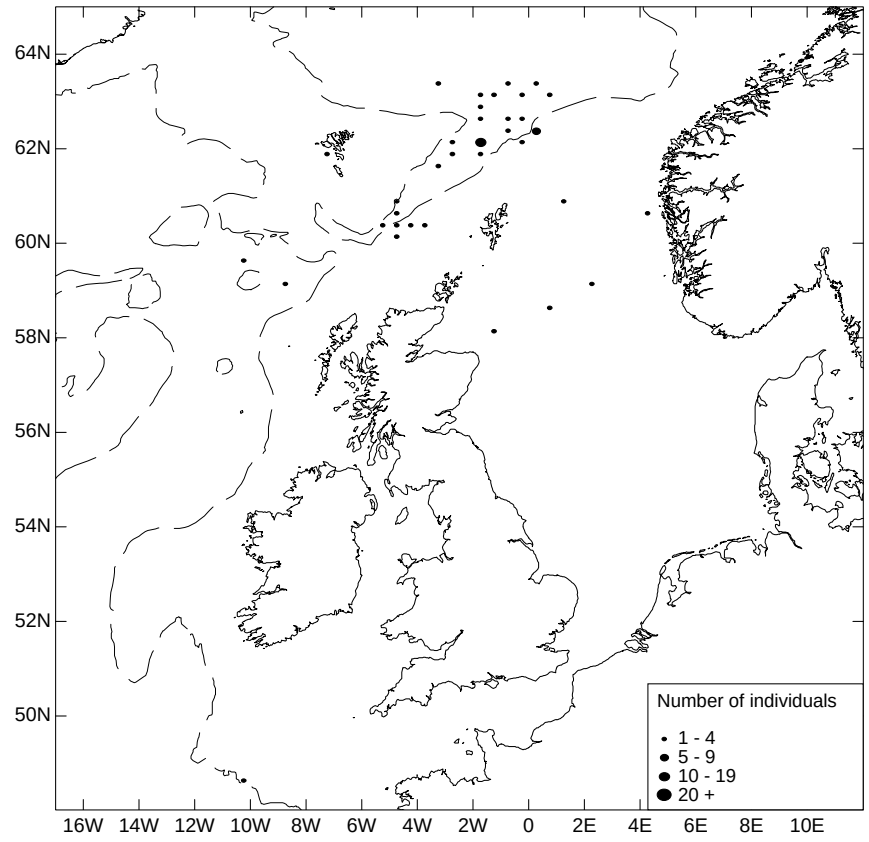


Figure 8 Distribution of unidentified whales during seismic surveys in 2000

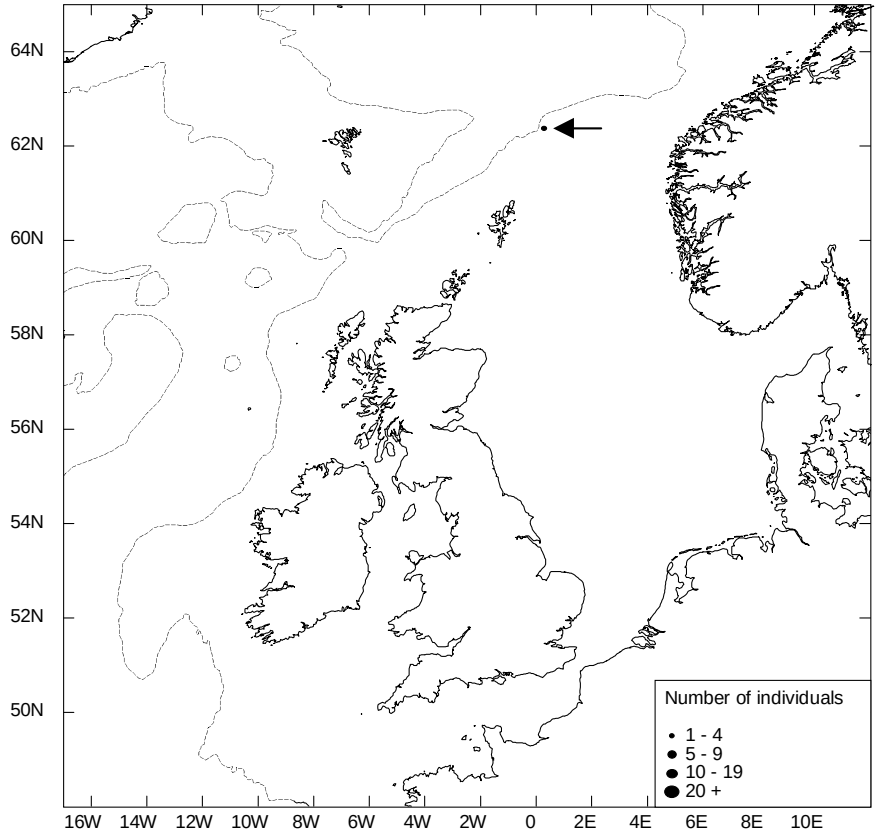


Figure 9 Location of sighting of probable northern right whale during seismic surveys in 2000

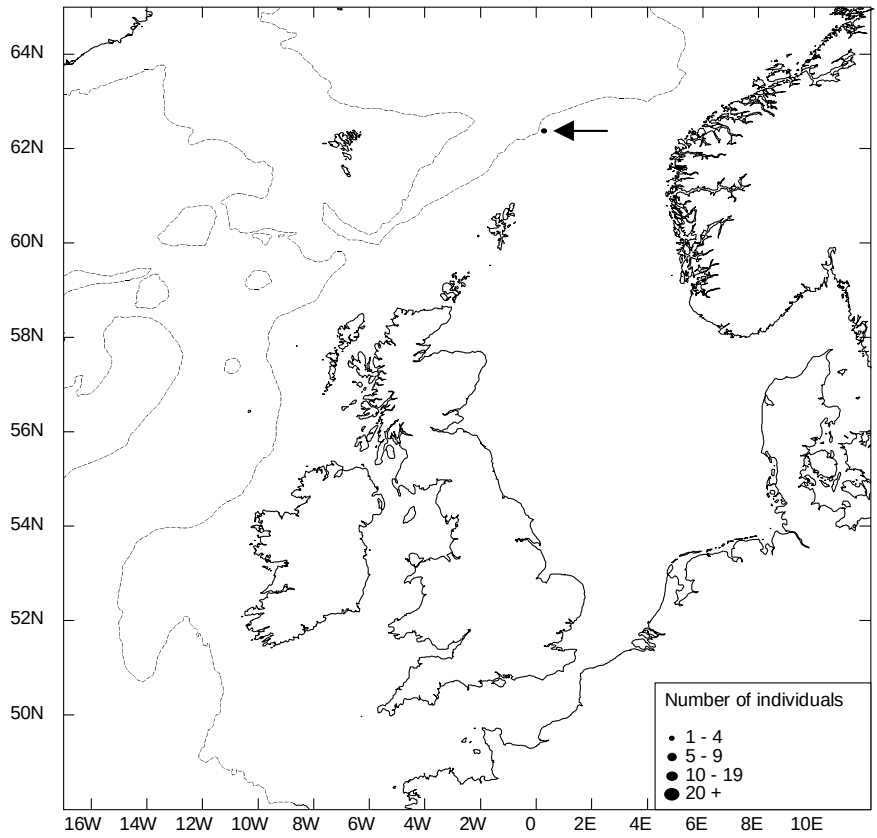


Figure 10 Distribution of humpback whales during seismic surveys in 2000

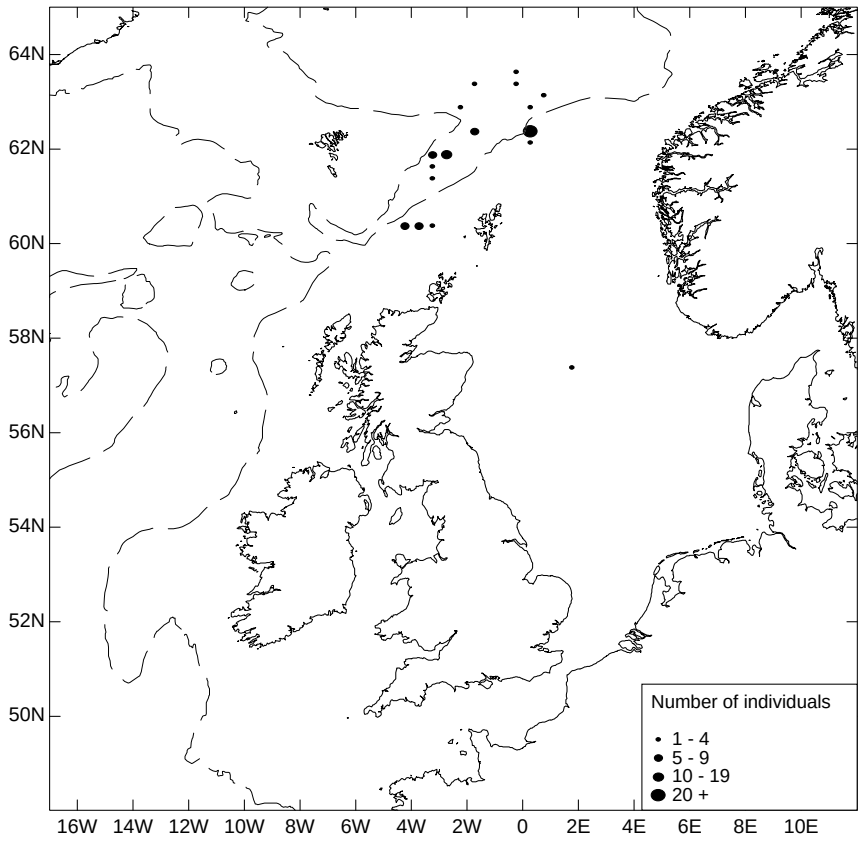


Figure 11 Distribution of fin whales during seismic surveys in 2000

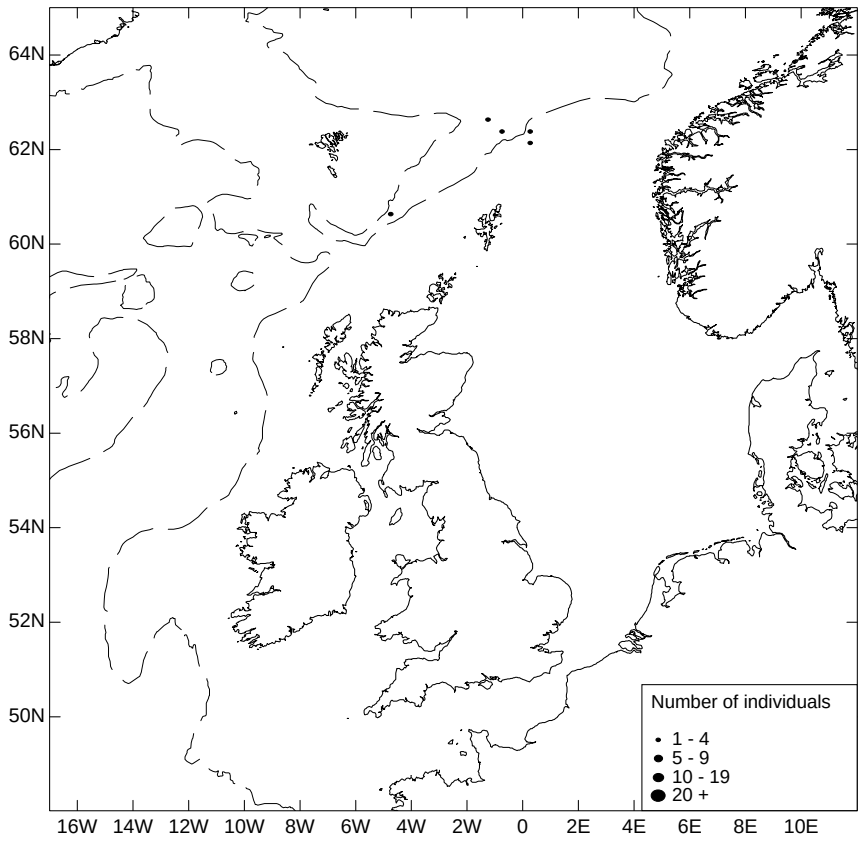


Figure 12 Distribution of sei whales during seismic surveys in 2000

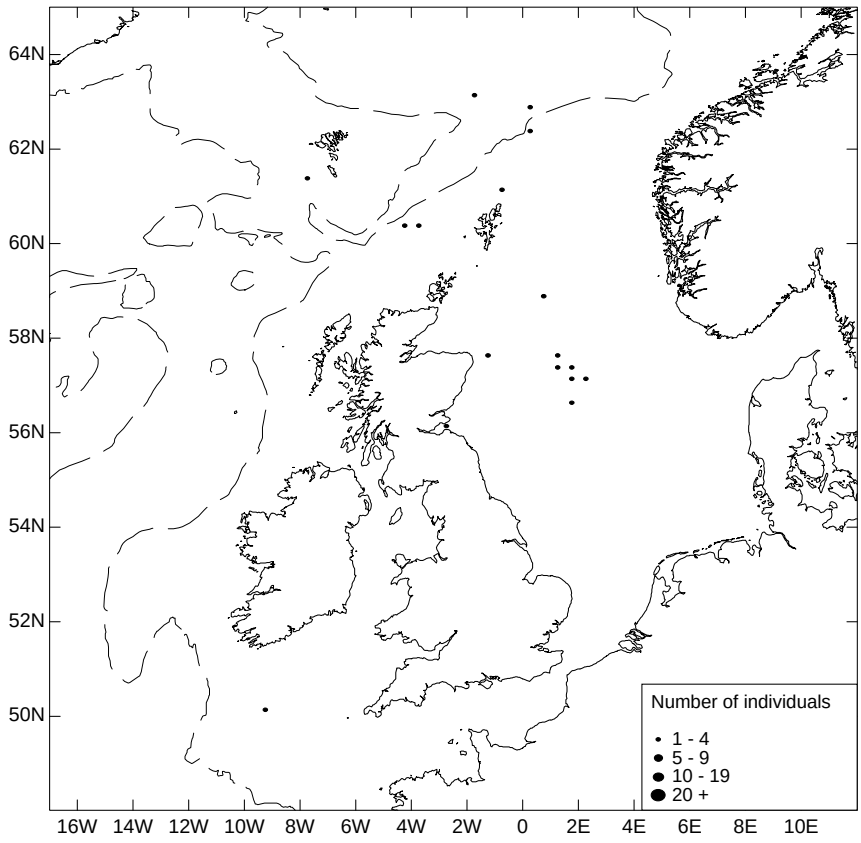


Figure 13 Distribution of minke whales during seismic surveys in 2000

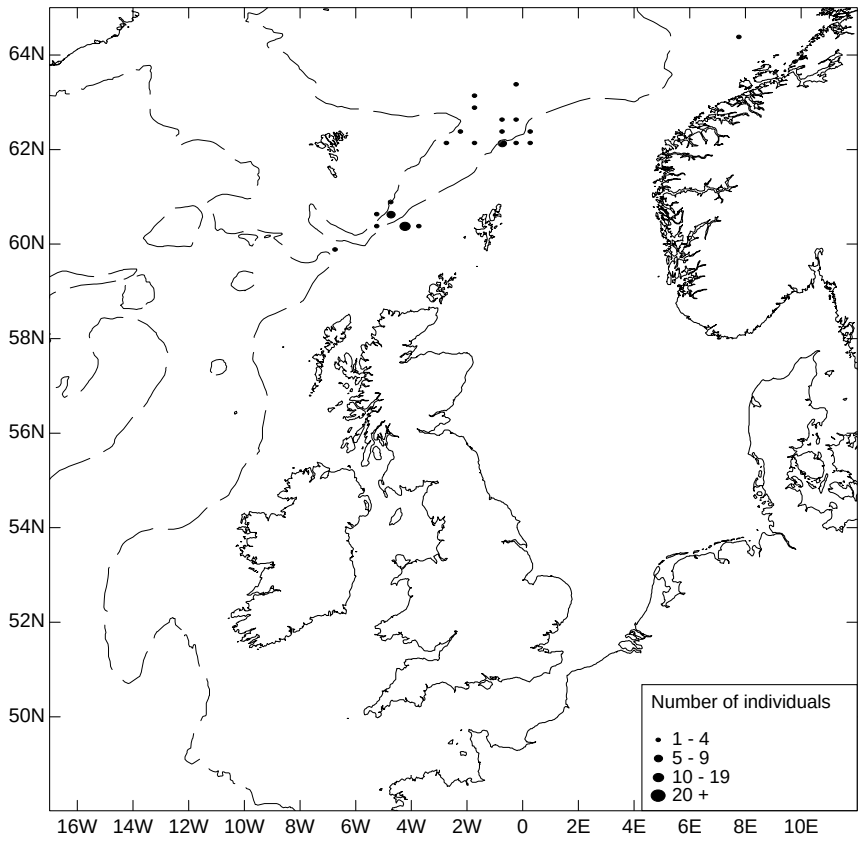


Figure 14 Distribution of sperm whales during seismic surveys in 2000

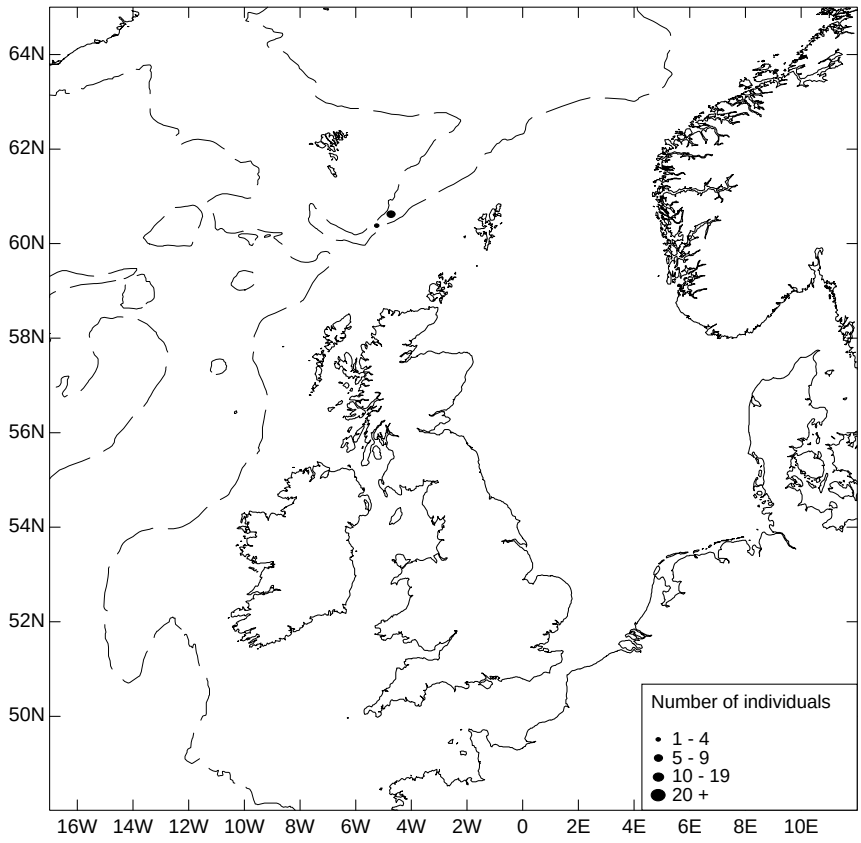


Figure 15 Distribution of northern bottlenose whales during seismic surveys in 2000

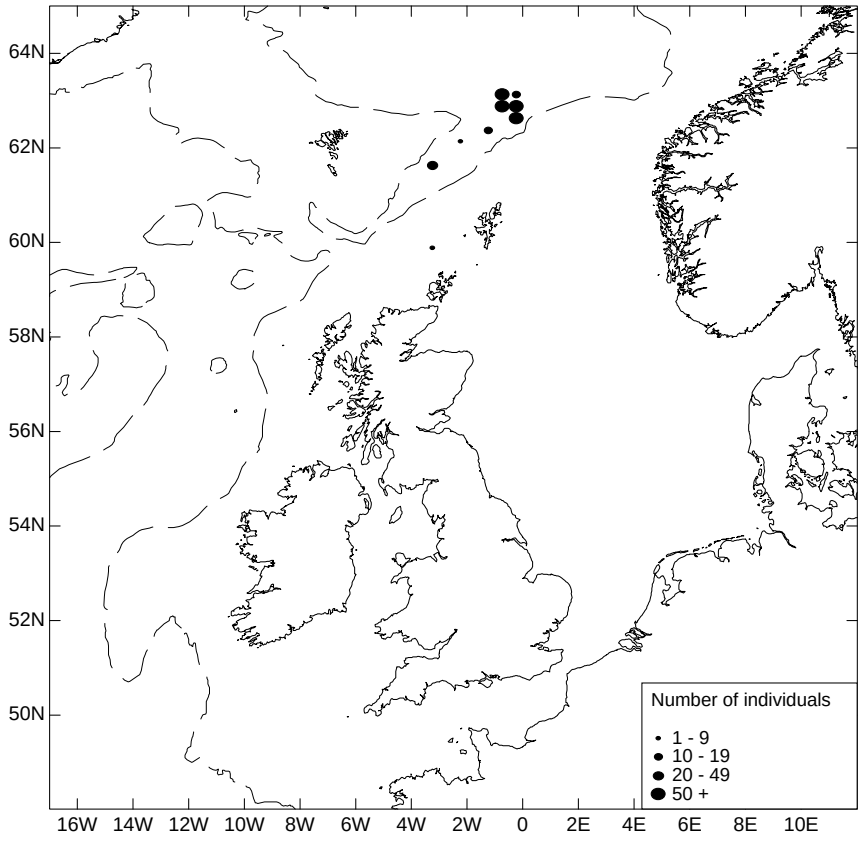


Figure 16 Distribution of pilot whales during seismic surveys in 2000

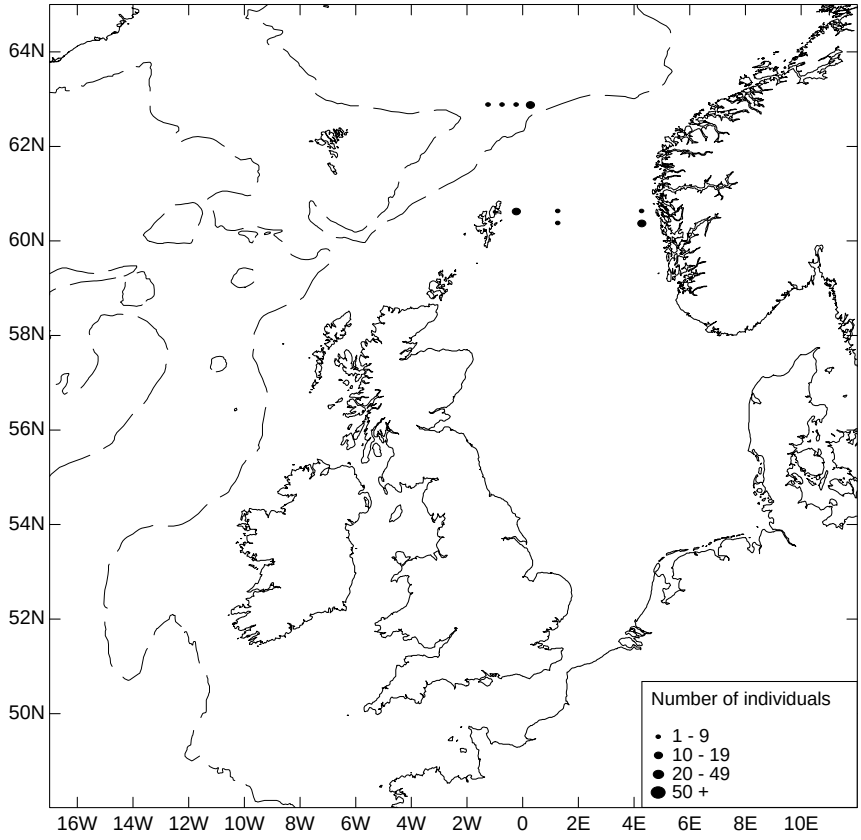


Figure 17 Distribution of killer whales during seismic surveys in 2000

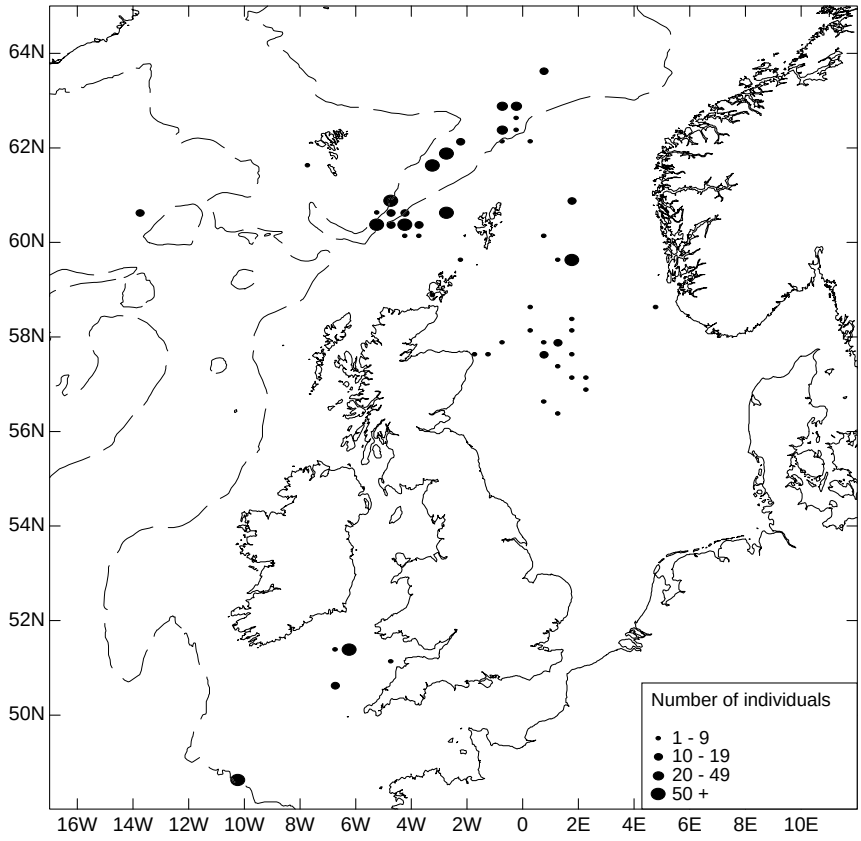


Figure 18 Distribution of unidentified dolphins during seismic surveys in 2000

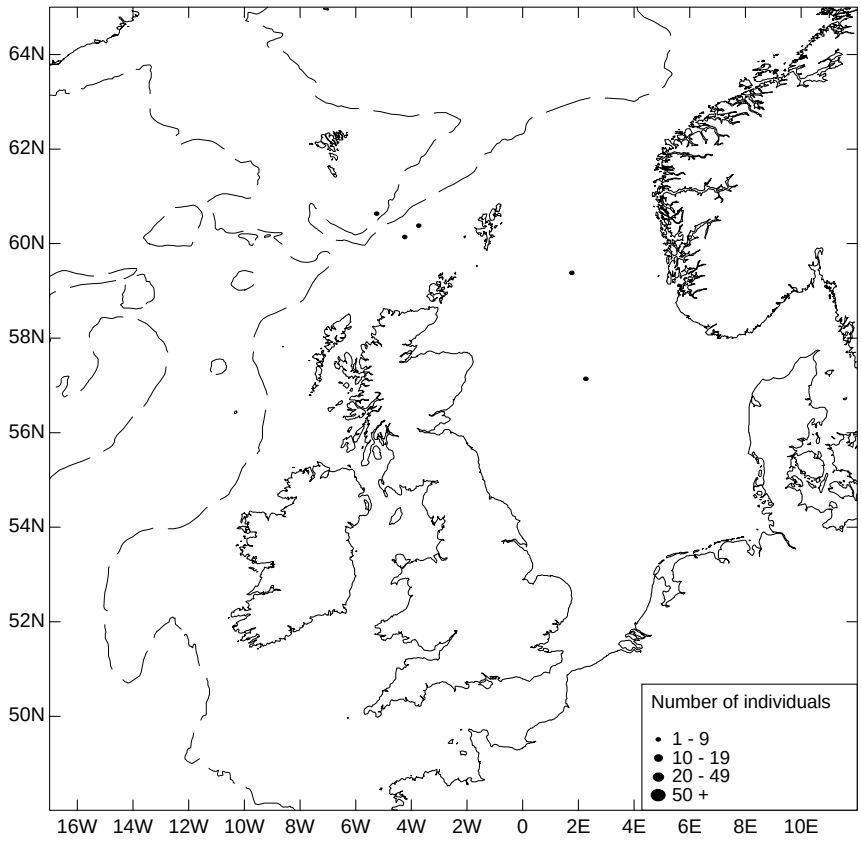


Figure 19 Distribution of Risso's dolphins during seismic surveys in 2000

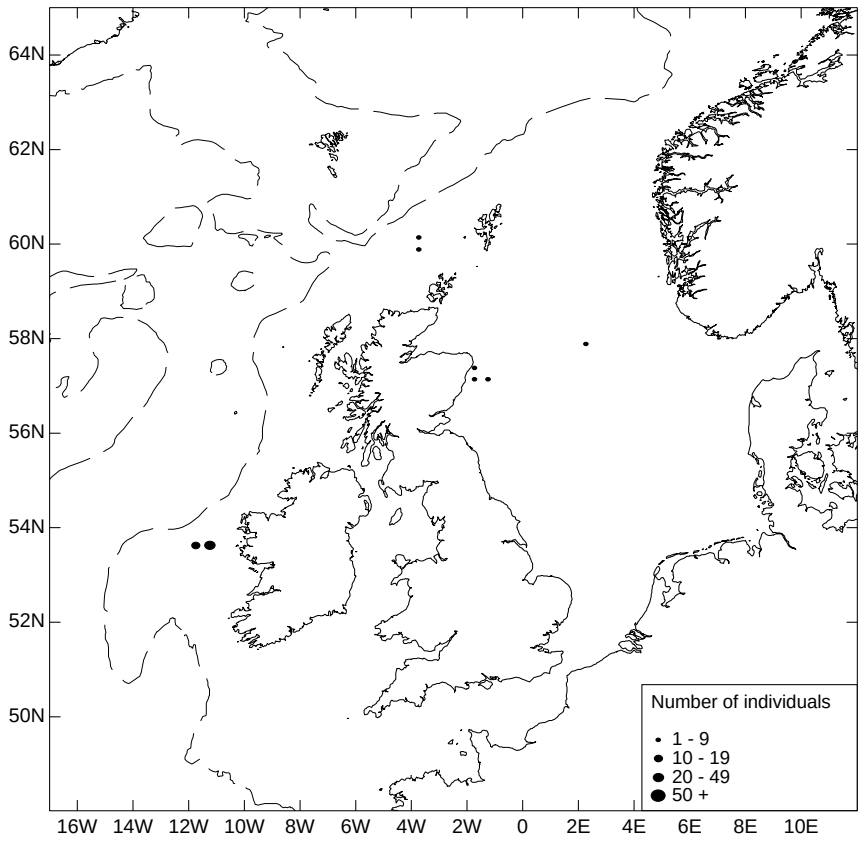


Figure 20 Distribution of bottlenose dolphins during seismic surveys in 2000

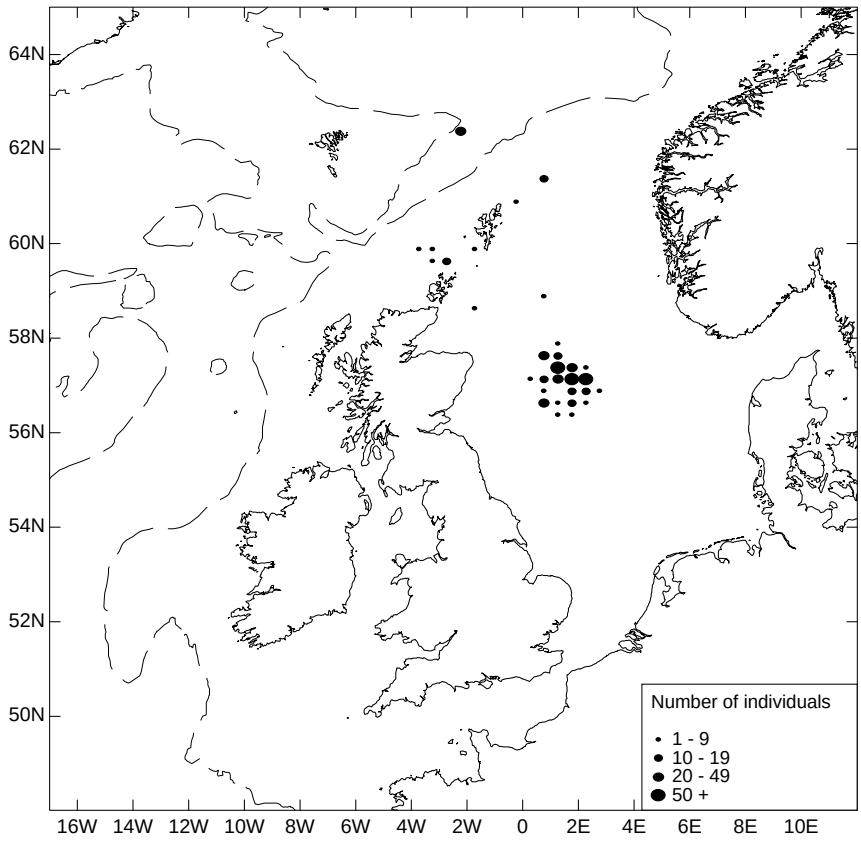


Figure 21 Distribution of white-beaked dolphins during seismic surveys in 2000

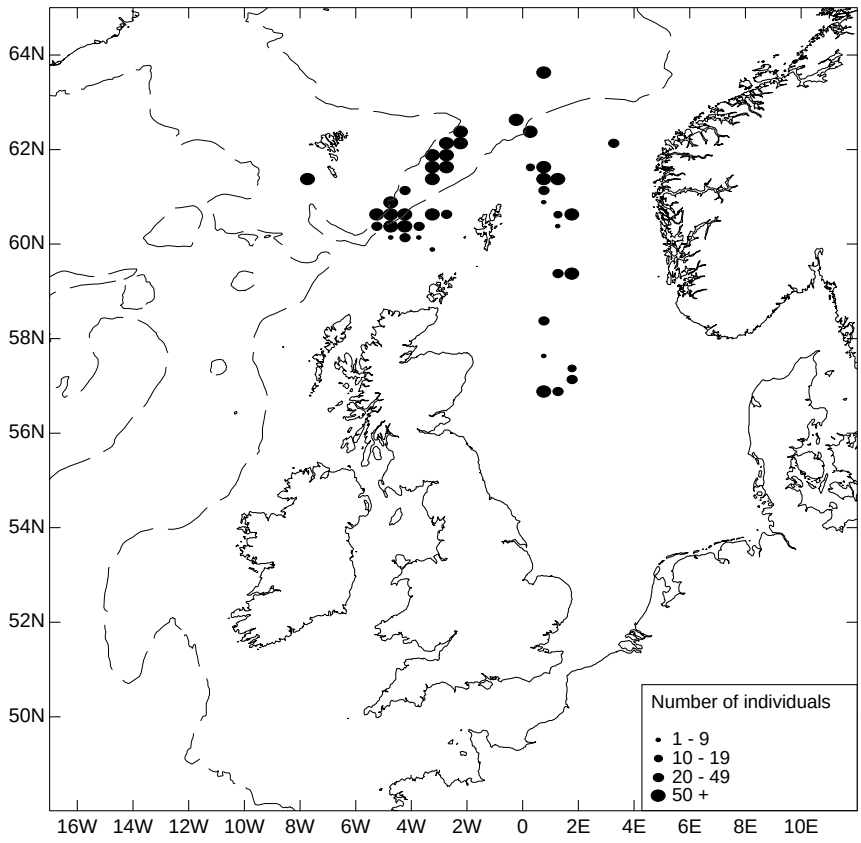


Figure 22 Distribution of white-sided dolphins during seismic surveys in 2000

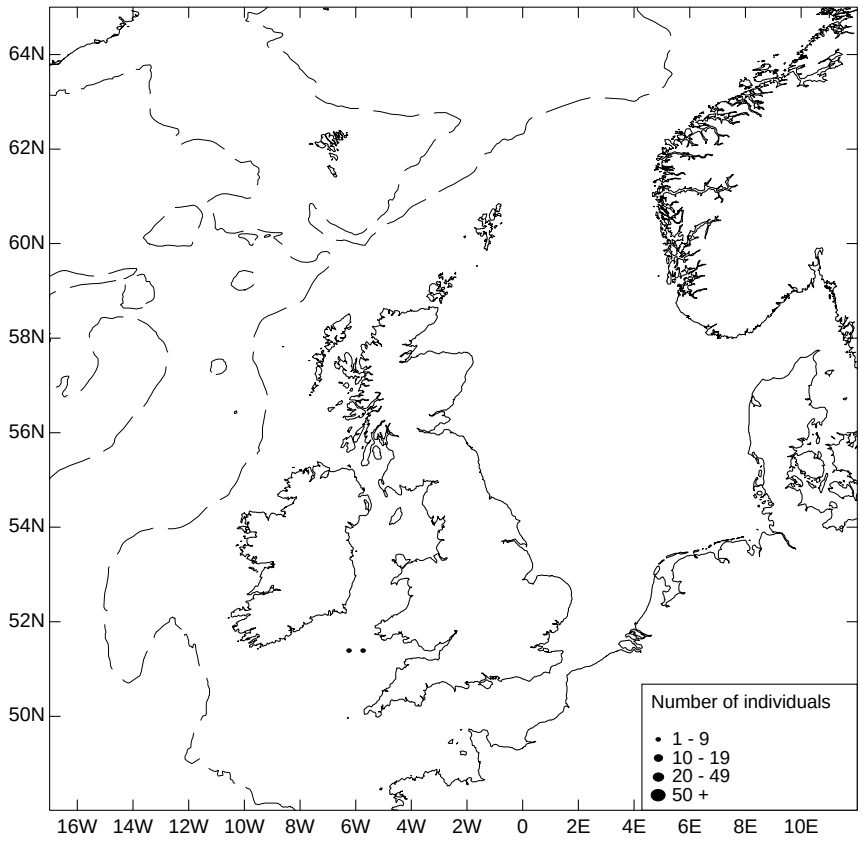


Figure 23 Distribution of common dolphins during seismic surveys in 2000

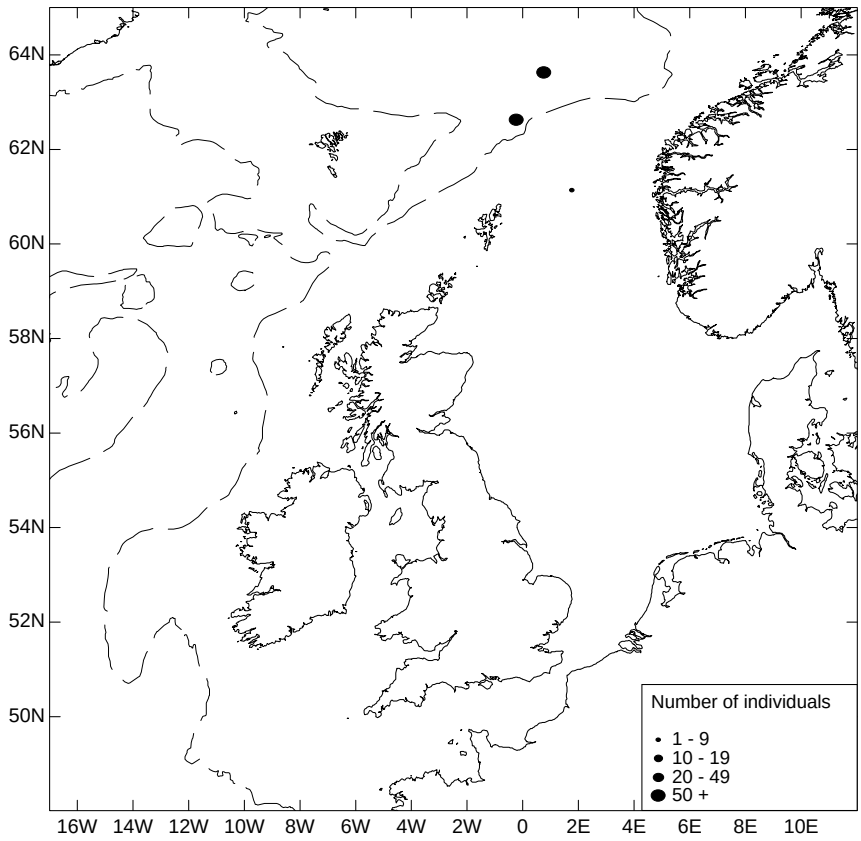


Figure 24 Distribution of striped dolphins (possible) during seismic surveys in 2000

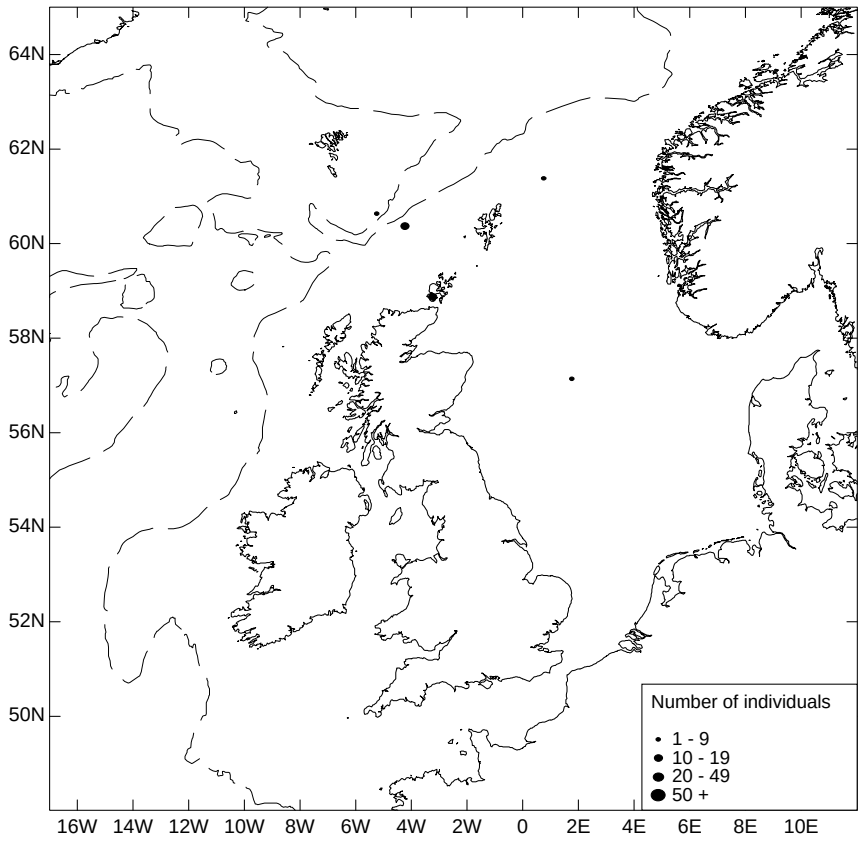


Figure 25 Distribution of harbour porpoises during seismic surveys in 2000

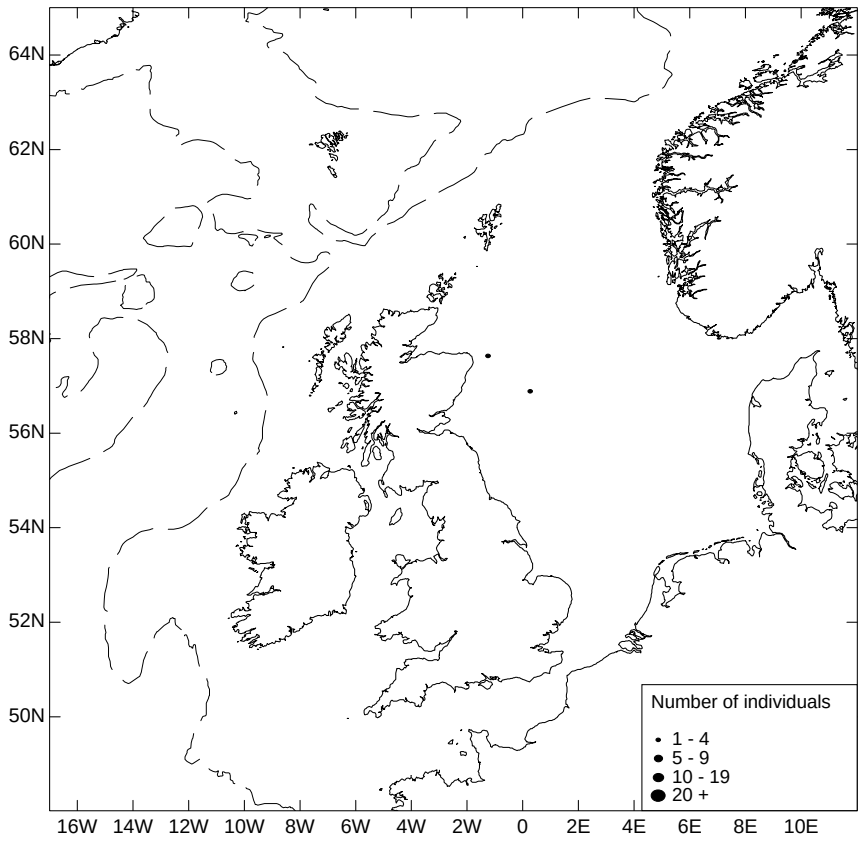


Figure 26 Distribution of grey seals during seismic surveys in 2000

6. Seasonal abundance and migration of marine mammals

There were no indications of any migratory patterns in the species observed, from either their distribution or their direction of travel. However, there were seasonal peaks of occurrence for some species (Figure 27). Sightings of fin whales were seasonal, occurring only during the summer (with the exception of one fin whale seen in November outside a period when effort was being recorded). Sightings of sperm whales extended from late spring until autumn, but peaked during the early part of this period. Both white-beaked and white-sided dolphins were seen from early summer through to late autumn, but whereas the sighting rate of white-sided dolphins peaked in August, that of white-beaked dolphins peaked in October. Minke whales were also seen from early summer until the autumn months, but in low numbers throughout.

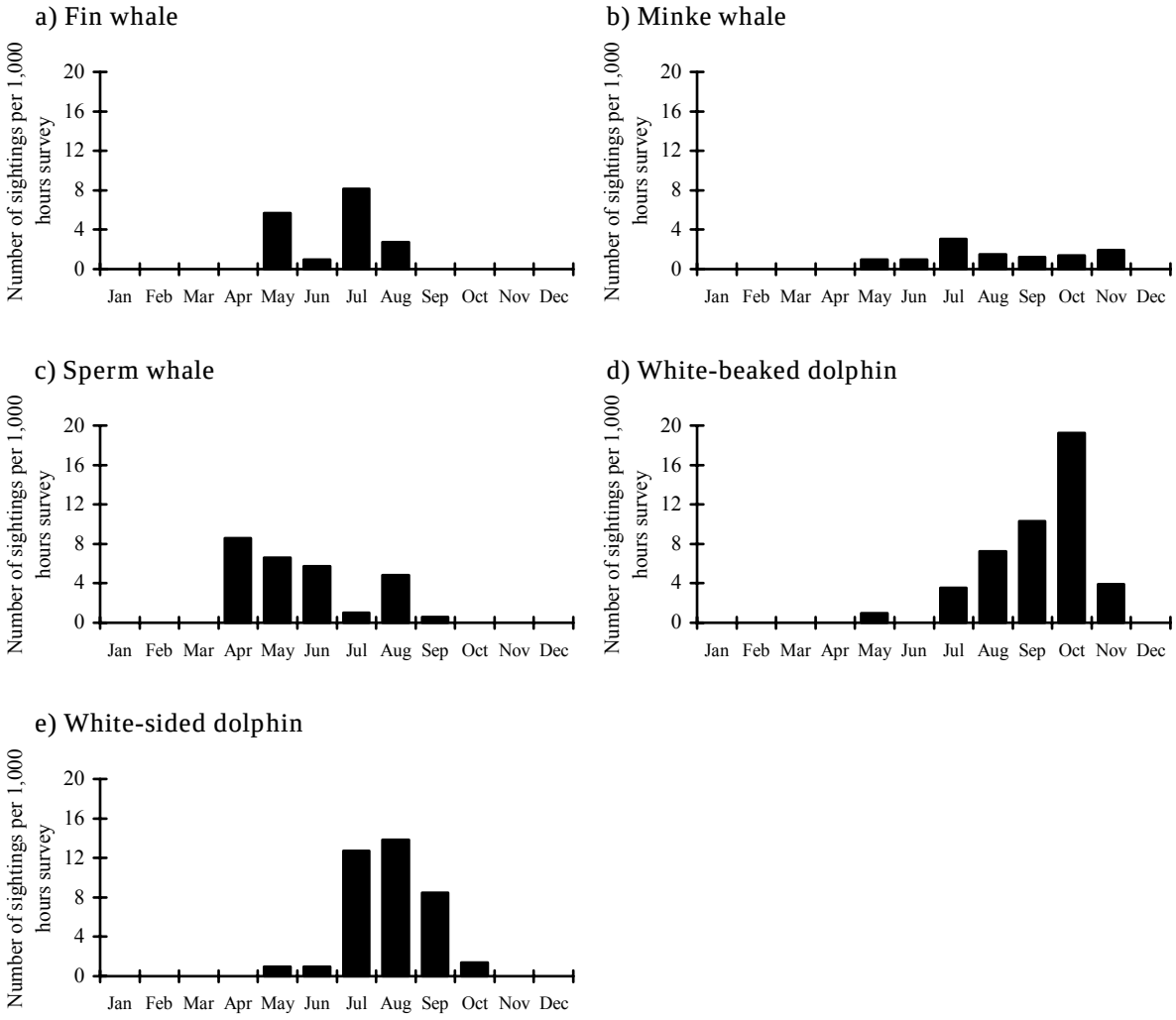


Figure 27 Sighting rates of cetaceans per month (only includes surveys where effort was correctly recorded).

7. Effects of seismic activity on marine mammals

Reports were received from a number of different types of seismic surveys, some with large arrays of airguns and others with much smaller airgun configurations firing at lower power levels. The reports received did not always specify precise airgun parameters, but in most cases did record the type of survey (site survey, 2D survey, 3D survey, 4D survey, 4C survey, etc.). For those reports that were matched to notifications of surveys, information on the type of survey was also available from the notification. Where airguns were used on site surveys they were of relatively low power, and may have been less likely to cause disturbance to marine mammals. When considering the effects of seismic activity on marine mammals, site surveys (including other similar surveys) were analysed separately from surveys with larger arrays of airguns; sections 7.1 - 7.5 exclude data from site surveys, which are considered separately in section 7.6.

7.1 Sighting rate of marine mammals

Sighting rates were calculated as number of sightings (not individuals) per unit effort (i.e. per 1,000 hours of observations). Only sightings from surveys where effort was recorded correctly were used. Sighting rates of most species were highest when the airguns were not firing (Figure 28). However, sighting rates of sperm whales and pilot whales were higher during periods of shooting, but not significantly so. For most species or species groups sample sizes were too small to assess the statistical significance of these results. Where sample size permitted testing, significant results were only found for white-beaked and white-sided dolphins, both of which were seen significantly more often when the airguns were not firing (Table 2).

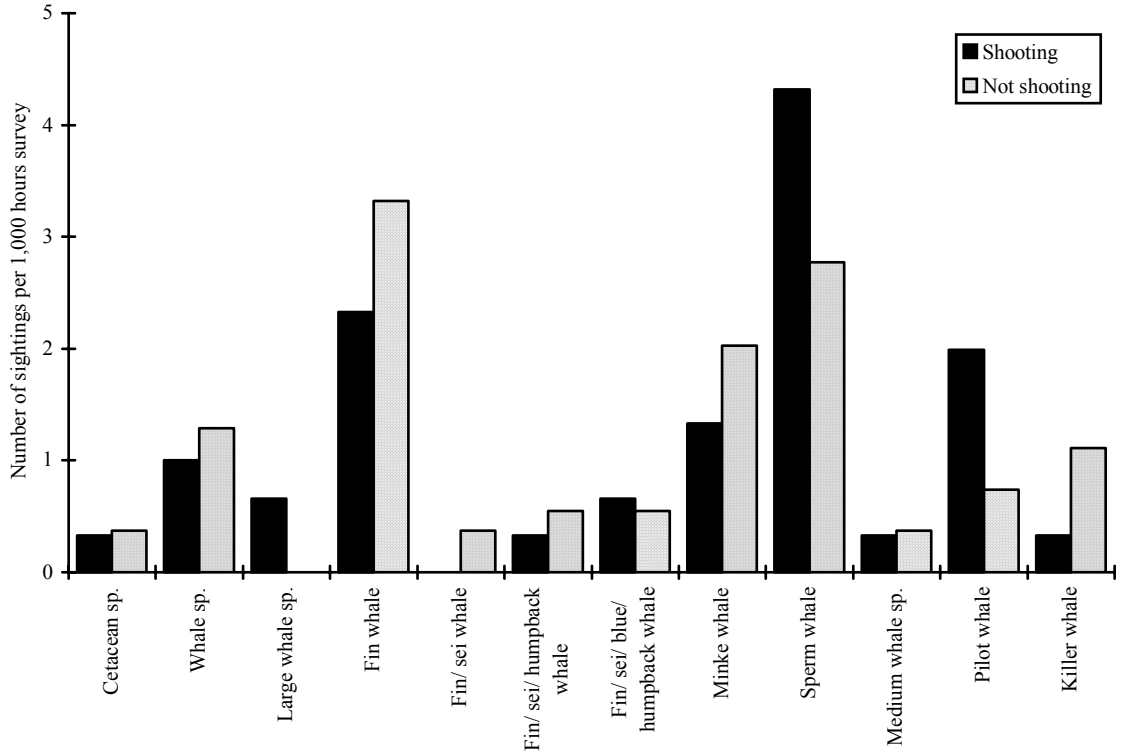
Table 2 Statistical significance of difference in frequency of occurrence of marine mammals in relation to seismic activity (excluding site surveys), not controlling for location, season or weather (n = sample size; d.f. = degrees of freedom; P = probability; n.s. = not significant).

Species	χ^2	*n*	*d.f.*	*P*
Fin whale	0.649	25	1	n.s.
Minke whale	0.537	15	1	n.s.
Sperm whale	1.400	28	1	n.s.
Dolphin sp.	0.734	19	1	n.s.
White-beaked dolphin	11.679	61	1	< 0.001
White-sided dolphin	4.333	61	1	< 0.05

Various factors could have influenced these results, for example the location or timing of surveys, or weather conditions. Marine mammal distribution and occurrence varies both spatially and temporally, and it is much easier to detect marine mammals in calm weather conditions with good visibility. It is important to account for such factors if the proportion of time spent shooting also varies in relation to them. For example, a tendency to shoot in weather conditions that are favourable for the detection of marine mammals could lead to increased sighting rates during periods of shooting. During 2000 the proportion of time spent engaged in seismic activity varied with location and season and was greatest in good weather conditions (Figures 3 - 6). Where sample size permitted sighting rates of marine mammals were re-calculated to minimise the variation caused by these potential sources of bias.

To re-calculate sighting rates, subsets of data were selected according to location and season, using various sources to establish known areas and months of peak abundance for each species (e.g. Bloor *et al.* 1996; Clark and Charif 1998; Evans 1980, 1990, 1992; JNCC 1995; NERC 1998; Northridge *et al.* 1995; Pollock *et al.* 1997, 2000; Skov *et al.* 1995). A preliminary analysis revealed that sighting rates of all species declined with increasing sea state and swell and with decreasing visibility, therefore periods of 'choppy' or 'rough' sea states, 'medium' or 'large' swell and 'moderate' or 'poor' visibility were disregarded when re-calculating sighting rates. The criteria used for selecting subsets of data are summarised in Table 3.

a) Baleen whales, large and medium odontocetes



b) Small odontocetes and seals

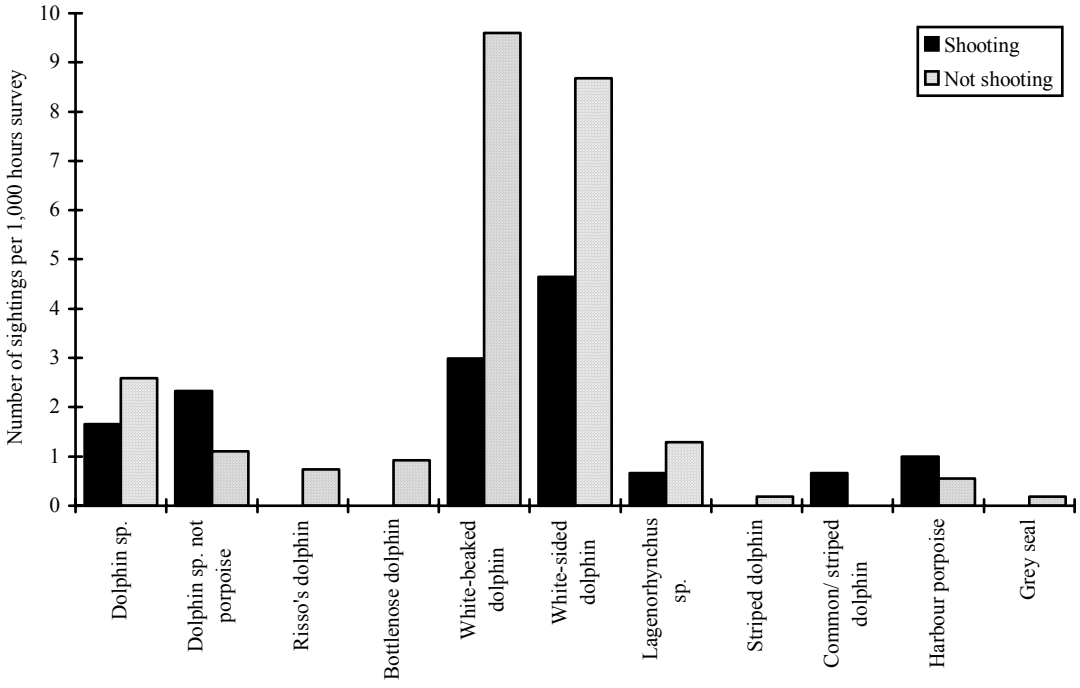


Figure 28 Sighting rates of marine mammals in relation to seismic activity (excluding site surveys, and not controlling for location, season or weather conditions).

Table 3 Criteria for selection of data for assessing sighting rate of marine mammals

Species	*Season*	*Areas*	*Sea state*	*Swell*	*Visibility*
All baleen whales combined	Jun - Sep	West of Shetland Rockall West of Ireland	Glassy Slight	Low	Good
Fin whale	Jun - Sep	West of Shetland Rockall	Glassy Slight	Low	Good
Minke whale	Jun - Sep	West of Shetland Rockall Northern North Sea West of Ireland	Glassy Slight	Low	Good
Sperm whale	May - Aug	West of Shetland Rockall West of Ireland	Glassy Slight	Low	Good
All dolphins combined	Jun - Sep	West of Shetland Rockall Northern North Sea West of Ireland South-West Approaches	Glassy Slight	Low	Good
White-beaked dolphin	Jun - Sep	West of Shetland Northern North Sea	Glassy Slight	Low	Good
White-sided dolphin	Jun - Sep	West of Shetland Rockall Northern North Sea	Glassy Slight	Low	Good

Sample sizes were only sufficient to permit re-calculation of sighting rates for six species or species groups. Sighting rates only varied significantly with seismic activity for white-sided dolphins, which were seen more often when the airguns were not firing (Figure 29; Table 4).

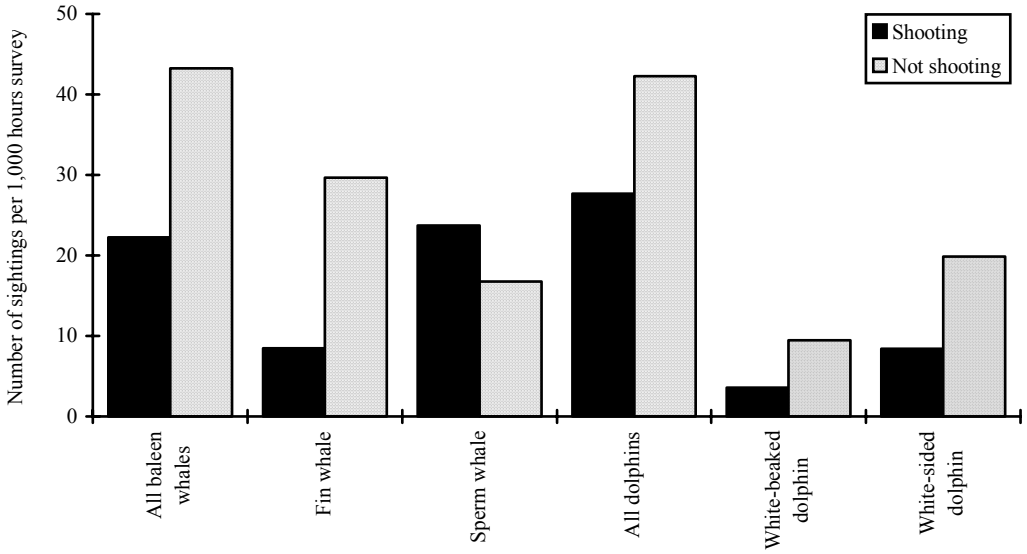


Figure 29 Sighting rates of marine mammals in relation to seismic activity (excluding site surveys), controlling for location, season and weather conditions.

Table 4 Statistical significance of difference in frequency of occurrence of marine mammals in relation to seismic activity (excluding site surveys), controlling for location, season and weather (n = sample size; d.f. = degrees of freedom; P = probability; n.s. = not significant).

Species	χ^2	*n*	*d.f.*	*P*
All baleen whales	2.148	27	1	n.s.
Fin whale	3.079	15	1	n.s.
Sperm whale	0.558	18	1	n.s.
All dolphins combined	2.961	75	1	n.s.
White-beaked dolphin	2.385	14	1	n.s.
White-sided dolphin	4.205	30	1	< 0.05

7.2 Distance of marine mammals from the airguns

The closest distance of approach to the airguns by marine mammals was recorded by observers. Median values were compared for species seen both during periods of shooting and during periods when the airguns were not firing. Weather conditions can affect an observer's ability to detect marine mammals at greater distances; this source of variation was reduced by selecting only those sightings occurring during better weather conditions, as defined in Table 3. Only those species where the sample size equalled or exceeded ten pods were used.

All the dolphin species tested (white-beaked dolphins, white-sided dolphins and all dolphins combined) were found to remain significantly further from the airguns during periods of shooting (Figure 30; Table 5).

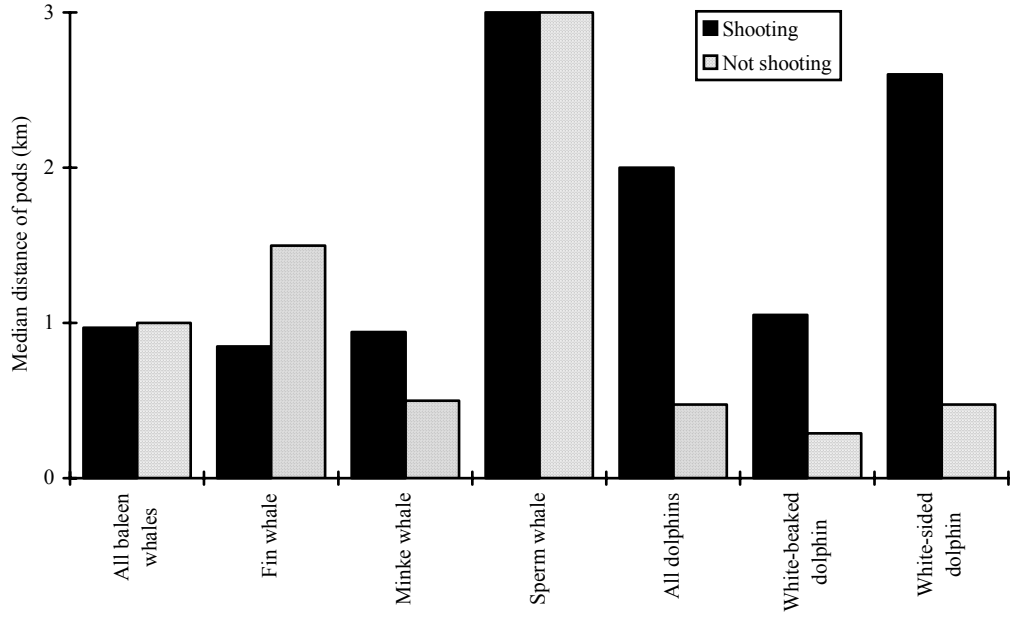


Figure 30 Median distance of marine mammals from the airguns in relation to seismic activity (excluding site surveys).

Table 5 Statistical significance of difference in distance of marine mammals in relation to seismic activity (excluding site surveys), controlling for weather (z = Wilcoxon statistic; n = sample size; P = probability; n.s. = not significant).

Species	*z*	*n*	*P*
All baleen whales combined	-0.015	39	n.s.
Fin whale	-0.227	17	n.s.
Minke whale	-0.074	13	n.s.
Sperm whale	-0.423	20	n.s.
All dolphins combined	3.834	95	0.00007
White-beaked dolphin	1.828	23	0.0336
White-sided dolphin	2.378	32	0.0087

The proportion of sightings of dolphins occurring within a given range of the airguns was reduced during periods of shooting for distances out to several kilometres from the source (Figure 31a). The Kolmogorov-Smirnov test showed that these differences were statistically significant (χ^2 approximation = 15.334, d.f. = 1, $p < 0.001$). There was a marked reduction in the proportion of dolphin sightings occurring at close range (less than 3 km) during periods of shooting. 28% of dolphins seen during periods of shooting approached to within 1 km of the airguns while only 17% came within 500 m of the airguns. When the airguns were not firing, 71% of dolphin sightings were within 1 km of the airguns, and 59% were within 500 m. There was no significant difference in the proportion of sightings of medium and large cetaceans within a given range of the airguns in relation to seismic activity (Figure 31b; Kolmogorov-Smirnov χ^2 approximation = 0.118, d.f. = 1).

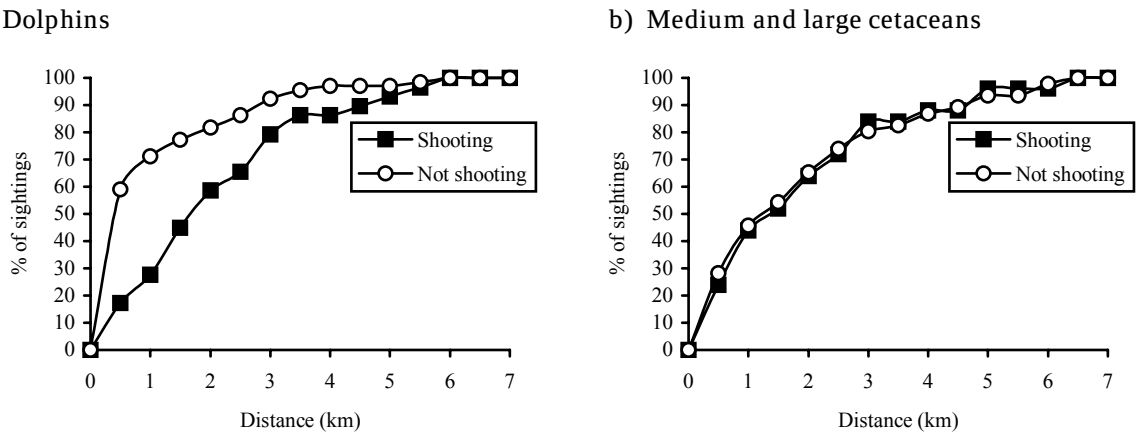


Figure 31 Proportion of marine mammal sightings occurring within specified distances of the airguns during good weather conditions, in relation to seismic activity (excluding site surveys).

7.3 Behaviour of marine mammals

Observers recorded any types of behaviour that were apparent during encounters with marine mammals. For 15% of encounters, nothing other than 'normal swimming' was recorded. In the remaining encounters 35 other types of behaviour were recorded, some being observed more frequently than others. Table 6 summarises the results for the more frequently-recorded behaviours. Similar behaviours, such as breaching, jumping and somersaulting, were combined. The number of encounters where each behaviour was exhibited during periods of shooting or not shooting is expressed as a percentage of the total number of encounters at the respective seismic activity. The resulting percentage thus indicates the tendency of animals to engage in a particular behaviour in relation to seismic activity. Where types of behaviour were exhibited more frequently by particular species, the results for those individual species are shown; otherwise species were combined as appropriate.

Table 6 Behaviour of marine mammals in relation to seismic activity, excluding site surveys (n = sample size; P = probability; n.s. = not significant; - = sample size too small to determine statistical significance).

Behaviour	*Species*	*% of encounters while shooting when behaviour was exhibited*	*% of encounters while not shooting when behaviour was exhibited*	χ^2	*n*	*P*
Feeding	All cetaceans combined	1.09	7.34	4.649	20	< 0.05
	All baleen whales	0.00	13.95	-	6	-
	Killer whale	0.00	50.00	-	5	-
	All dolphins combined	2.13	4.82	-	9	-
	White-sided dolphin	7.14	14.29	-	8	-
+ve interactions	All cetaceans combined	8.70	18.15	3.874	55	< 0.05
	All dolphins combined	6.38	25.90	6.463	46	< 0.05
	White-beaked dolphin	30.00	55.56	1.086	38	n.s.
-ve interactions	All cetaceans combined	6.38	0.00	-	3	-
Alteration of course	All cetaceans combined	6.52	0.39	-	7	-
Breaching, jumping or somersaulting	All cetaceans combined	21.74	23.55	0.097	81	n.s.
	All dolphins combined	40.43	34.34	0.380	76	n.s.
	White-beaked dolphin	50.00	28.57	-	23	-
	White-sided dolphin	50.00	15.44	-	30	-
Tail-slapping	All cetaceans combined	2.17	1.54	-	6	-
Porpoising	All cetaceans combined	11.96	13.51	0.126	46	n.s.
	All dolphins combined	23.40	20.48	0.148	45	n.s.
	White-beaked dolphin	10.00	11.11	-	8	-
	White-sided dolphin	50.00	42.86	0.126	28	n.s.
Fast swimming	All cetaceans combined	25.00	22.78	0.144	82	n.s.
	All dolphins combined	40.43	31.93	0.781	72	n.s.
	White-beaked dolphin	50.00	23.81	-	20	-
	White-sided dolphin	42.86	48.98	0.087	30	n.s.
Slow swimming	All cetaceans combined	26.09	20.85	0.840	78	n.s.
	All baleen whales	43.75	18.60	-	15	-
	Minke whale	80.00	38.46	-	9	-
	Sperm whale	38.46	23.53	-	9	-
	Pilot whale	71.43	60.00	-	8	-
	All dolphins combined	12.77	20.48	1.164	40	n.s.
	White-beaked dolphin	0.00	11.11	-	7	-
	White-sided dolphin	7.14	30.61	-	16	-
Milling	All cetaceans combined	3.26	1.16	-	6	-
	All dolphins combined	6.38	1.20	-	5	-
Surfacing infrequently	All cetaceans combined	10.87	11.58	0.030	40	n.s.
	All baleen whales	6.25	18.60	-	9	-
	All dolphins combined	10.64	9.04	-	20	-
Diving	All cetaceans combined	8.70	7.34	0.162	27	n.s.
	Minke whale	20.00	38.46	-	6	-
	Sperm whale	46.15	70.59	0.733	18	n.s.
Logging/ "resting"	All cetaceans combined	9.78	4.25	3.656	20	n.s.
	Sperm whale	46.15	41.18	0.043	13	n.s.
Widely dispersed group	All cetaceans combined	8.70	6.95	0.282	26	n.s.
	Pilot whale	71.43	20.00	-	6	-
	All dolphins combined	6.38	9.04	-	18	-
	White-sided dolphin	14.29	22.45	-	13	-
Close-knit group	All cetaceans combined	3.26	0.77	-	5	-
	All dolphins combined	4.26	1.20	-	4	-

Fewer cetaceans were observed feeding during periods of shooting than when the airguns were not firing. When all cetacean species were combined, this difference was statistically significant.

Some cetaceans, particularly white-beaked dolphins, engaged in positive interactions with the survey vessel or its equipment (i.e. bow-riding, approaching close to the vessel, swimming alongside the vessel or its associated equipment, following the vessel or swimming close ahead of the vessel). Such interactions

occurred mostly when the airguns were not firing. Although the results for white-beaked dolphin alone were not statistically significant, when all dolphins or all cetaceans were combined the increase in positive interactions with the vessel during periods when the airguns were not firing was statistically significant. Negative interactions (i.e. avoidance) were observed on only a few occasions, but always during periods of shooting. On a small number of occasions cetaceans were recorded as altering their course, mostly during periods of shooting; at these times 33% of course alterations were away from the vessel, with only 17% towards the vessel.

Breaching, jumping or somersaulting in dolphins occurred more often during periods of shooting than when the airguns were not firing, but not significantly so. Tail-slapping was seen infrequently, but mostly also during periods of shooting.

No significant effects of seismic activity on the swimming characteristics of cetaceans were observed. Although measurement of swimming speed can be subject to varying interpretation by different observers, most observers are capable of a simple assessment of whether speed is notably fast or slow based on prior experience of typical swimming speeds. Dolphins sometimes exhibited a tendency to swim faster during periods of shooting and more slowly when the airguns were not firing, but these differences were not statistically significant. Conversely, baleen whales and sperm whales tended to swim more slowly during periods of shooting, but sample sizes were too small to permit statistical testing of this. There was apparently little effect on the tendency of animals to porpoise. Milling was observed slightly more often during periods of shooting, but sample sizes were again too small to assess the significance of this. Dolphins showed a slight tendency to swim in dispersed groups when the airguns were not firing and in close-knit groups during periods of shooting, but sample sizes were too small to permit statistical testing.

There were also no significant effects of seismic activity on the surfacing of cetaceans. Both minke whales and sperm whales tended to dive more often when the airguns were not firing, but the results were non-significant for sperm whales while for minke whales sample sizes were too small to permit statistical testing. Similarly, baleen whales were more often recorded as surfacing infrequently when the airguns were not firing, but again sample sizes were too low to permit testing. Such results could, if significant, indicate a tendency to submerge less, i.e. remain at the surface, during periods of shooting. Logging or "resting", both behaviours used by observers to describe animals lying motionless at the surface, were also observed more often during periods of shooting, but again the results were not statistically significant.

The direction of travel of marine mammals relative to the survey vessel was recorded by observers in a diagram and was subsequently assigned to one of six categories. Table 7 presents the results for all species where direction of travel was recorded on ten or more occasions. For most species or species groups sample sizes were too small to permit statistical testing, but for all baleen whales combined, all dolphins combined and all cetaceans combined the direction of travel differed significantly in relation to seismic activity. Partitioning was used to ascertain where the differences lay. For all three groups, fewer pods were found to be heading towards the vessel during periods of shooting. For all baleen whales combined fewer were also found to be travelling parallel to the vessel but in the opposite direction during periods of shooting. This category would have included animals passing on a parallel track both at close ranges and at greater distances; those at close range would have been initially travelling towards the vessel, so the decrease in whales in this category during periods of shooting could have been linked to the decrease in whales heading towards the vessel. As well as fewer pods heading towards the vessel during periods of shooting, a significantly higher proportion of pods of dolphins were heading away from the vessel at these times.

Table 7 Direction of travel of marine mammals relative to the survey vessel in relation to seismic activity, excluding site surveys (d.f. = degrees of freedom; P = probability; n.s. = not significant; - = sample size too small to determine statistical significance).

Species	*Seismic activity*	*Towards ship*	*Away from ship*	*Crossing path of ship*	*Parallel to ship in same direction*	*Parallel to ship in opposite direction*	*Milling or variable*	χ^2	*d.f.*	*P*
Whale sp.	Shooting			1	1	1		-	-	-
	Not shooting			3	1	4				
All baleen whales combined	Shooting	1	2	6	3	2	2	6.062	2	< 0.05
	Not shooting	3	6	9	4	18	1			
Fin whale	Shooting		1	2	2		2	-	-	-
	Not shooting		3	3	1	12				
Minke whale	Shooting	1		3	1			-	-	-
	Not shooting	3	3	2	1	3	1			
Sperm whale	Shooting	1			7	4	1	-	-	-
	Not shooting		1	3	4	5	4			
Pilot whale	Shooting	1	1	1		4		-	-	-
	Not shooting	2				2	1			
Killer whale	Shooting							-	-	-
	Not shooting		2	2		6				
All dolphins combined	Shooting	4	8	11	2	14	6	25.862	3	<0.001
	Not shooting	51	3	41	14	33	14			
Dolphin sp.	Shooting	1		1	1	2	2	-	-	-
	Not shooting	4	2	7	2	4	1			
Dolphin sp. not porpoise	Shooting		1	1		3	1	-	-	-
	Not shooting	1		1		1	3			
White-beaked dolphin	Shooting	3	3	2		1	1	-	-	-
	Not shooting	35		12	4	5	5			
White-sided dolphin	Shooting		1	5		6	2	-	-	-
	Not shooting	6	1	15	6	16	4			
Lagenorhynchus sp.	Shooting				1	1		-	-	-
	Not shooting	1		2	2	3	1			
All cetaceans combined	Shooting	7	11	21	13	26	9	14.929	5	< 0.05
	Not shooting	58	13	59	23	69	20			

7.4 The influence of depth on the level of disturbance of marine mammals

There are many factors that could influence the propagation of sound underwater, and therefore influence the response of marine mammals to seismic activity; depth of the water column is one such factor. Seismic surveys in 2000 were conducted in varying locations covering a range of depths. The location recorded on the 'Location and Effort' forms (where these were completed correctly) was used to assign each day to one of three depth categories: 1) continental shelf (0-200 m); 2) shelf slope (200-1,000 m); 3) deep waters (> 1,000 m). A slightly higher proportion of time was spent shooting in deep waters than over the continental shelf or shelf slope (Table 8).

Table 8 Proportion of time spent shooting at different depths (excluding site surveys).

Depth	*Proportion of time spent shooting*
0-200 m	34.99%
200-1,000 m	33.97%
> 1,000 m	38.82%

The depth of water was normally recorded whenever marine mammals were seen. Median, minimum and maximum depths are presented in Table 9. Grey seals, bottlenose dolphins and common dolphins were only seen over the continental shelf, and most white-beaked dolphins were also seen in shelf waters. Risso's dolphins and harbour porpoises were seen over the shelf slope as well as over the continental shelf. Humpback, northern bottlenose and pilot whales were seen predominantly or exclusively in deep waters, while fin, sei and sperm whales were seen over the shelf slope as well as in deep waters. The probable

sighting of a northern right whale occurred over the deeper parts of the shelf slope. Other cetaceans (minke whales, killer whales, white-sided dolphins and possible striped dolphins) were seen in a range of depths.

Table 9 Median and range of depth of marine mammals encountered during seismic surveys

Species	*Median depth of pods (m)*	*Minimum depth (m)*	*Maximum depth (m)*	*Number of pods*
Grey seal	87.5	85	90	2
Cetacean sp.	1,026.5	14	1,640	8
Whale sp.	1,361.5	105	1,990	20
Large whale sp.	1,819.5	1,736	1,903	2
Northern right whale (probable)	950	950	950	1
All baleen whales combined	885	45	2,168	74
Humpback whale	1,013	1,013	1,013	1
Fin whale	995	90	2,168	32
Sei whale	1,070	859	1,523	5
Fin/ sei whale	926.5	623	1,630	2
Fin/ sei/ humpback whale	486	240	980	5
Fin/ sei/ blue/ humpback whale	1,283.5	554	1,880	8
Minke whale	146	45	1,995	21
Sperm whale	936	260	2,093	38
Humpback/ sperm whale	1,013	1,013	1,013	1
Medium whale sp.	636	80	2,700	4
Northern bottlenose whale	1,073.5	1,062	1,085	2
Pilot whale	1,498	85	1,756	13
Killer whale	770	102	1,712	12
All dolphins combined	152	14	2,073	300
Dolphin sp.	127.5	40	2,073	48
Dolphin sp. not porpoise	545	60	1,115	25
Risso's dolphin	359	80	800	5
Bottlenose dolphin	109.5	14	220	8
Unpatterned dolphin	880	880	880	1
White-beaked dolphin	86	50	1,719	86
White-sided dolphin	452.5	66	1,719	94
Lagenorhynchus sp.	184.5	85	1,457	12
Common dolphin	100.5	77	124	2
Striped dolphin (possible)	1,315	160	1,546	3
Common/ white-sided dolphin	1,080	1,080	1,080	1
Common/ striped dolphin	902.5	396	1,409	2
Common/ white-sided/ striped dolphin	1,120	1,120	1,120	1
Patterned dolphin	115	107	775	3
Harbour porpoise	500	40	880	9

There was no consistent pattern in the proportion of sightings occurring during periods of shooting in relation to depth of water (Table 10). Median tests showed that the results were non-significant for all species or species groups.

Table 10 Proportion of marine mammal encounters while shooting, at depths exceeding or not exceeding the median depth for each species, excluding site surveys (* = probability calculated using Fisher exact test due to small sample size; n = sample size; d.f. = degrees of freedom; P = probability; n.s. = not significant).

Species	*Sightings at depths not exceeding median depth - percentage of sightings encountered while shooting*	*Sightings at depths exceeding median depth - percentage of sightings encountered while shooting*	χ^2	*n*	*d.f.*	*P*
Whale sp.	25.00	25.00	*	16	-	n.s.
All baleen whales combined	27.59	24.14	0.000	58	1	n.s.
Fin whale	30.77	16.67	0.127	25	1	n.s.
Minke whale	33.33	22.22	*	18	-	n.s.
Sperm whale	46.67	40.00	0.000	30	1	n.s.
Pilot whale	16.67	0.00	*	12	-	n.s.
Killer whale	0.00	20.00	*	11	-	n.s.
All dolphins combined	17.76	26.42	1.845	213	1	n.s.
Dolphin sp.	17.65	31.25	0.255	33	1	n.s.
Dolphin sp. not porpoise	57.14	50.00	*	13	-	n.s.
White-beaked dolphin	13.51	13.89	0.086	73	1	n.s.
White-sided dolphin	31.25	12.90	2.097	63	1	n.s.
Lagenorhynchus sp.	16.67	20.00	*	11	-	n.s.

7.5 Sightings during the soft-start

There were fourteen sightings of marine mammals during the soft-start (Table 11); four were first seen prior to the soft-start commencing but were still present as the soft-start commenced, while the remainder were all first detected once the soft-start was underway.

Of the four sightings that were first observed prior to the soft-start commencing, three came within 500 m of the airguns at some stage during the encounter. For one of these sightings it was clear that the animals had been within this zone prior to the soft-start commencing and shooting had been delayed until after the animals had moved away from this zone. For another sighting it was clear that the animals came close only after the soft-start had commenced. For the third sighting the information given was ambiguous, but on balance it appeared that the animals probably only came close after the soft-start had commenced.

Reactions of marine mammals to the soft-start can be divided into two categories: instantaneous reactions to the commencement of shooting (e.g. startle responses), and more prolonged reactions throughout the soft-start. An opportunity to observe the former is provided by encounters that span the period prior to and during the soft-start. On one occasion an observer watching a group of pilot whales recorded that, "All submerged when guns started". It is not clear from this ambiguous statement whether the animals submerged as a reaction to the airguns starting, or whether the animals were already submerged when the airguns commenced firing. There were no other occasions when obvious reactions at the instant the airguns commenced firing, i.e. reactions that could constitute a startle response, were noted.

Reactions of marine mammals during the course of the soft-start were apparently mixed. On occasions when marine mammals were seen both prior to and during the soft-start, observers were not always specific about which behaviours occurred before shooting commenced and which occurred when the airguns were firing. However, from these sightings and from those which were first seen during the soft-start, it appears that there were probably three occasions when white-beaked dolphins approached the vessel and engaged in bow-riding after the soft-start had commenced. There was also one occasion when white-sided dolphins were observed feeding, apparently undisturbed, in the latter stages of a soft-start. However, there were also four occasions when cetaceans were observed heading away from the vessel during the soft-start, mostly during the early stages, and sometimes swimming at speed.

Table 11 Sightings during the soft-start, arranged in order of progression through the soft-start

Time elapsed since commencement of soft-start when animals sighted (mins) (and proportion of the soft-start this represents)	*Duration of soft-start (mins)*	*Species*	*Number of animals*	*Closest distance to airguns (metres) (and distance at commencement of soft-start)*	*Behaviour*
Seen beforehand	20	Pilot whale	65	75 [a] (> 500)	Dispersed group; slow-swimming; logging; spy-hopping; approached ship; "All submerged when guns started"
Seen beforehand	32	White-beaked dolphin	20	160 [b] (1,500)	Tail-slapping; fast swimming; jumping; approached vessel; bow-riding; swimming alongside paravane
Seen beforehand	26	White-beaked dolphin	6	360 [b] (550)	Slow swimming; approached vessel; bow-riding for 5 mins then went away
Seen beforehand	24	White-sided dolphin	18	1,800 (2,300)	Heading in general direction of vessel then headed away with periods of fast swimming and porpoising
2 (0.08)	26	Fin whale	1	800	Normal swimming; heading away from vessel
2 (0.08)	24	White-sided dolphin	1	650	Surfacing infrequently; porpoising; heading away from vessel
12 (0.44)	27	*Lagenorhynchus* sp.	1	650	Surfacing infrequently; swimming parallel to vessel in opposite direction
14 (0.45)	31	Common/ striped dolphin	2	420	Fast swimming; avoided vessel (swimming rapidly away)
17 (0.65)	26	Dolphin sp.	20	3,500	Slow swimming; breaching; variable directions
16 (0.76)	21	Sperm whale	1	5,000	Swimming parallel to vessel in same direction then dived
16 (0.76)	21	White-beaked dolphin	4	240	Approached vessel; bow-riding
22 (0.79)	28	Fin whale	3	1,900	Normal swimming
22 (0.85)	26	Harbour porpoise	5	2,000	Fast swimming; swimming parallel to vessel in opposite direction
25 (0.93)	27	White-sided dolphin	8	600	Feeding; variable directions

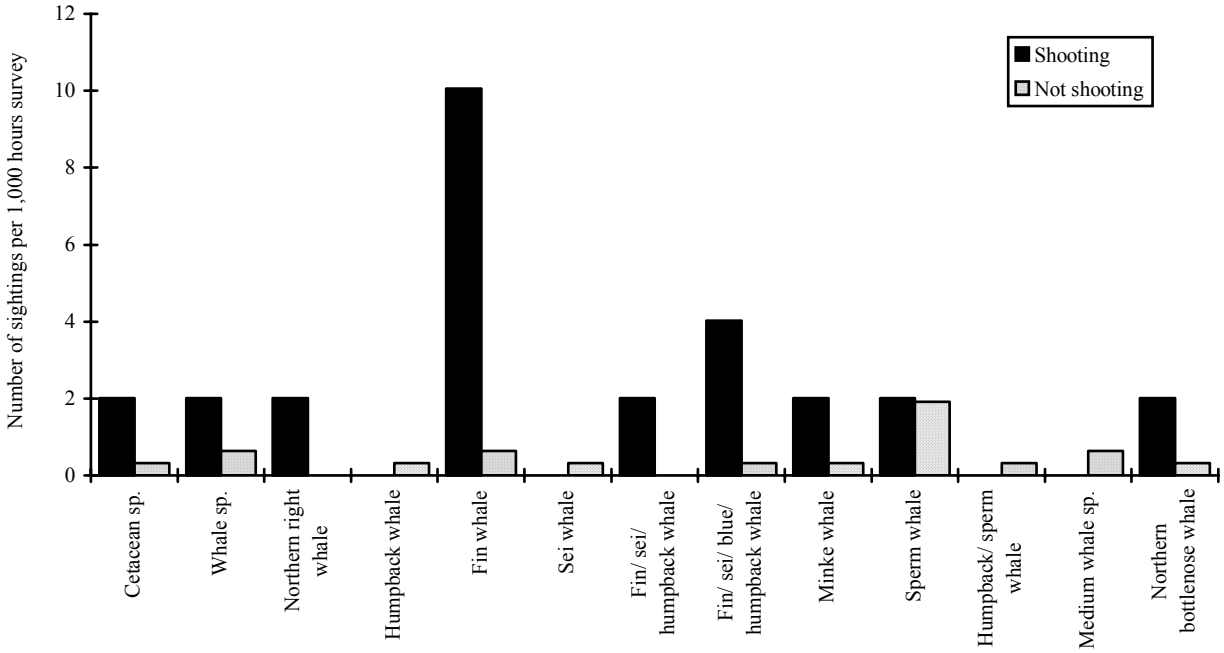
a animals were within 500 m of the airguns prior to the soft-start, but had moved beyond this distance 20 minutes before the soft-start commenced

b animals had not entered within 500 m radius of the airguns before the soft-start commenced

7.6 The effects of site surveys on marine mammals

30% of the time spent watching for marine mammals in 2000 was during site surveys, and 27% of the sightings occurred during these surveys. However, relatively little time was spent shooting during site surveys, resulting in low sample sizes for assessing any effects of seismic activity. In many cases sighting rates were higher during periods of shooting than when the airguns were not firing, although many of the dolphin species were not seen at all during periods of shooting (Figure 32). Sample sizes did not permit statistical testing for any species or species groups.

a) Baleen whales, large and medium odontocetes



b) Small odontocetes

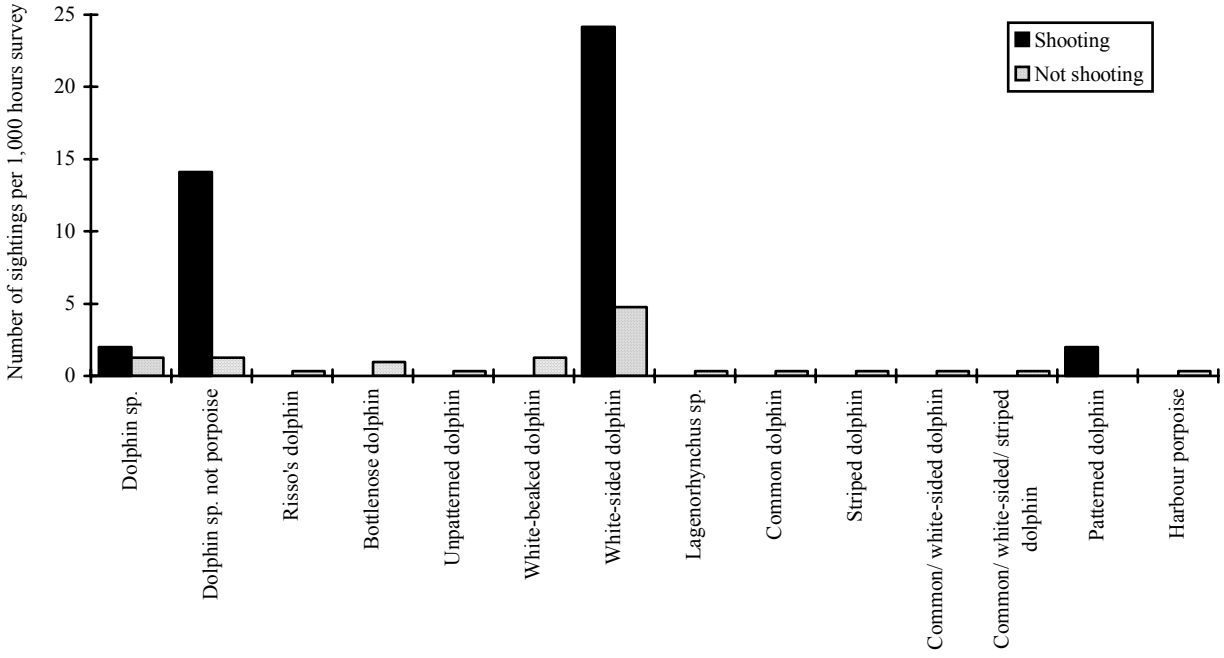


Figure 32 Sighting rates of marine mammals in relation to seismic activity during site surveys (not controlling for location, season or weather conditions).

To reduce potential bias caused by variations in location, season or weather conditions, subsets of data were selected according to the criteria in Table 3. As well as reducing bias, this had the effect of increasing the relative proportion of time spent shooting in the sub-sample, thereby permitting statistical testing in two cases. After controlling for these sources of bias, it could be seen that sighting rates of white-sided dolphins and all dolphins combined did not differ significantly with seismic activity during site surveys (Figure 33; Table 12).

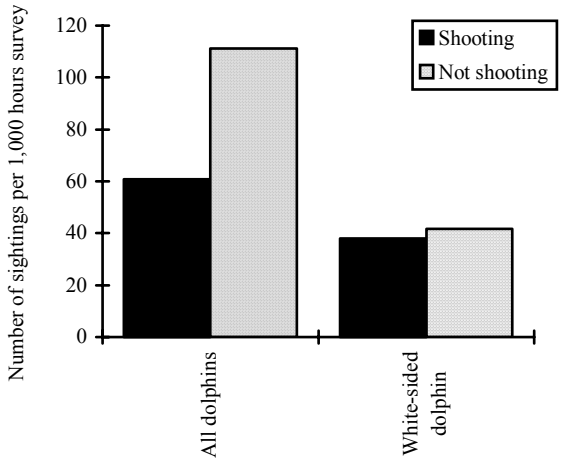


Figure 33 Sighting rates of marine mammals in relation to seismic activity during site surveys, controlling for location, season and weather conditions.

Table 12 Statistical significance of difference in frequency of occurrence of marine mammals in relation to seismic activity during site surveys, controlling for location, season and weather (n = sample size; d.f. = degrees of freedom; P = probability; n.s. = not significant).

Species	χ^2	*n*	*d.f.*	*P*
All dolphins combined	1.999	24	1	n.s.
White-sided dolphin	0.023	11	1	n.s.

The influence of weather conditions on the ability of observers to detect animals was controlled for when comparing the distance of marine mammals from the airguns. Only sightings during better weather conditions, as defined in Table 3, were used. The results are presented where sample sizes equalled or exceeded ten. No significant differences were found in the distance at which white-sided dolphins or all dolphins combined remained from the airguns in relation to seismic activity during site surveys (Figure 34; Table 13). There was only a slight reduction in the proportion of marine mammals occurring within a given range of the airguns during periods of shooting (Figure 35), and this was found to be non-significant (Kolmogorov-Smirnov test χ^2 approximation = 0.488, d.f. = 1).

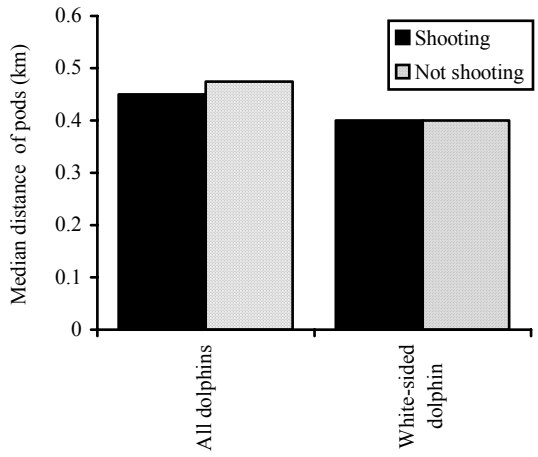


Figure 34 Median distance of marine mammals from the airguns in relation to seismic activity during site surveys

Table 13 Statistical significance of difference in distance of marine mammals in relation to seismic activity during site surveys, controlling for weather (z = Wilcoxon statistic; n = sample size; P = probability; n.s. = not significant).

Species	*z*	*n*	*P*
All dolphins combined	0.230	28	n.s.
White-sided dolphin	0.082	12	n.s.

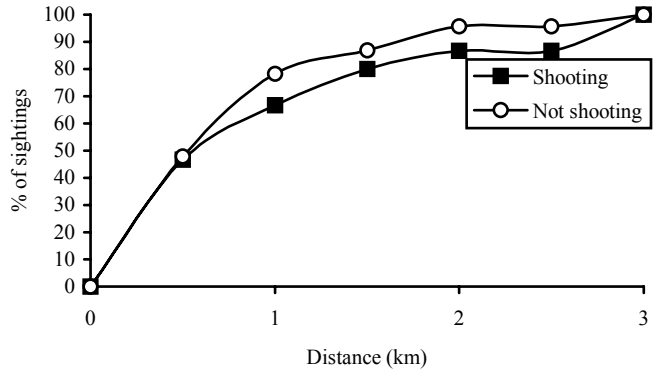


Figure 35 Proportion of marine mammal sightings occurring within specified distances of the airguns during good weather conditions, in relation to seismic activity during site surveys.

Table 14 Behaviour of marine mammals in relation to seismic activity during site surveys (n = sample size; P = probability; n.s. = not significant; - = sample size too small to determine statistical significance).

Behaviour	*Species*	*% of encounters while shooting when behaviour was exhibited*	*% of encounters while not shooting when behaviour was exhibited*	χ^2	*n*	*P*
Feeding	All dolphins combined	8.00	7.94	-	7	-
+ve interactions	All cetaceans combined	2.56	17.05	-	16	-
	All dolphins combined	0.00	20.63	-	13	-
	White-beaked dolphin	0.00	63.64	-	7	-
Breaching, jumping or somersaulting	All cetaceans combined	30.77	15.91	2.922	26	n.s.
	All dolphins combined	44.00	22.22	2.992	25	n.s.
	White-beaked dolphin	100.00	27.27	-	5	-
	White-sided dolphin	50.00	29.41	0.840	12	n.s.
Porpoising	All dolphins combined	20.00	14.29	-	14	-
	White-sided dolphin	14.29	47.06	-	10	-
Fast swimming	All cetaceans combined	25.64	26.14	0.002	33	n.s.
	All dolphins combined	36.00	34.92	0.006	31	n.s.
	White-beaked dolphin	0.00	45.45	-	5	-
	White-sided dolphin	42.86	47.06	0.030	14	n.s.
Slow swimming	All cetaceans combined	38.46	23.86	2.026	36	n.s.
	All dolphins combined	44.00	28.57	1.291	29	n.s.
	White-sided dolphin	35.71	35.29	-	11	-
Surfacing infrequently	All cetaceans combined	23.08	10.23	3.143	18	n.s.
	All dolphins combined	24.00	11.11	-	13	-
Surfacing frequently	All cetaceans combined	10.26	2.27	-	6	-
Diving	All cetaceans combined	10.26	9.09	-	12	-
	All baleen whales	33.00	14.29	-	4	-
	Sperm whale	100.00	57.14	-	5	-
Widely dispersed group	All cetaceans combined	12.82	12.50	-	16	-
	All dolphins combined	20.00	15.87	-	15	-
	White-sided dolphin	28.57	52.94	1.086	13	n.s.

No significant effects of seismic activity on the swimming or surfacing characteristics of marine mammals were observed during site surveys (Table 14). More baleen whales and sperm whales were recorded as diving during periods of shooting, but sample sizes were too small to assess the significance of this. Cetaceans were more likely to breach or jump during periods of shooting, but this was found to be non-significant. Positive interactions of cetaceans, particularly white-beaked dolphins, with the vessel or its equipment occurred more often when the airguns were not firing, but sample sizes were too small to permit statistical testing.

Table 15 presents the direction of travel of marine mammal pods relative to the vessel during site surveys, for all species or species groups where this was recorded on ten or more occasions. Sample sizes were only sufficient to permit statistical testing for all dolphins combined and all cetaceans combined, but in both cases the results were found to be significant. For all dolphins combined, fewer were found to be travelling towards the vessel, across its path or in the same direction as it during periods of shooting, while more were heading away from the vessel, parallel to it in the opposite direction or heading in varying directions. For all cetaceans combined, fewer were found to be heading towards the vessel than in other directions during periods of shooting.

Table 15 Direction of travel of marine mammals relative to the survey vessel in relation to seismic activity during site surveys (d.f. = degrees of freedom; P = probability; n.s. = not significant; - = sample size too small to determine statistical significance).

Species	*Seismic activity*	*Towards ship*	*Away from ship*	*Crossing path of ship*	*Parallel to ship in same direction*	*Parallel to ship in opposite direction*	*Milling or variable*	χ^2	*d.f.*	*P*
All baleen whales combined	Shooting		1	3		5	1	-	-	-
	Not shooting	1	1		1	3	1			
All dolphins combined	Shooting		5	2	2	13	3	15.037	3	< 0.01
	Not shooting	15	6	13	9	13	7			
Dolphin sp.	Shooting						1	-	-	-
	Not shooting	3	1	5	4	1	1			
Dolphin sp. not porpoise	Shooting		1		1	5		-	-	-
	Not shooting			1	1	3				
White-beaked dolphin	Shooting			1		1		-	-	-
	Not shooting	7	1		1	1	1			
White-sided dolphin	Shooting		3	1	1	7	2	-	-	-
	Not shooting	1	3	6	2	3	2			
All cetaceans combined	Shooting		6	5	2	20	6	18.079	5	< 0.01
	Not shooting	20	10	14	10	19	13			

Little time was spent shooting over the continental shelf during site surveys, while more time was spent shooting over the shelf slope or deep waters (Table 16). For all dolphins combined, a higher proportion were seen during periods of shooting in deeper waters than was the case in shallower waters (Table 17). While this could reflect an increased tolerance of shooting in deeper waters, it is more likely to reflect the increased time spent shooting in these areas.

Table 16 Proportion of time spent shooting at different depths during site surveys

Depth	*Proportion of time spent shooting*
0-200 m	7.89%
200-1,000 m	43.28%
> 1,000 m	45.73%

Table 17 Proportion of marine mammal encounters while shooting during site surveys, at depths exceeding or not exceeding the median depth for each species (* = probability calculated using Fisher exact test due to small sample size; n = sample size; d.f. = degrees of freedom; P = probability; n.s. = not significant).

Species	*Sightings at depths not exceeding median depth - percentage of sightings encountered while shooting*	*Sightings at depths exceeding median depth - percentage of sightings encountered while shooting*	χ^2	*n*	*d.f.*	*P*
All baleen whales combined	55.56	62.50	*	17	-	n.s.
All dolphins combined	11.36	46.51	11.459	87	1	< 0.001
Dolphin sp.	0.00	14.29	*	15	-	n.s.
Dolphin sp. not porpoise	66.67	50.00	*	12	-	n.s.
White-beaked dolphin	0.00	33.33	*	13	-	n.s.
White-sided dolphin	50.00	40.00	0.039	31	1	n.s.

8. Compliance with guidelines

Compliance with the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* was measured in several ways. The aspects considered were: 1) the level of notification and reporting of seismic surveys; 2) the use of appropriate personnel as marine mammal observers; 3) the maintenance of an adequate watch for marine mammals prior to shooting commencing; 4) the delay in commencing shooting if marine mammals were close by; and 5) the use of a soft-start procedure. Application of the guidelines is required under licence conditions in blocks licensed in the 16th and subsequent rounds of offshore licensing. However, all companies have agreed through their trade associations (UKOOA, IAGC) to adopt the guidelines throughout UK waters. It was assumed that if a report was received from a survey then the operator or contractor intended to comply with the guidelines during that survey, thus the maintenance of a watch, delays put into effect and the use of a soft-start were monitored for all surveys from which reports were received. 'Record of Operations' forms were used to obtain this information - these forms were completed correctly for 57.5 surveys.

8.1 Notification and reporting of surveys

In total, JNCC received notification of and/or reports from 100 seismic surveys (including site and similar surveys) conducted in UK or adjacent waters during 2000. Those in UK waters were separated into those conducted in blocks licensed in the 16th, 17th and 18th rounds of offshore licensing (where compliance with the guidelines, and thus notification and submission of a report, is a licence condition) and those conducted in other blocks.

JNCC received notifications of and/or reports from 34 seismic surveys conducted during 2000 in blocks licensed in the 16th, 17th and 18th rounds of offshore licensing. For four of these surveys no report was received, while for another four surveys no notification was received. Overall, the proportion of surveys that were both notified and reported had decreased slightly from levels in 1999, but was still greater than in previous years (Table 18).

Table 18 Notification and reporting of seismic surveys in blocks subject to the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys*, 1996-2000.

Notification and/or report received	***1996***	***1997***	***1998***	***1999***	***2000***
Notification and report	38%	51%	56%	81%	76%
Notification only (no report)	17%	40%	29%	16%	12%
Report only (no notification)	45%	9%	15%	3%	12%

JNCC received notification of and/or reports from 63 additional seismic surveys taking place in UK waters in 2000. There were only four surveys in blocks licensed outside the 16th, 17th and 18th rounds of offshore licensing that were not notified, but there were 21 surveys where reports were not submitted, although in ten cases no airguns were used ('Location and Effort' forms might nevertheless have been expected from these surveys).

Three reports were received from seismic surveys in waters adjacent to UK waters (Norwegian, Danish and Irish). Data from these were incorporated into the database for examining marine mammal distribution and assessing the effects of seismic activity on marine mammals, but these data were excluded when assessing compliance with the guidelines.

Reports were also received from three seismic surveys conducted outside European waters. It is also known that there were at least two additional seismic surveys outside UK waters that were conducted in accordance with the guidelines. A number of reports were also sent in from other vessels and platforms used by the oil industry, working in UK waters. Only data received from seismic survey vessels operating in UK or adjacent waters fall within the scope of the present report, but those vessels and platforms contributing additional data are listed in Appendix 4 and the data have been retained for future use.

8.2 The use of appropriate personnel

The term 'dedicated marine mammal observer', from here onwards, is taken to mean someone with experience of marine mammal observations, dedicated to that task alone during the survey, and whose normal role on seismic surveys is that of marine mammal observer. It does not include those personnel who are normally fishery liaison officers, but who may on occasion be dedicated to the task of marine mammal observations. The term 'dedicated observer' includes any personnel dedicated to the task of marine mammal observations, i.e. does include fishery liaison officers who may be dedicated to marine mammal observations for a specific survey.

The use of dedicated marine mammal observers on seismic surveys in UK waters has slowly increased since the guidelines were introduced in 1995 (Figure 36). The number of surveys with dedicated marine mammal observers was compared to the total number of known seismic surveys, including those where reports were not submitted (but excluding surveys where no airguns were used, where used of a dedicated marine mammal observer would not be expected). It was assumed that if no report was submitted then a dedicated marine mammal observer was not used. Eighteen surveys used dedicated marine mammal observers; on six of these two dedicated marine mammal observers were used. Although the use of dedicated marine mammal observers has increased, most surveys during 2000 continued to use fishery liaison officers or members of ships' crews to undertake the additional role of marine mammal observer, while a small number used fishery liaison officers dedicated to undertaking marine mammal observations. It was only site surveys that relied entirely on members of ships' crews to carry out observations. Over one-fifth of site surveys during 2000 relied solely on ships' crew members to fulfil the role of marine mammal observer. Dedicated marine mammal observers were used less often on site surveys (15%) than on larger scale surveys (25%).

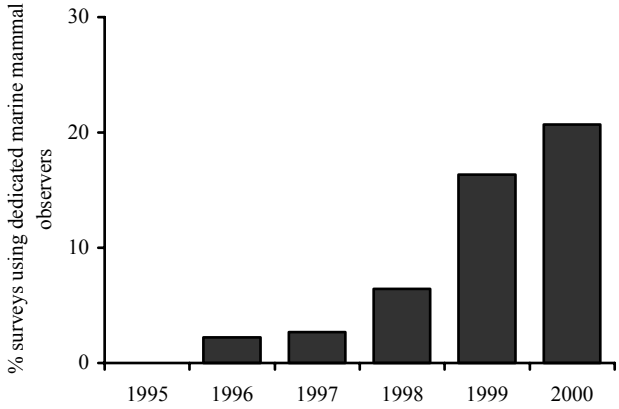


Figure 36 The proportion of seismic surveys in UK waters for which dedicated marine mammal observers were used

In areas of importance for marine mammals, the guidelines require that operators should seek to provide the most appropriately qualified and experienced personnel to act as marine mammal observers. Waters to the west of Shetland and in the Rockall area are important for marine mammals in general, while other areas may also be important, particularly for certain species (e.g. the northern North Sea for white-beaked dolphin, bottlenose dolphin, minke whale and harbour porpoise). There were 15 surveys in areas West of Shetland and Rockall during 2000; seven used dedicated marine mammal observers, five used fishery liaison officers to undertake the additional role of marine mammal observer, while for the remaining three no reports were received, thus it is assumed that no observations were undertaken. Most of the surveys in these areas without dedicated marine mammal observers were site surveys and most were of relatively short duration. Where fishery liaison officers were used in place of dedicated marine mammal observers, these personnel had all undergone training.

On some occasions when notification was received of a survey in an area of importance for marine mammals, JNCC specifically requested the presence of a particular type of personnel, e.g. dedicated, trained marine mammal observers. There were 21 surveys for which such requirements were made. Sometimes requirements were made for two observers, referred to here as the primary and secondary observers. Table 19 summarises the extent to which the actual observers used met the requirements specified. While primary

observers did not always meet the specified criteria, they did so more often than secondary observers. When secondary observers were requested, less than half met the specified requirements. There were a number of occasions when no observers were used in spite of specific requests.

Table 19 Compliance with specific requests for type of observer

Observer	*Observer met requirements*	*Observer did not meet requirements*	*No observer used*
Primary	13 (61.90%)	4 (19.05%)	4 (19.05%)
Secondary	7 (41.18%)	5 (29.41%)	5 (29.41%)

JNCC often requested that observers were trained, i.e. had attended an appropriate training course specific to working as a marine mammal observer on seismic surveys. In areas where marine mammals are likely to be abundant it is important that the marine mammal observer is dedicated (i.e. does not undertake any other role during the survey), and therefore is not distracted by other duties. In many cases JNCC requested the presence of dedicated observers. In some cases, in areas of importance for marine mammals, the observer was required to be a cetacean biologist. For primary observers, the requirement least often met was for the observer to be a cetacean biologist. For secondary observers, the requirement least often met was that they were dedicated to the task of marine mammal observations.

There were a few instances where the specified requirements were exceeded. For example, there were two surveys that used cetacean biologists when the specific requests made did not include this requirement. There were also nine surveys where cetacean biologists were used where no specific requests for observers were made. However, it must be remembered that for surveys in areas of importance for marine mammals the guidelines require operators to provide "the most appropriately qualified and experienced personnel to act as marine mammal observers .... If possible, such observers should be experienced cetacean biologists". Therefore it should be expected that qualified, experienced cetacean biologists should be used for some surveys as a matter of course, without a specific additional request from JNCC.

8.3 Watches for marine mammals

The guidelines require that a watch for marine mammals commences at least 30 minutes prior to any use of the airguns. For surveys where 'Record of Operations' forms were completed correctly, the times of watches could be checked against the times of shooting. During 2000 there were 2,543 recorded occasions when the airguns were used in UK waters, of which 1,678 occurred during daylight hours. During hours of darkness a visual search for marine mammals was not possible. A pre-shooting search of adequate duration (at least 30 minutes) was carried out for 77% of occasions when use of the airguns commenced during daylight hours (79% in 16th, 17th and 18th round blocks, and 75% in other blocks). There were a number of occasions when the pre-shooting search was either absent or shorter than the required minimum duration.

Inadequate pre-shooting searches were more common during site surveys than during larger scale surveys (Table 20). Absent searches were slightly more common in blocks licensed in the 16th, 17th and 18th rounds of offshore licensing, while short searches were more common in other blocks, particularly on site surveys. Most short searches were between 20 and 29 minutes duration, but some were very short, with a duration of less than ten minutes. A small number of pre-shooting searches terminated before shooting commenced (excluding those at the end of the day that stopped when darkness fell).

Table 20 Duration of pre-shooting searches for marine mammals

Duration of search	*16th, 17th and 18th round blocks*		*Other blocks*		*All surveys combined*
	Not site surveys	*Site surveys*	*Not site surveys*	*Site surveys*	
No search	14 (3.35%)	10 (3.32%)	14 (2.23%)	3 (0.90%)	41 (2.44%)
Search stopped before firing commenced	0 (0.00%)	1 (0.33%)	4 (0.64%)	5 (1.51%)	10 (0.60%)
1-9 minutes	1 (0.24%)	14 (4.65%)	1 (0.16%)	70 (21.08%)	86 (5.13%)
10-19 minutes	2 (0.48%)	9 (2.99%)	1 (0.16%)	21 (6.33%)	33 (1.97%)
20-29 minutes	36 (8.61%)	62 (20.60%)	33 (5.26%)	85 (25.60%)	216 (12.87%)
30 minutes or more	365 (87.32%)	205 (68.11%)	574 (91.55%)	148 (44.58%)	1,292(77.00%)

Short or prematurely terminated searches were most common when members of ships' crews were fulfilling the role of marine mammal observer (Table 21). Dedicated marine mammal observers provided the highest standard of pre-shooting searches, while members of ships' crews provided the lowest standard, accounting for a high proportion (61%) of the inadequate pre-shooting searches on site surveys.

Table 21 Duration of pre-shooting searches for marine mammals in relation to type of observer

Duration of search	*Dedicated marine mammal observer*	*Fishery liaison officer*	*Ship's crew*
No search	22 (2.84%)	16 (2.31%)	3 (1.44%)
Search stopped before firing commenced	4 (0.52%)	1 (0.14%)	5 (2.39%)
1-9 minutes	8 (1.03%)	13 (1.88%)	65 (31.10%)
10-19 minutes	8 (1.03%)	8 (1.15%)	17 (8.13%)
20-29 minutes	44 (5.67%)	90 (12.99%)	82 (39.23%)
30 minutes or more	690 (88.92%)	565 (81.53%)	37 (17.70%)

8.4 Delays in shooting

Observers were asked to record on the 'Record of Operations' form whether marine mammals were present before shooting commenced, and what action was taken if necessary. As an additional check, 'Record of Sighting' forms were cross-referenced with the 'Record of Operations' forms - for all sightings where animals occurred within 500 m of the airguns when the airguns were not already firing, the time recorded on the 'Record of Sighting' form was checked against the 'Record of Operations' form to ascertain how much time had elapsed between the last sighting of the animals and firing next commencing.

There were ten occasions during 2000 when marine mammals were detected within 500 m of the airguns when shooting was due to commence (Table 22), out of a total of 2,596 uses of the airguns (i.e. a delay situation occurred for less than 0.5% of survey lines). Three of these instances occurred in blocks licensed prior to the 16th round of offshore licensing, or outside UK waters, therefore compliance with the guidelines was not a licence condition. The remaining seven instances occurred in blocks where compliance with the guidelines was a licence condition.

Table 22 Marine mammal sightings occurring within 500 m of the airguns at times when shooting was due to commence

Species	*Distance from airguns (metres)*	*Action taken*	*Minutes after last sighting when firing began*	*Duration of soft-start (minutes)*	*Sighting noted on 'Record of Operations' form*	*Block licence*
Sperm whale + white-sided dolphin	200	Delayed shooting	20	14 (site survey)	Yes	16th round
Pilot whale	75	Delayed shooting	20 *	20	Yes	17th round?
Dolphin sp.	200	Delayed shooting	23	20 (site survey)	Yes	16th round
Bottlenose dolphin	500	Delayed shooting	25	26	Yes	Irish
White-beaked dolphin	380	No action	14	27	No	Not 16th/17th/18th round
White-sided dolphin	200	Delayed shooting	21	9 (not full power)	Yes	17th round
White-sided dolphin	200	Delayed shooting	30	51	Yes	17th round
White-sided dolphin	300	Delayed shooting	37	23 (site survey)	Yes	16th round
White-sided dolphin	400	Delayed shooting	20	20	Yes	18th round
White-sided dolphin	460	Delayed shooting	20	20	Yes	Not 16th/17th/18th round

* time after the animals had left the 500 m zone around the airguns

There was full compliance with the guidelines on six of the seven occasions where licence conditions dictated that the guidelines should have been followed. In all seven cases shooting was delayed for at least 20 minutes

after the animals were last seen (or in one case, 20 minutes after the animals left the 500 m zone around the airguns). On one occasion the subsequent soft-start reached full power levels in less than 20 minutes, but on all other occasions when full power was reached, the duration of the soft-start met or exceeded the required minimum of 20 minutes. On all seven occasions, dedicated marine mammal observers were used.

There were two occasions in UK waters outside 16th, 17th or 18th round blocks when marine mammals came within 500 m of the airguns when shooting was due to start. In both instances dedicated marine mammal observers were used, but the correct procedures under the guidelines were followed in only one case. In the other case the airguns commenced firing just 14 minutes after white-beaked dolphins were bow-riding. It was recorded that the dedicated marine mammal observer conducted the pre-shooting search, but the dolphins were seen by the chief steward and fishery liaison officer. It is not known how soon they informed the marine mammal observer or any members of the seismic crew. The marine mammal observer was apparently unaware, even after the event, that there had been any transgressions in the guidelines. In his report he wrote "On no occasions were marine mammals sighted within 500 m of the airguns and within 20 minutes of the soft-start. No delays to the survey due to the presence of marine mammals therefore occurred."

There was one instance when marine mammals came within 500 m of the airguns when shooting was due to commence in Irish waters. Although not subject to the guidelines, shooting was delayed for at least 20 minutes after the last sighting and the subsequent soft-start was at least 20 minutes long. On this occasion a fishery liaison officer was acting as marine mammal observer.

8.5 Soft-starts

The guidelines state that whenever the airguns are used there should be a soft-start procedure, with the power building up gradually from a low energy level to full power over at least 20 minutes. Observers routinely recorded the time of commencement of the soft-start and the time when full power was reached on the 'Record of Operations' form. Occasions when the airguns never reached full power (e.g. if shooting was aborted during the soft-start) were disregarded in the analysis, as were occasions when problems with the airguns resulted in unusually protracted soft-starts. Soft-starts during test firing of the airguns were analysed separately, as the soft-start could also be unusually protracted at these times. There was one occasion when JNCC permitted a shortened soft-start for five survey lines because of difficulties due to an exclusion zone around diving operations; these soft-starts were also excluded from the analysis.

The guidelines recognise that on some site surveys the seismic sources always remain at low power levels, but guidance issued by JNCC in March 2000 states that site surveys should use a full soft-start unless a prior waiver has been agreed with JNCC. The duration of soft-starts for site surveys was analysed separately from other surveys.

For larger scale surveys in 16th, 17th and 18th round blocks, where the duration of the soft-start should always have been at least 20 minutes, the mean duration was 23 minutes (Table 23). For these surveys, a high proportion of soft-starts met or exceeded the required minimum duration of 20 minutes. Only 5% were shorter than 20 minutes and none were absent. Outside these blocks the standard of soft-starts was slightly lower, with 10% being shorter than 20 minutes, but again none being absent. Only a small number of soft-starts were longer than one hour.

Table 23 Soft-starts used during seismic surveys in 2000 (excluding site surveys).

Parameter	*16th/17th/18th round blocks*	*Other blocks*
Minimum duration (minutes)	1	1
Maximum duration (minutes)	112	145
Mean duration (minutes)	23	25
Sample size	558	919
Number of occasions when there was:		
no soft-start	0 (0.00%)	0 (0.00%)
soft-start < 20 minutes	28 (5.02%)	96 (10.45%)
soft-start > 1 hour	7 (1.25%)	9 (0.98%)
soft-start ≥ 20 minutes	530 (94.98%)	823 (89.55%)

When airguns were used during site surveys, the standard of soft-starts was considerably lower (Table 24). The standard also varied depending on the location of the survey. In 16th, 17th and 18th round blocks, where

compliance with the guidelines is a licence condition, slightly over one-third of soft-starts met or exceeded the required minimum duration (although over one-third were absent). Outside these blocks, less than 1% of soft-starts were of adequate duration. A high proportion of soft-starts on site surveys outside 16th, 17th or 18th round blocks were absent. For a number of site surveys it was reported that the crew and observers, whether fishery liaison officers or marine mammal observers, came to an agreement that full soft-starts were not necessary, without consulting JNCC. There was only one site survey where an observer, in this case a dedicated marine mammal observer, consulted JNCC to ask whether a waiver could be granted. A waiver was not granted, so full soft-starts were used for that survey.

Table 24 Soft-starts used during site surveys in 2000

Parameter	*16th/17th/18th round blocks*	*Other blocks*
Minimum duration (minutes)	0	0
Maximum duration (minutes)	35	23
Mean duration (minutes)	11	2
Sample size	452	516
Number of occasions when there was:		
no soft-start	180 (39.82%)	331 (64.15%)
soft-start < 20 minutes	105 (23.23%)	181 (35.08%)
soft-start > 1 hour	0 (0.00%)	0 (0.00%)
soft-start ≥ 20 minutes	167 (36.95%)	4 (0.78%)

On larger scale surveys short soft-starts were more prevalent when fishery liaison officers were carrying out marine mammal observations (whether dedicated or not) than when dedicated marine mammal observers were used (Table 25). There were no cases when members of ships' crews were responsible for marine mammal observations on surveys with large airgun arrays. However, members of ships' crews were often used on site surveys, and when this was the case less than 1% of soft-starts were of adequate duration (Table 26). There were also very few soft-starts of adequate duration when fishery liaison officers were used on site surveys, and a high proportion of soft-starts in these cases were absent. The highest standard of soft-starts on site surveys occurred when dedicated marine mammal observers were used, but even then fewer than half of the soft-starts were of adequate duration.

Table 25 Duration of soft-starts in relation to type of observer (excluding site surveys).

Parameter	*Dedicated marine mammal observer*	*Fishery liaison officer*	*Ship's crew*
Sample size	712	765	-
Number of occasions when there was:			
no soft-start	0 (0.00%)	0 (0.00%)	-
soft-start < 20 minutes	41 (5.76%)	83 (10.85%)	-
soft-start ≥ 20 minutes	671 (94.24%)	682 (89.15%)	-

Table 26 Duration of soft-starts on site surveys in relation to type of observer

Parameter	*Dedicated marine mammal observer*	*Fishery liaison officer*	*Ship's crew*
Sample size	376	347	245
Number of occasions when there was:			
no soft-start	92 (24.47%)	318 (91.64%)	101 (41.22%)
soft-start < 20 minutes	129 (34.31%)	14 (4.03%)	143 (58.37%)
soft-start ≥ 20 minutes	155 (41.22%)	15 (4.32%)	1 (0.41%)

On most occasions reasons for short or absent soft-starts were not given. In a few cases pressures of time-sharing were cited. There was one instance when an observer recorded that two soft-starts were "legitimately short (as defined in the guidelines), permitted as part of a time-share arrangement". There are no exemptions mentioned for time-sharing in the guidelines, and the guidance note issued early in 2000 emphasises that full soft-starts should be used even in time-share situations. The observer in this case was a

dedicated marine mammal observer, but although she had experience of marine mammal observations she had little experience of seismic surveys and had not undergone training.

For the survey where shortened soft-starts were permitted because of an exclusion zone around divers, JNCC stated that soft-starts of 5-8 minutes duration would be permissible for five survey lines, and requested that these lines were shot in daylight and in calm conditions to allow the maximum possible chance of detecting any marine mammals present. Four of the soft-starts had a duration of three minutes or less, and two of these were in conditions of poor visibility (500 m and 200 m). On this survey a dedicated marine mammal observer was present. There was a similar situation on another survey where eight soft-starts were shortened due to the proximity of divers, but no consultation with JNCC was held before shortening the soft-starts. In this case a fishery liaison officer was acting as marine mammal observer.

There was one site survey where a single airgun was fired intermittently at approximately five minute intervals between lines, before beginning the proper soft-start. The dedicated marine mammal observer on this survey recognised that this was not a typical procedure under the guidelines, but it is not known whether he tried to dissuade the crew from this practice.

There were 22 occasions when full power was reached during testing of the airguns. In only one case was the soft-start less than 20 minutes long. There were additionally 54 occasions when the airguns were tested without full power being reached. Such tests could at times be protracted, with a maximum duration of test firing at less than full power being 260 minutes.

9. Quality of observations

'Location and Effort' forms were completed correctly for 69% of surveys from which reports were received in 2000. This represents an increase in standards from 1999 but a decline in standards from some previous years (Table 27). Dedicated marine mammal observers nearly always completed these forms correctly - errors or missing forms were mostly attributable to fishery liaison officers or members of ships' crews. The forms were not completed for 11 (15%) surveys from which reports were received, all of which were site surveys. Of these 11 surveys, 5.5 were using untrained members of the ship's crew to act as marine mammal observers; these personnel were possibly unaware of the existence of the forms. 'Location and Effort' forms were completed but were incorrect for 12.5 (17%) surveys from which reports were received. On ten of these surveys there was a common error: observers recorded the number of hours spent shooting during a 24 hour period rather than during the time that they were watching for marine mammals. This was found to be a common error during 1997, so training seminars from 1998 onwards have specifically addressed this issue. On 8.5 of the ten surveys where this error was made the observers were either untrained or were trained prior to 1998. The majority of trained observers making this mistake, irrespective of the date of their training, were initially completing the 'Location and Effort' forms correctly after they had been trained, with the mistake occurring as time elapsed since their training. There were three other types of error found on the 'Location and Effort' form, each occurring in only one instance, and all by untrained observers.

Table 27 Standard of recording forms on surveys from which reports were received (* = information not available).

	1996	*1997*	*1998*	*1999*	*2000*
'Location and Effort' form completed correctly	60%	72%	78%	53%	69%
'Record of Operations' form completed correctly	n/a	n/a	81%	82%	84%
Downgraded sightings on 'Record of Sighting' form	*	35%	25%	23%	13%
No description on 'Record of Sighting' form	*	12%	3%	10%	2%
Identification wrong	*	5%	2%	<1%	<1%

Most of the instances where 'Record of Operations' forms were not completed or were completed incorrectly can also be attributed to untrained or not recently trained fishery liaison officers or members of ships' crews. These forms were completed correctly for 84% of the surveys where airguns were used and from which reports were received, which represents a marginal improvement from previous years (Table 27). They were not completed for 13% of these surveys and contained errors for only 3% of surveys. Untrained observers or observers trained prior to the introduction of the 'Record of Operations' form accounted for 6.5 of the 8.5 surveys where this form was not completed. All surveys where this form was either not completed or was completed incorrectly were site surveys.

There appeared to be a problem with completing the recording forms on site surveys. There should be no seismic surveys (including site surveys) for which no forms are completed and returned to JNCC; even if no airguns are used and no sightings occur, the 'Location and Effort' form should still be completed, recording the length of time spent watching for marine mammals. If airguns are used 'Record of Operations' forms should also be completed recording details of their use. If there are any sightings of marine mammals the 'Record of Sighting' form should be completed. At least one type of recording form that should have been completed was missing for over half (51%) of all known site surveys in UK waters in 2000, while for one-quarter (25%) no recording forms of any kind were submitted.

The quality of descriptions given on the 'Record of Sighting' form had improved in 2000 (Table 27). The proportion of identifications that were downgraded due to missing or inadequate descriptions had decreased to 13%. The proportion of forms with no description was as its lowest ever level, these coming mostly from untrained observers. There was only a very small proportion of sightings where the identification was definitely wrong i.e. did not agree with the description given, which represents a continued improvement from earlier years.

Identification by trained observers was generally better than that by untrained observers (Table 28); fewer identifications were downgraded for trained observers, fewer sightings had no accompanying description and they used the broad categories of 'cetacean', 'whale', 'large whale', 'medium whale', 'dolphin' or 'seal' less often. Dedicated marine mammal observers, who were mostly cetacean biologists, had better identification skills than fishery liaison officers or members of ships' crews (Table 29).

Table 28 Identification skills of trained and untrained observers

	Trained observer	*Untrained observer*
Identification downgraded	8%	21%
No description	1%	4%
Broad identification categories used	13%	24%

Table 29 Identification skills and detection ability of different types of observers

	Dedicated marine mammal observer	*Fishery liaison officer*	*Member of ship's crew*
Identification downgraded	9%	26%	24%
No description	1%	1%	4%
Broad identification categories used	13%	29%	32%
Mean detection rate per 1,000 hours	126.51	51.67	0.00

Dedicated marine mammal observers were much more efficient at detecting marine mammals than fishery liaison officers; in most cases fishery liaison officers were not dedicated to the task of marine mammal observations, and their other duties may at times have distracted them. Using only periods of good weather conditions during surveys in areas and months of peak marine mammal abundance the detection rate for dedicated marine mammal observers was at least double that of other personnel (Table 29; figures exclude sightings brought to the observer's attention by other personnel). There were only two sightings on the 15 surveys where members of ships' crews were assigned the task of marine mammal observations, although during other surveys these personnel were responsible for 23 incidental sightings.

There was one aspect of completion of the 'Record of Sighting' form that caused minor difficulties in the analysis. When seismic activity (i.e. whether the airguns were firing or not) changed during the course of an encounter with marine mammals, observers sometimes did not distinguish between behaviours observed while the airguns were firing and those observed when they were not firing. Although it is only a minority of sightings for which seismic activity changes, it would be useful if such distinctions could be made.

As with other years, there were several reports where old versions of the forms had been used, and therefore some information that is now requested was omitted.

10. Discussion

10.1 Distribution of marine mammals

Survey effort was unequal, varying both spatially and temporally. This will have influenced the observed distribution of marine mammals. Nevertheless, broad patterns of distribution were apparent which for many species concurred with previous knowledge.

Fin, sei, sperm, pilot and northern bottlenose whales were all seen predominantly or exclusively in deep waters, as would be expected (Clark and Charif 1998; Evans 1990; JNCC 1995; NERC 1998; Pollock *et al.* 2000; Skov *et al.* 1995; Stone 1997, 1998a, 2000, 2001; Thompson 1928). One probable fin whale was seen in the shallower waters of the North Sea; there have occasionally been probable sightings of this species in the North Sea previously (Camphuysen and Winter 1995; NERC 1998). The only sighting of a humpback whale also occurred in deep waters. Although humpback whales are sometimes seen in inshore waters around the UK (e.g. Fisher 2000; NERC 1998), they are known to occur in deep offshore waters (Clark and Charif 1998; Pollock *et al.* 2000; Stone 1997, 1998a, 2000, 2001). White-sided dolphins were common in both deep offshore waters of the Faroe-Shetland Channel and in the shallower shelf waters of the northern North Sea, both areas where they have been found previously (Evans 1990, 1992; JNCC 1995; NERC 1998; Pollock *et al.* 2000; Skov *et al.* 1995; Stone 1997, 1998a, 2000, 2001).

For some other species, most sightings occurred in shelf waters, e.g. minke whale, Risso's dolphin, bottlenose dolphin, white-beaked dolphin, and harbour porpoise. Of these, white-beaked dolphins were mostly restricted to the northern North Sea, where concentrations have been found previously (Evans 1992; NERC 1998; Northridge *et al.* 1995), while other species were more widespread. Evans (1992) records the minke whale as being widely distributed along the Atlantic seaboard of Britain and Ireland but also occurring regularly in the northern and central North Sea, which concurs with the observed distribution during seismic surveys in 2000. Bottlenose dolphins were sometimes seen relatively close inshore; while this species sometimes occurs in offshore waters, it is more often recorded in inshore waters (Evans 1992). Risso's dolphins are also known to occur close inshore (Evans 1992; JNCC 1995), although sightings of this species from seismic surveys during 2000 occurred some distance from land. Harbour porpoises are known to be widespread around the UK (Northridge *et al.* 1995).

For some species latitude (and presumably sea temperature) influenced distribution. Killer whales were seen in northern areas, while common dolphins were seen to the south-west of the UK, in St. George's Channel. For both species this concurred with previous knowledge of their distribution (e.g. Evans 1992; JNCC 1995). It is likely that some of the unidentified dolphins seen in the Celtic Sea and South-West Approaches were common dolphins.

There were three possible sightings of striped dolphins, all occurring north of 61°N. Around the UK this species is mostly seen in south-western waters, although a northwards expansion has been noted with sightings occurring in deep waters to the west of Scotland (Evans 1992), and several freshly dead animals stranding in Shetland in 1999 (Fisher 2000).

Perhaps the most notable cetacean sighting during 2000 was that of a probable northern right whale, near the 1,000 m isobath to the north of Shetland. The northern right whale is endangered, with an estimated 300 animals in the north-west Atlantic (IWC 2001), and very few in the north-east Atlantic. There have only been eight confirmed sightings (comprising 11 individuals) in the north-east Atlantic since 1960 (Øien *et al.* 2001). The most recent confirmed sighting in the north-east Atlantic was in a Norwegian fjord (at 69°N) in September 1999, and was identified from photographs as being an adult male from the north-west Atlantic stock. All other confirmed sightings of northern right whales in the north-east Atlantic since 1960 have been between 28°N and 52°N. The identity of the northern right whale seen during seismic surveys in 2000 was not certain, and therefore it must remain as an unconfirmed sighting.

No common seals were seen during seismic surveys in 2000. Grey seals were seen off the east coast of Scotland, where there are a number of breeding sites.

10.2 The effects of seismic activity on marine mammals

As in previous years, there was some evidence of avoidance by dolphins during periods of shooting. Only two species of dolphin (white-beaked and white-sided dolphins) were seen sufficiently often to enable comparison of periods of shooting with periods when the airguns were silent. Sighting rates of white-sided dolphins were lower during periods of shooting, while both white-sided and white-beaked dolphins were observed to remain further from the airguns when they were firing, as did all dolphins combined. When all dolphins were combined, fewer were observed to be heading towards the vessel and more away from the vessel during periods of shooting, and fewer engaged in positive interactions with the vessel or its equipment at these times. All of the aforementioned effects could suggest avoidance of the area immediately around the vessel during periods of seismic activity. Similar effects have been observed in white-beaked dolphins, white-sided dolphins and all dolphins combined in most years since recording forms were first issued to collect data from UK seismic surveys (Stone 1997, 1998a, 2001). There has also been evidence of avoidance of seismic activity by common dolphins (Goold 1996).

Dolphins use higher frequencies than those typically emitted by seismic airguns; seismic exploration generally utilises frequencies up to 220 Hz while the greatest auditory sensitivities of dolphins lie within the range 10-150 kHz (Evans and Nice 1996, from various sources). However, noise of higher frequencies is emitted incidentally during seismic operations. Goold and Fish (1998) found that noise from seismic airguns dominated the 200 Hz - 22 kHz bandwidth at ranges of up to 2 km from the source, and that even at 8 km from the source seismic emissions exceeded background noise at frequencies of up to 8 kHz. They concluded that noise from seismic airguns would be clearly audible to dolphins at a range of at least 8 km from the source.

Baleen whales use much lower frequencies than those of dolphins (e.g. fin whales produce constant calls at 20-40 Hz, minke whales produce moans and grunts at 60-140 Hz; Evans and Nice 1996, from various sources). Seismic airguns produce most energy at low frequencies, so it might be expected that seismic activity would affect baleen whales more than dolphins. So far there has been much less evidence of avoidance of seismic activity by baleen whales than by dolphins around the UK. The only statistically significant effect observed during 2000 was that when all baleen whales were combined, fewer were observed to be heading towards the vessel during periods of shooting. This effect was also observed in 1999 (Stone 2001). In each of the previous years for which data exists, some species of baleen whale have been found to remain further from the airguns during periods of shooting while others have not (Stone 1997, 1998a, 2000, 2001). A reduction in sighting rates during periods of shooting has never been observed for baleen whales in the UK. However, in other areas there have been studies demonstrating avoidance of seismic activity by baleen whales (Ljungblad *et al.* 1988; McCauley *et al.* 1998; Richardson *et al.* 1986, 1995).

Various parameters can be used to demonstrate avoidance or lack of it, e.g. sighting rate, distance from the airguns, direction of travel relative to the vessel, and the presence or absence of positive interactions with the vessel. Between 1996 and 2000, there were 26 statistically testable results for these parameters amongst the various species or species groups of baleen whales. Only eight of the 26 results were statistically significant indicating avoidance. During the same period there were 33 testable results for these same parameters for dolphin species or species groups, of which more than half (18) were statistically significant. This may serve as an indication of the relative level of avoidance of seismic activity by baleen whales and by dolphins.

It would be premature, however, to assume that there are no adverse effects of seismic activity on baleen whales. There may be other factors influencing the observed results, for instance some effect on their behaviour that may influence the ease of detection of baleen whales, thus influencing sighting rates. There has been only one year where sample sizes have permitted assessment of the effects of seismic activity on the diving behaviour of baleen whales, but on that occasion fewer baleen whales were observed to dive during periods of shooting (Stone 2000). A tendency to remain at the surface could lead to falsely inflated sighting rates during periods of shooting. Situations such as this should be considered before dismissing the potential for disturbance of baleen whales from seismic activity. It should also be remembered that any long term effects of seismic activity may not be apparent for many years. Furthermore, there may be effects that cannot be detected from the available data. Responses to acoustic disturbance may include some form of alteration of vocalisations, that would not be apparent from visual observations. A reduction in vocalisations in response to seismic activity has been found in bowhead whales (Richardson 1997). Similarly, any effects on their physiology are largely unknown. An increase in the respiration rate of fin whales within 1 km of the airguns during periods of shooting has been indicated by shorter blow intervals when compared to periods when the airguns were silent (Stone 1998b). Other studies have also indicated alterations in surfacing, respiration and dive cycles in baleen whales in response to seismic activity, sometimes at considerable distances from the source (Ljungblad *et al.* 1988; Richardson *et al.* 1985, 1986, 1995).

There were no observable significant effects of seismic activity on sperm whales during 2000, nor have there been any in previous years in UK waters (Stone 1998a, 2000, 2001). However, sample sizes have precluded testing of most parameters other than sighting rate and distance from the airguns, and sometimes the proportion of animals diving. Sperm whales were only seen in the area West of Shetland, with sighting rates declining throughout the season from a peak in April; this may have been due to natural movements of sperm whales, or it could have been due to movement out of the area after the commencement of seismic activity in April. In the Gulf of Mexico seismic activity has been found to result in a decrease in abundance of sperm whales and negative effects on their communication and orientation behaviour (Mate *et al.* 1994; Rankin and Evans 1998). As with baleen whales, it would be premature to dismiss the possibility of disturbance of sperm whales from seismic activity while so many parameters remain unknown.

Effects of seismic activity on cetaceans in general are indicated by the effects observed when all species are combined. The resulting increase in sample size increases the power of the statistical tests used. During periods of shooting there was a significant reduction in pods heading towards the vessel and a significant reduction in pods engaging in positive interactions with the vessel. Similar significant effects when all cetaceans are combined have been found for most of the previous years for which data are available (Stone 1997, 1998a, 2000, 2001).

When all cetaceans were combined there was also a significant reduction in the proportion of encounters when feeding was observed during periods of shooting. In previous years reduced numbers of cetaceans have been observed to be feeding during periods of shooting (Stone 1998a, 2000, 2001), although the reduction was only significant in one of these years. The possibility that cetaceans are inhibited from feeding by seismic activity is potentially a serious threat to the wellbeing of both individuals and populations.

There have been relatively few sightings of marine mammals during the soft-start from which to assess the response of animals to this procedure. From observations during 2000, it appeared that white-beaked dolphins may sometimes approach the vessel to bow-ride during the soft-start. Such reactions could mean that the soft-start does not achieve its intended aim of allowing animals sufficient time to move out of the way before full power levels are reached. However, there were at least an equal number of occasions when cetaceans headed away from the vessel during the soft-start. Further study of the response of marine mammals to the soft-start is merited to establish whether it achieves its intended aim. In an attempt to encourage observers to distinguish between firing during the soft-start and firing at full power, the 'Record of Sighting' form was amended in early 2001 to include 'Soft-start' as an option when recording the activity of the airguns at the time of the sighting. It is hoped that this will result in more data with which to examine the effects of the soft-start procedure.

In previous years sample sizes have not been sufficient to assess the effects of site surveys on marine mammals. Sample sizes were still relatively low in 2000, but nevertheless statistical testing was possible for some results. White-sided dolphins and all dolphins combined were not seen any less often during periods of shooting, nor did they remain further from the airguns. It seems therefore that the effects of seismic activity may be less for site surveys than for larger scale seismic surveys, as might be expected. However, when all dolphins or all cetaceans were combined, there were fewer heading towards the vessel during periods of shooting than at other times, which may indicate that a low level of disturbance nevertheless exists during site surveys.

10.3 Quality of observations

The quality of observations can be assessed using two criteria: the ability of observers to detect marine mammals, and their ability to provide full and accurate information. The most important of these is detection ability; delays in shooting when animals are close by, as required by the guidelines, will not happen unless an observer is proficient at detecting marine mammals. Detection rates were higher when dedicated marine mammal observers, who were mostly cetacean biologists, were used. Fishery liaison officers had improved their ability to detect marine mammals from previous years, but still did not meet the standard of dedicated marine mammal observers. Reliance on members of ships' crews to detect marine mammals was not effective, although such personnel provided a valuable contribution in alerting marine mammal observers to the presence of marine mammals which had escaped detection by the latter (including occasions when the marine mammal observer was not on watch).

Recording full and accurate information, whilst not reducing disturbance to marine mammals, is nevertheless beneficial. Assessment of the effects of seismic activity on marine mammals, and measurement

of the level of compliance with the guidelines would not be possible without this information. Information from the 'Record of Operations' form is used to assess compliance with the guidelines. Effort and the duration of shooting whilst watching for marine mammals, as recorded on the 'Location and Effort' form, is essential for calculating sighting rates in relation to seismic activity, while the weather information recorded on this form is used to eliminate bias in various aspects of the analysis. Species identification enables comparison of the effects of seismic activity on the various species. Identification skills overall had improved, but were better for dedicated marine mammal observers (mostly cetacean biologists) than other personnel, and were better for observers who had undergone training. Problems in completing the 'Location and Effort' and 'Record of Operations' forms (erroneous information or missing forms) occurred mainly when untrained or not recently trained fishery liaison officers or members of ships' crews undertook the role of marine mammal observer. Thus it seems that a combination of training and the use of dedicated marine mammal observers (usually cetacean biologists) results in the highest quality of data.

It is hoped that observers will take note of the recommendation that distinctions should be made between behaviours occurring when the airguns are firing and those occurring when they are not firing for encounters during which seismic activity changes. Future training seminars should include this recommendation.

The proportion of site surveys for which recording forms were missing was high. There is a lack of knowledge regarding the potential effects of seismic activity during site surveys on marine mammals, therefore greater use of the recording forms to collect data from these surveys would be extremely beneficial.

The ideal type of personnel to be used in terms of quality of observations is a trained, dedicated marine mammal observer, preferably a cetacean biologist, thus ensuring a high detection rate of marine mammals and the provision of high quality data.

10.4 Compliance with guidelines

The procedures for notifying JNCC of forthcoming seismic surveys and submitting reports afterwards appear to be working reasonably well, although there is still room for improvement. Imminent changes to procedures, moving from survey notification to survey permitting, will require that improvements are made.

Compliance with the procedures required by the guidelines has been monitored since the 'Record of Operations' form was introduced in 1998. Table 30 compares compliance in 2000 with that of previous years (figures cited for previous years may vary slightly from those reported previously, as data from these years has been re-analysed to include data arriving too late for inclusion in earlier reports). The standard of pre-shooting searches in 2000 in blocks where compliance with the guidelines is a licence condition had declined from previous years, although the standard in other blocks remained relatively constant compared to 1999 levels. The main problem with pre-shooting searches seemed to lie with site surveys, particularly where members of ships' crews were responsible for marine mammal observations. The standard of pre-shooting searches by members of ships' crews had declined from previous years, while those of fishery liaison officers had shown a gradual improvement and those of dedicated marine mammal observers had remained consistently high. It should be remembered that it is important that seismic crews routinely provide adequate advance warning of shooting to enable marine mammal observers to carry out their duties.

Table 30 Compliance with the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* in UK waters, 1998-2000 (information not available prior to 1998).

	16th/ 17th/ 18th round blocks			*Other blocks*		
	1998	***1999***	***2000***	***1998***	***1999***	***2000***
Pre-shooting searches of adequate duration	86%	85%	79%	68%	77%	75%
Soft-starts of adequate duration (not site surveys)	86%	87%	95%	71%	71%	90%
Delays in shooting when necessary	20%	57%	86%	0%	0%	50%

Other aspects of compliance with the guidelines had shown an increase in standards. The standard of soft-starts (excluding those on site surveys) had increased in all UK blocks (Table 30). Similarly, there was an increase in the proportion of occasions when correct procedures were followed when a delay in shooting was necessary due to the close proximity of marine mammals. In 2000 the first delay occurred outside blocks where compliance with the guidelines is a licence condition, and it is also pleasing to note that for the first time there was a delay in shooting in waters adjacent to the UK (Irish waters; not included in Table 30). It is

also worth noting that the delay in Irish waters occurred when a fishery liaison officer was responsible for marine mammal observations, the first known occasion when correct procedures have been followed in a delay situation involving this type of personnel. Such improvements in the standards of compliance with the guidelines are to be welcomed.

It is encouraging to note that the use of dedicated marine mammal observers continues to increase. However, there were still a number of surveys in areas of importance for marine mammals where dedicated marine mammal observers were not used. The use of such personnel is to be encouraged and in future is likely to be required. Not only do dedicated marine mammal observers have higher detection rates of marine mammals and provide high quality data, but their standard of pre-shooting searches is higher than that of other personnel, and the standard of soft-starts on site surveys is higher when they are used.

There were also a number of surveys where operators or seismic contractors did not use observers meeting the requirements that JNCC specified, in particular regarding secondary observers. It is not too surprising that obtaining cetacean biologists as primary observers was sometimes difficult, given that there is sometimes a lack of availability of suitable personnel. However, the lack of use of a second dedicated observer, not necessarily a cetacean biologist, when requested, is more surprising, and perhaps indicates a certain reluctance by some parts of the industry to accept the costs involved in engaging two dedicated observers.

There were seven surveys involving two vessels (one receiving vessel and one source vessel) during 2000, and a further three surveys where a second vessel was used as the source vessel for a short period for undershooting. Of the seven surveys where two vessels were used throughout the duration of the survey, there were only two where observers (in one case a dedicated marine mammal observer) were on the source vessel, while for the remaining five surveys observers (all fishery liaison officers) were on the receiving vessel. Fishery liaison officers are best placed on the receiving vessel to ensure fishing vessels remain clear of the seismic vessel's cables, but marine mammal observations should be carried out from the source vessel to enable a proper search for marine mammals in the immediate vicinity of the airguns. For this reason it is recommended that on dual vessel surveys it is inappropriate for fishery liaison officers to combine fishery liaison duties with marine mammal observations. Instead, it is recommended that dedicated marine mammal observers are engaged and placed on the source vessel (see section 10.5 and Stone 2001). On none of the three surveys involving undershooting were observers transferred to the second source vessel, even though in two cases they were dedicated marine mammal observers and there was no need for them to remain on the first vessel that had temporarily become a receiving vessel only.

There are some concerns regarding site surveys. Pre-shooting searches were often inadequate on site surveys. Soft-starts on site surveys were also often of inadequate duration, especially when dedicated marine mammal observers were not on board. The guidance note issued by JNCC in March 2000 stated that all site surveys should use a full soft-start unless a prior waiver has been agreed with JNCC, but there was only one site survey where a waiver was sought. Although there may be valid difficulties with conducting a soft-start procedure on site surveys (Stone 2001), this nevertheless does not excuse operators or seismic contractors from consulting JNCC and discussing any difficulties they have. It is noteworthy that for the only site survey where a waiver was requested, it was left to the marine mammal observer to request a waiver once the survey had begun, rather than the operator or seismic contractor sorting out any difficulties beforehand. It has been recommended that the next revision of the guidelines addresses this issue (see section 10.5 and Stone 2001), but until then operators and seismic contractors should consult JNCC if they wish to be exempted from the soft-start on site surveys. Marine mammal observers should also be aware of this requirement, and should ascertain whether JNCC have granted a waiver before agreeing to forego soft-starts on site surveys.

Submission of reports is another aspect of the guidelines that was less than satisfactory for site surveys. Reports were often missing or incomplete. For those site surveys where no reports were submitted, it is impossible to be certain who had responsibility for marine mammal observations. However, it seems likely that for these surveys neither dedicated marine mammal observers nor fishery liaison officers were present, as both types of personnel are aware of the need to complete and return the recording forms. In the absence of such personnel, members of ships' crews are usually assigned the task of marine mammal observations; this is a relatively common, although not very satisfactory, situation on site surveys. Ultimately, however, it is the operator's or seismic contractor's responsibility to ensure that someone undertakes marine mammal observations and that reports of these observations are submitted. As noted above, there is a need for further data from site surveys, so the routine submission of complete reports would be beneficial.

The industry has agreed to adopt the guidelines throughout UK waters, and not just in those blocks where compliance with the guidelines is a licence condition (16th, 17th and 18th round blocks). For larger scale surveys it seems that the guidelines are now being applied throughout all UK waters, with little difference in

the standard of pre-shooting searches and soft-starts between blocks, and one instance of shooting being delayed outside 16th, 17th and 18th round blocks. In 2000, 53% of larger scale surveys were conducted outside 16th, 17th and 18th round blocks, so the application of the guidelines throughout the UK is welcomed. However, for site surveys a difference still remains, with the standard of soft-starts being extremely low outside blocks where compliance with the guidelines is a licence condition. The majority (72%) of site surveys in UK waters in 2000 were conducted outside 16th, 17th and 18th round blocks. Many blocks licensed prior to the 16th round and many unlicensed blocks are in areas of importance for marine mammals. The effects of seismic activity during site surveys are largely unknown, although there are indications of at least low level disturbance of marine mammals (see sections 7.6 and 10.2). It is important, therefore, that there is a high level of compliance with the guidelines throughout all UK waters, regardless their licence status, for all types of seismic survey.

10.5 Considerations for future revisions to guidelines

Two previous reports discussed various items that should be considered when the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* are next revised. These are listed below; it should be noted that these are only suggestions, and will not necessarily all be adopted. Some, however, are already mentioned in the *Guidance note on the implementation of the guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* produced by JNCC in March 2000 (Appendix 1). Items mentioned on this guidance note still need to be incorporated into the guidelines, but should already be routine practice, therefore these are listed first. For a full discussion of the reasons for each suggestion, and the advantages and disadvantages in adopting them, readers are referred to the previous reports (Stone 2000, 2001). The list of previous suggestions is followed by further items for consideration.

1). Prohibition of shooting which is not necessary for the normal operations of a seismic survey or for a soft-start, hence preventing continual shooting between lines (guidance note and Stone 2000).

2). A requirement for a full soft-start of at least 20 minutes in time-sharing situations (guidance note and Stone 2001).

3). Clarification of the requirement for a soft-start during site surveys (guidance note and Stone 2001).

4). Clarification of the application of the guidelines to test firing - requirements for pre-shooting searches and full soft-starts, and delays in shooting if marine mammals are detected within 500 m of the airguns (guidance note and Stone 2001).

5). A requirement for two marine mammal observers during the summer months at higher latitudes (guidance note and Stone 2001).

6). The use of acoustic methods as technology becomes available, to aid detection of marine mammals (guidance note and Stone 2001).

7). Consideration should be given to whether the current requirement for the duration of the soft-start is adequate (Stone 2001).

8). A requirement for a maximum duration of the soft-start (Stone 2000).

9). A requirement to cease further increases of power if marine mammals appear close to the airguns during the soft-start (Stone 2000).

10). Measurement of the soft-start in terms of distance rather than time (Stone 2001).

11). There should be a definition of "well out of range" in the sentence, "If marine mammals are present, the start of the seismic sources should be delayed until they have moved away, allowing adequate time after the last sighting (at least 20 minutes) for the animals to move well out of range" (Stone 2001).

12). Consideration should be given to the consequences of time-sharing (Stone 2000).

13). The marine mammal observer should be on board the source (= airgun) vessel (Stone 2001).

14). Extra protection (e.g. cessation of firing) could be given to species which are endangered, such as the northern right whale (Stone 2000).

15). Circulation of the guidelines amongst personnel involved in other seismic operations e.g. vertical seismic profiling on drilling rigs (Stone 2001).

16). Substitution of the word 'guidelines' with a less ambiguous alternative, e.g. 'procedures' (Stone 2001).

Of the above suggestions, there is one that requires fairly urgent attention, that being the requirement for soft-starts on site surveys. The guidance note issued in March 2000 stated that all site surveys should use a full soft-start (of at least 20 minutes), unless a prior waiver has been agreed with JNCC. The results from 2000 clearly show that full soft-starts are frequently not being used on site surveys, nor are operators or seismic contractors seeking waivers from JNCC. Instead it seems that this requirement is, to a large extent, being ignored. There are sometimes practical difficulties in performing a conventional soft-start on site surveys, but nevertheless the situation where a requirement is being ignored cannot continue. It has been recommended that either companies are made fully aware of the need to apply for exemptions from the soft-start on site surveys, or that the requirement for a soft-start is modified to take account of the difficulties encountered, either by relaxing the requirement for a soft-start in certain circumstances or by proposing alternative means of achieving a soft-start that would be more feasible for these types of survey (for a full discussion of these recommendations see Stone 2001). A modification of the requirement for a soft-start on site surveys may take some time to consider and put into effect, so as an immediate measure it is recommended that seismic contractors routinely undertaking site surveys are made aware of this requirement and the need to apply to JNCC for waivers if conducting a full soft-start presents genuine difficulties for them.

There are three further items for consideration that have not been discussed previously. On one survey an observer questioned what should happen if there is a short break in firing; does there need to be another soft-start? This situation may arise if there are technical problems resulting in the cessation of firing in the middle of a survey line. Such problems are often temporary and crews wish to re-commence firing at full power as soon as possible to avoid unnecessary loss of seismic data (and the need for excessive infill which could result in a prolonged survey with a greater overall noise input to the marine environment). Informal guidance from JNCC on occasions in the past has been that if there is a gap in firing of 15 minutes or less, then firing may resume without the need for another soft-start, unless marine mammals are detected within 500 m of the airguns in the meantime. If during the gap in firing marine mammals are detected within 500 m of the airguns, there should be a delay in re-commencing shooting for at least 20 minutes after the animals are last seen, and then firing should re-commence with a soft-start of at least 20 minutes duration. If the gap in firing is more than 15 minutes then a full soft-start of at least 20 minutes should be employed regardless of whether marine mammals are detected or not. This informal guidance has never been included in either the guidelines or the guidance note, but it perhaps should be included in a future revision of the guidelines. However, it would have to be qualified so that is not open to abuse, i.e. it should be specified that it is for cases of genuine technical problems where firing ceases in the middle of a survey line, so that it cannot be used as a means of avoiding performing a soft-start at the beginning of a line after a short turn.

The second new item for consideration is that the guidelines should perhaps be translated into different languages. This was suggested by an observer who encountered difficulties when working on a vessel with a predominantly Russian crew. People of many nationalities work on seismic survey vessels but, of those for whom English is not their first language, Norwegian and Russian are perhaps among the most common nationalities encountered. Whilst many Norwegians are proficient at speaking and understanding English, there would perhaps be some merit in producing a Norwegian translation of the guidelines as well as a Russian translation.

The third new item for consideration is the implications of the Habitats Directive (*Council directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora*). In November 1999 a high court judge ruled that the Habitats Directive applies to the UKCS and to superjacent waters up to a limit of 200 nautical miles from the baseline from which the territorial sea is measured. As a consequence of this ruling, regulations known as *The offshore petroleum activities (conservation of habitats) regulations 2001* came into force on 31st May 2001. Under these regulations any geological survey (which would include all seismic and site surveys) on the UK continental shelf requires prior written consent of the Secretary of State. Regulation 10 states that oil and gas activities shall not deliberately disturb any creature listed on Annex IVa of the Habitats Directive (which includes all cetaceans), nor cause deterioration or destruction of breeding sites or resting places of any such creature. Contravention of Regulation 10 constitutes an offence under the regulations, and individual personnel as well as corporate bodies can be deemed guilty of an offence and be

liable to prosecution and punishment. The introductory section of the guidelines should be amended to refer to these regulations, making it clear that deliberate disturbance of cetaceans is an offence under the regulations (as well as under existing legislation such as the *Wildlife and countryside act 1981*).

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13. Appendices

Appendix 1 *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys (April 1998)* and *Guidance note on the implementation of the guidelines for minimising acoustic disturbance to marine mammals from seismic surveys (March 2000)*

Appendix 2 Marine mammal recording forms used during 2000

Appendix 3 Current marine mammal recording forms and *Guide to using marine mammal recording forms*

Appendix 4 Additional reports received by JNCC during 2000

Appendix 5 Scientific names of species mentioned in the text

Appendix 1

GUIDELINES FOR MINIMISING ACOUSTIC DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS

April 1998 Version

These guidelines are aimed at minimising acoustic disturbance to marine mammals from seismic surveys and other operations where acoustic energy is released. Application of the guidelines is required under licence conditions in blocks licensed under the 16th and 17th rounds of offshore licensing. However, member companies of the UK Offshore Operators Association (UKOOA) and the International Association of Geophysical Contractors (IAGC) have indicated that they will comply with these guidelines in all areas of the UK Continental Shelf (UKCS) and in some cases elsewhere. The guidelines apply to all marine mammals, including seals, whales, dolphins and porpoises. All surveys using higher energy seismic sources (including site surveys as well as large scale seismic surveys) should comply with these guidelines.

Precautions to reduce the disturbance caused by seismic surveys

Seismic surveys at sea do not necessarily constitute a threat to marine mammals, if care is taken to avoid situations which could potentially harm the animals.

A. The Planning Stage

When a seismic survey is being planned, operators should:

- Contact the Joint Nature Conservation Committee (JNCC - see Further Information for address) to determine the likelihood that marine mammals 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).

- In areas which are important for marine mammals (as indicated in consultation with the JNCC) operators should seek to provide the most appropriately qualified and experienced personnel to act as marine mammal observers on board the seismic survey vessel. If possible, such observers should be experienced cetacean biologists. As a minimum, it is recommended that observers should have attended an appropriate training course.

- If advised to do so by the JNCC, 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 marine mammals are abundant, properly conducted observation and recordings using qualified observers (see above) carried out before, during and after the seismic survey, can provide valuable information on its effect.

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

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

B. During the Seismic Survey

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

- LOOK AND LISTEN

  Beginning at least 30 minutes before commencement of any use of the seismic sources, the operator and observers should carefully make a visual check from a suitable high observation platform to see if there are any marine mammals within 500 metres, using the cues mentioned later in these guidelines to detect the presence of cetaceans. 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 marine mammal presence cannot be obtained.

- DELAY

  If marine mammals are present, the start of the seismic sources should be delayed until they have moved away, allowing adequate time after the last sighting (at least 20 minutes) for the animals to move well out of range. Hydrophones may also be useful in determining when cetaceans have moved. In situations where seal(s) are congregating immediately around a platform, it is recommended that commencement of the seismic sources begins at least 500 m from the platform.

- THE SLOW BUILD UP

  Where equipment allows, power should be built up slowly from a low energy start-up (e.g. starting with the smallest air-gun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity. There should be a soft start every time the air-guns are used, even if no marine mammals have been seen. The soft start may only be waived for surveys where the seismic sources always remain at low power levels e.g. some site surveys.

- KEEP IT LOW

  Throughout the survey, the lowest practicable power levels should be used.

C. Report after the survey

A report detailing marine mammals sighted (standard forms are available from JNCC), the methods used to detect them, problems encountered, and any other comments will help increase our

knowledge and allow us to improve these guidelines. Reports should be sent to the JNCC (see Further Information for address). Reports should include the following information:

- Date and location of survey
- Number and volume of airguns used
- Nature of air-gun discharge frequency (in Hz), intensity (in dB re. 1μPa or bar metres) and firing interval (seconds), or details of other acoustic energy used
- Number and types of vessels involved in the survey
- A record of all occasions when the air-guns were used, including the watch beforehand and the duration of the soft-start (using standard forms)
- Details of any problems encountered during marine mammal detection procedures, or during the survey
- Marine mammal sightings (using standard forms)
- Details of watches made for marine mammals 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 or physical disturbance to marine mammals. The recommendations contained in the guidelines should assist in ensuring that all marine mammals in areas of proposed seismic survey activity are protected against possible injury, and disturbance 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. The guidelines have been reviewed twice by the Joint Nature Conservation Committee following consultation with interested parties and in the light of experience after their use since 1995.

Please note: As these guidelines are concerned with reducing risks to marine mammals, 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 (equivalent in Northern Ireland is Article 10 of the Wildlife (Northern Ireland) Order 1985). 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, etc.) Regulations 1994 and The Conservation (Natural Habitats, etc.) Regulations Northern Ireland 1995.

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 UK 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".

Marine mammal presence in UK waters

Records indicate there may be 22 species of cetacean either resident in, or passing through, UK 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. Northern right whales are very rare - they are an endangered species, having been hunted very close to extinction.

There are two species of seal which are resident in UK waters, the common or harbour seal and the grey seal. Both species breed in the UK, with common seals pupping in June/ July, and grey seals pupping from September to December, the exact timing depending on their location. Seals may be particularly vulnerable to disturbance during the pupping season. Other species, such as the hooded seal, may occasionally be seen in waters to the north of the UK.

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 (at least 30 minutes) for sightings to be made prior to commencement of any use of the seismic sources

- 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 vocally active 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. Large whales surface less often and may remain submerged for some time.

- 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 large 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), although some may swim at much slower speeds. 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 reduced. 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 approximately ten seconds - the timing dependent on the objectives of the survey.

Potential effects of acoustic disturbance on cetaceans

The most prevalent form of acoustic disturbance in UK 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, although this does not necessarily mean that the animals are

unaffected. 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 from airguns affects cetaceans is not well known for all species, 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 (particularly bowhead whales) of older air-gun arrays, which were different from those currently in use.

Seismic air-guns are designed to produce low frequency noise, generally below 200 Hz, used to build up a picture of the seabed and the underlying strata. 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 3 kHz, which are likely to overlap with the dominant frequencies used by seismic air-guns. The sensitivity of toothed dolphins to sound falls sharply below 1 kHz, and sounds below 0.2 kHz are probably inaudible to them. The sounds used by dolphins for communication are often above 4.8 kHz, and echolocation sounds can occur up to 200 kHz. 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 disturbance of dolphins by seismic activity (Goold 1996b, Stone 1997, 1998).

Seismic activity 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. There is no evidence to suggest that injury has occurred to any cetacean in UK waters as a result of seismic activity, although such injuries may be difficult to detect. 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 surveying 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:

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Joint Nature Conservation Committee
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ANNEX

CONTACT NAMES AND ADDRESSES

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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)

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

Telephone 01334 462630
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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. Prepared 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.

Evans, P.G.H. & Nice, H. 1996. *Review of the effects of underwater sound generated by seismic surveys on cetaceans.* Report to UKOOA, Sea Watch Foundation, Oxford.

Goold, J.C. 1996a. Broadband characteristics and propagation of air gun acoustic emissions in the southern Irish Sea. *(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 76:* 811-820.

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.

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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.

To Statutory Nature Conservation Agencies, Department of Trade and Industry, Seismic Contractors, Oil Companies, Marine Mammal Observers, International Association of Geophysical Contractors, United Kingdom Offshore Operators Association.

GUIDANCE NOTE ON THE IMPLEMENTATION OF THE GUIDELINES FOR MINIMISING ACOUSTIC DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS

March 2000

The aim of this note is threefold; to clarify our position with respect to the use of Marine Mammal Observers; to respond to queries raised in relation to the application of the 'Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys' and to provide an update on the JNCC marine mammal web pages. The information below is complimentary to the Guidelines and should be used in conjunction with them. On points of detail it will provide supplementary Guidance.

Use of dedicated Marine Mammal Observers (MMOs) during seismic surveys.

This note has been produced ahead of the main period of United Kingdom Continental Shelf (UKCS) seismic activity in order to inform companies of the JNCC position with regard to the use of dedicated MMOs during seismic surveys. The JNCC will continue to look at PON 14 applications and assess the need for MMOs on a case by case basis, however this note is intended to provide advance notice of the advice the JNCC is likely to give. It is intended that this will enable companies to better plan the financial and logistical requirements that surveys will likely require and assist those companies supplying MMOs to better predict demand.

JNCC advise that MMOs be used in areas where cetacean sensitivities are sufficiently high to merit it. This varies temporally and geographically and also reflects the varying sensitivity of individual species to seismic sources and their conservation status. We advise that a prerequisite for MMOs is to have attended a short course. We are able to supply details of those carrying out these courses. This basic requirement is adequate for areas of moderate sensitivity where an MMO is requested. For more sensitive areas a suitably qualified and experienced cetacean biologist must be used. Cetacean biologists must have also attended an MMO training course.

In northerly latitudes daylight hours during the spring and summer months are long. Under these circumstances it is not practical to expect a single MMO to collect high quality data for all daylight hours. **Therefore all surveys requiring MMOs taking place between 1 April and 1 November north of 57^0 latitude will be required to use two MMOs.** Where this is in a sensitive area two trained cetacean biologists will be required. We do not anticipate there will normally be exceptions to this. The use of a second crewmember with other onboard responsibilities is not considered an adequate substitute.

Companies should be aware that the use of an MMO does not in itself waive licence conditions.

A summary of the likely requirements of the major UK sea areas where seismic surveying is currently conducted and their MMO requirements is given below.

i. Southern North Sea

Cetacean sensitivities are generally low to moderate. An MMO is usually not required. However, JNCC request that a watch be kept for marine mammals and a report containing location, effort and sightings forms be submitted

ii. Central and Northern North Sea

Cetacean sensitivities are highly variable and it is not possible to generalise. Some surveys will require an MMO, others will not. MMOs who are experienced, trained cetacean biologists will not normally be required but this is not invariably the case, particularly in northern latitudes. Also see below.

iii. Moray Firth

Cetacean sensitivities are high. Any seismic operation (including site surveys) conducted in the Moray Firth will require experienced, trained cetacean biologists.

iv. North and west of Shetland, west of the Hebrides

Cetacean sensitivities are high. Any seismic operation (including site surveys) will require experienced, trained cetacean biologists.

v. Irish Sea Basin

Cetacean sensitivities are generally low to moderate. An MMO is not always required. However, JNCC request that a watch is kept for marine mammals and a report containing location, effort and sightings forms is submitted. An exception to this is St George's Channel and the area off Cardigan Bay, which is of high sensitivity.

Companies proposing a survey outwith the above areas should consult JNCC as a matter of course. For any survey in a sensitive area we advise early consultation. Advice is provided on the basis of our current understanding of cetacean distribution and is subject to change in the light of new research.

Feedback to issues raised by MMOs and Companies

We would like to extend our 0thanks MMOs and Companies that have been active in providing feedback to JNCC on issues arising from the implementation of the 'Guidelines for Minimising acoustic Disturbance to marine mammals from Seismic Surveys'. We are grateful for your comments and would encourage more comments in future. We are not formally reviewing the Guidelines this year, but may do at the end of the 2000 season: this review will take account of these points.

i. Soft starts for 'timeshare' situations and for site surveys

In 'timeshare' situations and for site surveys the necessity for a soft start of the full 20 minutes duration has been questioned. We consider that in both situations the soft start should be for a minimum of 20 minutes as for all other surveys. The only exception to this is for a minority of site surveys where a waver has been agreed with the JNCC prior to the start of the survey.

ii. Continual shooting between lines

The practice of continuing to shoot whilst turning between lines is not encouraged. Firing should stop at the end of the line.

iii. Test firing of guns

The whole array should not be fired without a full soft start. Wherever possible, a gradual increase in capacity should be used, regardless of whether the test is at full capacity or not. In daylight hours where any seismic source, regardless of capacity is being test fired there needs to be a pre-firing scan as per the Guidelines. The MMO, if present, must be given advance warning.

iv. Redesign of JNCC reporting forms

We have received several comments suggesting improvements to the JNCC recording forms. We accept that they are not ideal but do not currently have the resources to update them. We would encourage suggestions on how best to improve them and intend to update them for the 2001 season. In the interim we request that reports be submitted on JNCC forms to prevent difficulties when performing analysis.

v. Gun use at night

We would advise that there is provision for the systematic recording of gun use during the hours of darkness when the MMO is not on duty. These records should be made available to the MMO.

vi. Use of hydrophones

Substantial progress has been made in the development of this detection technique and we anticipate that hydrophone use will increase when the technology becomes commercially available.

vii. Problems encountered implementing the Guidelines at sea.

The JNCC is willing to respond to queries where difficulties are encountered at sea.. Please contact the undersigned.

JNCC Website

We are currently developing marine mammal pages for the JNCC website. This project has been delayed due to lack of resources and the redesign of the entire site. We hope to run pages that present interesting information and images on marine mammals and provide a forum for feedback from MMOs and other interested parties. In the meantime please address any queries to the undersigned. The JNCC website may be viewed at www.jncc.gov.uk.

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Appendix 2

MARINE MAMMAL RECORDING FORM - RECORD OF OPERATIONS

Ship ..... Client ..... Contractor .....

Complete this form every time the airguns are used, whether for shooting a line or for testing or for any other purpose. Times should be in GMT.

Date	Who carried out a search for marine mammals? (Job title)	Time when pre-shooting search for marine mammals began	Time when search for marine mammals ended	Were hydro-phones used?	Were marine mammals seen before the airguns began firing?	Time when marine mammals were last seen	Was there any reason why marine mammals may not have been seen? (e.g. swell, fog, etc.)	If marine mammals were present, what action was taken? (e.g. delay shooting)	Time when soft start began	Time when airguns reached full power	Time when airguns stopped

Please return to JNCC, Dunnet House, 7 Thistle Place, Aberdeen, AB10 1UZ (fax. 01224 621488; e-mail seismic@jncc.gov.uk).

MARINE MAMMAL RECORDING FORM - LOCATION AND EFFORT DATA

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

Observer(s) ..... Survey type (site, 2D, 3D etc.) .....

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

Date	Block number	Number of daylight hours during which a watch for marine mammals 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	Swell Choose from: O = low M = medium L = large	Visibility Choose from: P = poor M = moderate G = good

Return to: JNCC, Dunnet House, 7 Thistle Place, Aberdeen, AB10 1UZ (fax. 01224 621488; e-mail seismic@jncc.gov.uk).

MARINE MAMMAL 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="4">How did this sighting occur? (please tick box)
While you were keeping a continuous watch for marine mammals □
Spotted incidentally by you or someone else □
Other (please specify) □</td></tr>
<tr><td colspan="2">Ship</td><td colspan="2">Observer</td></tr>
<tr><td colspan="3">Ship's position (latitude and longitude)</td><td>Water 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 animals in relation to ship (draw arrow)
  </td></tr>
<tr><td colspan="3">Behaviour</td><td>Direction of travel of animals (compass points)</td></tr>
<tr><td>Activity of ship</td><td>Airguns firing

Yes / No</td><td colspan="2">Closest distance of animals 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; e-mail seismic@jncc.gov.uk).

Appendix 3

MARINE MAMMAL RECORDING FORM - RECORD OF OPERATIONS

Ship .....…… Client .....….... Seismic Contractor ..... JNCC SS ref. no. .....

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any other purpose.
Times should be in GMT.

Date	Airgun activity			Pre-shooting search					Action necessary		
	Time when soft start began	Time when airguns reached full power	Time when airguns stopped	Who carried out a search for marine mammals? (Job title)	Time when pre-shooting search for marine mammals began	Time when search for marine mammals ended	Was there any reason why marine mammals may not have been seen? (e.g. dark, fog, swell, etc.)	Were hydro-phones used?	Were marine mammals present in the 30 minutes before the airguns began firing?	If yes, give time when marine mammals were last seen	If marine mammals were present, what action was taken? (e.g. delay shooting)

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MARINE MAMMAL RECORDING FORM - LOCATION AND EFFORT DATA

Ship ..... Ship type (seismic/guard etc.) ..... Survey type (site, 2D, 3D, 4C etc.) ….....… JNCC SS ref. no. .....

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: G = glassy (like mirror) S = slight (no or few white horses) C = choppy (many white horses) R = rough (large waves, foam crests, spray)	Swell Choose from: O = low (< 2 m) M = medium (2-4 m) L = large (> 4 m)	Visibility Choose from: P = poor (< 1 km) M = moderate (1-5 km) G = good (> 5 km)

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MARINE MAMMAL RECORDING FORM - RECORD OF SIGHTING

Options in italics should be circled or underlined as appropriate

Date	**Time** (GMT)	**JNCC SS ref. no.**	**Sighting no.**

How did this sighting occur? (please tick box)

While you were keeping a continuous watch for marine mammals □
Spotted incidentally by you or someone else □
Other (please specify) □

Ship	**Observer**

Ship's position (latitude and longitude)	**Water depth** (metres)

Species	**Certainty of identification** *Definite / probable / possible*

Total number	**Number of adults** **Number of juveniles**

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)	**Photograph or video taken** *Yes / No*
	Direction of travel of animals in relation to ship (draw arrow) 

Behaviour	**Direction of travel of animals** (compass points)

Activity of ship	**Airguns firing** (when animals first seen) *Yes / No / Soft-start*	**Closest distance of animals from airguns** (metres) (Record even if not firing)

Please continue overleaf or on a separate sheet if necessary

Return to: JNCC, Dunnet House, 7 Thistle Place, Aberdeen, AB10 1UZ
(fax. 01224 621488; e-mail seismic@jncc.gov.uk).

GUIDE TO USING MARINE MAMMAL RECORDING FORMS

Please read this before completing the marine mammal recording forms. If you are unclear about any aspect of using the recording forms, please seek advice from JNCC (contact details at end).

There are three forms to be completed:

1) Record of Operations - summary of seismic operations
2) Location and Effort Data - basic information on where you looked for marine mammals, how long you looked for, and what the weather conditions were
3) Record of Sighting - information on each sighting of marine mammals.

Each of the three forms is explained in more detail below. Even if you see no marine mammals during the entire survey Record of Operations and Location and Effort forms should be completed and returned to JNCC. These forms are designed so that you can provide, in a standard format, the minimum information that is needed. Please do not alter the forms, but do feel free to provide any additional information that you think would be of benefit.

Each form asks for a JNCC SS ref. no. (JNCC seismic survey reference number). This should be obtained from JNCC before the survey.

Record of Operations

This form asks for basic information on all uses of the airguns throughout the survey. JNCC will use this form to see how well your survey followed the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys*. You should complete one line on this form each time the airguns are used, whether for shooting a line, for testing, or for any other purpose (seismic crews do not routinely record test firing, so you will need to ask them to make a note of any times when they are testing the guns).

Airgun activity You should record all airgun activity at any time of day, including times when the airguns are firing overnight. You are asked to record the times of three key stages of airgun activity: a) when the soft-start began; b) when the airguns reached full power (this is not necessarily the same time as the start of line, as the airguns may reach full power before the start of line); and c) when they stopped firing. You should record this information for any uses of the guns, including testing - you may need to remind the seismic crew of the need for a soft-start when testing the guns. If the guns stop before reaching full power, put "No full power" (or "NFP") in the column headed "Time when the airguns reached full power" and record the time the airguns stopped as usual.

Pre-shooting search You are also asked to record the time you started looking for marine mammals before the airguns started firing (the pre-shooting search), and the time you stopped watching. You should record the times of all pre-shooting searches, but you do not have to provide details of other watches on this form (but include these if you are not sure whether they are relevant). A pre-shooting search should be carried out prior to all uses of the airguns during daylight hours (including test firing). You may leave the times of the pre-shooting search blank if you did not watch because it was dark, but the airgun activity should still be recorded. You are asked if there was any reason why marine mammals may have been missed (e.g. it was dark, or there was a large swell/ fog/ rough seas, etc.).

Action necessary You should record whether marine mammals were present in the 30 minutes prior to the airguns starting firing, and if they were, the time at which they were last seen. If they were present you will need to record what action was taken if necessary under the guidelines (e.g. delay shooting), or indicate a reason why no action was necessary (e.g. animals were more than 500 m away or were last seen more than 20 minutes before firing commenced).

Location and Effort Data

The Location and Effort form should be completed for every day of the survey, regardless of whether you actually see any marine mammals or not, and regardless of whether there is any seismic activity. You may fill in as many lines per day of this form as you wish.

This form includes basic information e.g. ship's name, survey type, date, observer's name, time of watch, duration of watch and duration of shooting, blocks transited and weather conditions during the watch. Further notes on some of these are given below.

Duration of watch You will need to record how long you spent looking for marine mammals, in hours and minutes. This should only include periods when you were actually concentrating on looking for marine mammals.

Length of time airguns were shooting while you were looking for marine mammals This information is important to assess the effects of seismic activity on marine mammal abundance. You should record how long the airguns were firing during each watch for marine mammals (not during a whole 24 hour period). The length of time the guns were shooting during the watch should include any uses of the guns (i.e. should include any run-in to a line, soft-start or test firing, as well as the time spent shooting a line). You must not include time spent firing when you were not watching for marine mammals (e.g. during hours of darkness).

Blocks transited while looking for marine mammals You should record the blocks passed through during each watch - block numbers are preferred, but if you are not sure of them you may give start and end positions in latitude and longitude instead (but please try to avoid giving just a prospect name in this column). You may find a map of quadrants and blocks somewhere on board the ship e.g. in the instrument room.

Weather conditions Weather conditions during the watch should also be recorded. Wind force should be on the Beaufort scale (1-12), e.g. W5. If you record it as speed in knots please make this clear, e.g. W 9 knots, so that JNCC can convert it to Beaufort later. Sea state should be classed as glassy (sea like a mirror, or small ripples), slight (small wavelets with no or few white horses), choppy (small to moderate waves with frequent white horses) or rough (larger waves, extensive white foam crests, perhaps breaking, probably some spray). Those observers who are familiar with Beaufort sea states may record these if they wish, bearing in mind that the sea state at any given time may not correspond to the wind force at that time. Swell should be recorded as low (0-2 m), medium (2-4 m) or large (more than 4 m). 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 in when you see marine mammals. Most of the details you are asked to record are self-explanatory, but notes on some items are given below for clarification.

Time There is sufficient space in this box to put both a start and end time of the sighting if the animals are present for some time.

JNCC SS ref. no. This should be the same reference number as on the Record of Operations and Location and Effort forms, and should be obtained from JNCC prior to the survey commencing.

Sighting no. Use numbers in sequence, starting at 1 for the first sighting of the survey. Where more than one species occur together, these should be recorded together on the same form or on separate forms sharing the same sighting number.

How did this sighting occur You should indicate whether you spotted the marine mammals while you were keeping a continuous lookout. Sometimes someone else may call your attention to a marine

mammal that you would otherwise not have seen, in which case you should tick the second box (spotted incidentally) - JNCC need to know this to make an accurate assessment of sighting rate.

Position This is the ship's position at the time of the sighting (please remember to include whether you are east or west of the Greenwich meridian). There is sufficient space in this box to enter a start and end position if the animals are around for some time.

Depth This is the depth of water at the position given, in metres.

Species Identify marine mammals 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/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 marine mammals 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 essential to include a description of the animal, even if you are certain which species it is. The identity of sightings without descriptions, or with poor descriptions, will be downgraded. 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. Some 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).

Photograph or video taken If you have the opportunity to photograph or video the animal this may be used later to help confirm identification. Any photographs or videos should be sent to JNCC, clearly labelled with the date of the survey, the ship's name, the survey operator and seismic contractor. Where possible, use cameras where date and time can be recorded on the film so that photographs/ video footage can be matched to the correct Record of Sighting form.

Direction of travel of animals The direction of travel should be given in two ways - in relation to the boat (draw an arrow on the diagram), 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
- slow 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/ spy-hopping (animal almost vertical in the sea with 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, soft-start, 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 marine mammals were first seen. If the animals were first seen during the soft-start, circle this option. If airgun activity changes while the animals are still present, add a note to say this.

Closest distance of animals from airguns This should be filled in whether or not the airguns are firing when marine mammals are seen. If the airguns are not out, then use the closest distance to the ship or to the normal position of the airguns (but please say which you are using).

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

Completed forms should be returned to:

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

Tel. 01224 655704
Fax. 01224 621488
E-mail seismic@jncc.gov.uk

Appendix 4

Additional reports received by JNCC during 2000

Seismic survey vessels and associated guard vessels operating outside Europe:

Alize	Angola, Gabon
Toisa Panther (guard vessel)	Mauritania

Other vessels and platforms operating in UK and adjacent waters:

Bucentaur (geotechnical survey vessel)	?
Castoro Sei (pipelaying platform)	North Sea
CSO Orelia (dive support vessel)	North Sea
Highland Spirit (standby vessel)	West of Shetland
Iolair (semi-submersible vessel)	West of Shetland
Jack Bates (drilling rig)	Rockall, West of Shetland
Long Sand (dredger)	North Sea
Petrojarl Foinaven (FPSO)	West of Shetland
Santa Fe Monitor (drilling rig)	North Sea
Transocean Leader (drilling rig)	West of Shetland

Appendix 5

Scientific names of species mentioned in the text

Common seal	*Phoca vitulina*
Grey seal	*Halichoerus grypus*
Bowhead whale	*Balaena mysticetus*
Northern right whale	*Eubalaena glacialis*
Humpback whale	*Megaptera novaeangliae*
Blue whale	*Balaenoptera musculus*
Fin whale	*Balaenoptera physalus*
Sei whale	*Balaenoptera borealis*
Minke whale	*Balaenoptera acutorostrata*
Sperm whale	*Physeter macrocephalus*
Northern bottlenose whale	*Hyperoodon ampullatus*
Pilot whale	*Globicephala melas*
Killer whale	*Orcinus orca*
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*