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Marine mammal observations during seismic surveys in 1999

Carolyn J Stone

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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 501 sightings of marine mammals (13,398 individuals) during seismic surveys in UK waters and some adjacent areas in 1999. 14,341 hrs 19 mins were spent watching for marine mammals during seismic surveys in 1999.

2. The most frequently seen species was the white-beaked dolphin. White-sided dolphins, sperm whales, minke whales and killer whales were also seen with moderate frequency, with lower numbers of sightings of other species. There were significantly more sightings of minke whales and white-beaked dolphins when compared to previous years. 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 allowing 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 minke whales, sperm whales, white-beaked dolphins and all dolphins combined did not differ significantly with seismic activity.

4. After taking account of weather conditions at the time of the sighting, white-beaked dolphins, all dolphins combined and all baleen whales 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 an increased tendency for cetaceans to engage in fast swimming and breaching, jumping or somersaulting during periods of shooting. This increased tendency was evident at distances of up to 4 km or more from the source for breaching, jumping or somersaulting, and at distances of up to 3 km for fast swimming. Positive interactions of cetaceans with the survey vessel or its equipment occurred significantly more often when the airguns were not firing.

6. When all cetaceans were combined, significantly more were found to be heading away from the vessel and fewer heading towards it during periods of shooting (excluding site surveys). More were also milling or travelling in various directions during periods of shooting. When all baleen whales were combined, significantly more were found to be heading away from the vessel during periods of shooting; for white-beaked dolphins and all dolphins combined significantly fewer were heading towards the vessel when the airguns were firing.

7. No significant effects of seismic activity were observed for site surveys, but sample sizes were low, precluding allowance for potential sources of bias such as weather conditions.

8. Both notification and a report were received by JNCC for 81% of seismic surveys taking place during 1999 (in blocks licensed in the 16th, 17th and 18th rounds of offshore licensing).

9. The duration of pre-shooting searches for marine mammals met or exceeded the required minimum of 30 minutes for 85% of occasions when the airguns were used during daylight hours in blocks where compliance with the guidelines was a licence condition. On 6% of occasions when the airguns were used during daylight hours in these blocks there was no pre-shooting search, while on 9% of occasions the pre-shooting search was shorter than the required minimum duration or was terminated prematurely. The proportion of short or absent pre-shooting searches was higher in other blocks. Short or absent pre-shooting searches occurred more frequently when fishery liaison officers or members of ships' crews were acting as marine mammal observers than when dedicated marine mammal observers were used; members of ships' crews were the least likely to perform an adequate pre-shooting search.

10. Excluding site surveys, 87% of soft-starts met or exceeded the required minimum duration of 20 minutes in blocks where compliance with the guidelines was a licence condition. Short or absent soft-starts were more frequent in other blocks. Short or absent soft-starts were more frequent when dedicated marine mammal observers were not present.

11. 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; on two of the seven occasions no action was taken to minimise disturbance to the marine mammals and shooting commenced shortly after they were seen, while on a third occasion the delay was shorter than the minimum required and the subsequent soft-start was also short.

12. Dedicated marine mammal observers were much more efficient at detecting marine mammals than other personnel - mean sighting rates for dedicated marine mammal observers were more than eight times higher than that of other personnel. Dedicated marine mammal observers also made fewer errors when completing the recording forms.

13. The proportion of seismic surveys using dedicated marine mammal observers has steadily increased since the introduction of the guidelines, although in 1999 it was still only on a minority of surveys that such observers were used. The use of dedicated marine mammal observers is recommended, both in terms of compliance with the requirements of the guidelines and the provision of accurate data. Sole reliance on members of ships' crews to carry out observations of marine mammals was found to be the least effective alternative.

14. Revised standard recording forms are proposed in line with comments and suggestions received. A number of items for consideration when the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys* are next revised are discussed.

15. Low sample sizes for many species limited the use of the data. It is recommended that the next analysis performed combines data from 1998, 1999 and 2000. As the recording forms have remained the same throughout these three years this would provide an opportunity to increase sample sizes, both for individual species and for site surveys.

2. INTRODUCTION

In recent years there has been considerable concern over the issue of acoustic disturbance to marine mammals. The Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) includes amongst its requirements that range states should work towards "the prevention of … disturbance, especially of an acoustic nature". As part of the UK's response to ASCOBANS, following development work by the Joint Nature Conservation Committee (JNCC) the then Department of the Environment published the *Guidelines for minimising acoustic disturbance to small cetaceans* in February 1995. These guidelines aimed to reduce disturbance to cetaceans from seismic surveys, where the use of airguns generates sound, mostly of low frequency. Baleen whales also produce low frequency sounds, and are thus considered to be vulnerable to disturbance from seismic surveys (e.g. Moscrop and Simmonds 1994 and references therein). Although toothed whales and dolphins use higher frequency sounds for communication and echolocation, seismic operations may incidentally emit high frequency sounds (Goold and Fish 1998), so these species may also be vulnerable to disturbance (Goold 1996; Stone 1997, 1998a).

Since their original publication, the guidelines have been revised on two occasions by JNCC. The latest revision (April 1998) applies precautionary measures to all marine mammals, this revision being appropriately 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). Under the guidelines, operators are required 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 are advised to provide appropriately qualified and experienced personnel to act as marine mammal observers on surveys taking place in areas of importance for marine mammals. Throughout a seismic survey, the guidelines require that 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 (revised versions of these forms are included in Appendix 3). The results of the analysis of data recorded during 1999 are presented here.

3. METHODS

Watches for marine mammals were carried out on seismic survey vessels throughout daylight hours on surveys conducted during 1999. Details of seismic (= airgun) activity, the watch for marine mammals and any sightings were recorded on standard recording forms (Appendix 2). Data from 66 surveys were forwarded to JNCC, covering 72 quadrants (Figure 1).

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, then identifications were amended on the basis of the information available. This usually involved downgrading of identifications from one species to a group of similar species which the animal could have been, based on the description given. For example, if an observer identified an animal as a white-beaked dolphin, but the only description was of an "animal a few metres long with a sickle shaped fin", then this sighting would have been entered into the database as dolphin sp., i.e. an unidentified dolphin. Videos or photographs, where available, were used to confirm identification; these were viewed prior to examining the recording forms, to allow an independent assessment of identification. Where this differed considerably from the observer's identification, the videos were viewed again as a final check before amending the identification recorded by the observer.

Some of the analyses involved calculating numbers of sightings per unit effort (i.e. per 1,000 hours survey). For these analyses, only those sightings from surveys where effort was correctly recorded were used (53% 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. As the proportion of time spent shooting also varied according to location, season and weather conditions, it was important to take account of 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. Accordingly, each quadrant was assigned to one of five geographical areas (Figure 1). Weather conditions were recorded daily (or occasionally more frequently) by observers, with sea state classed as 'glassy', 'slight', 'choppy' or 'rough', swell 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).

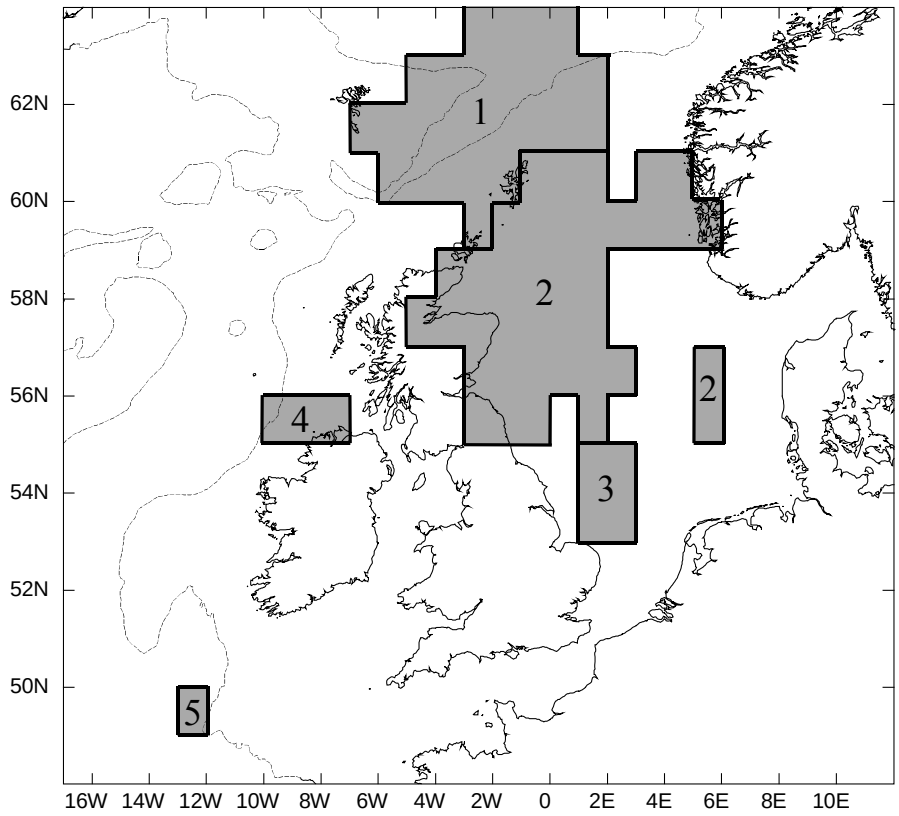


Figure 1 Quadrants surveyed for marine mammals from seismic survey vessels in 1999, and areas used in analysis: 1) West of Shetland; 2) Northern North Sea; 3) Southern North Sea; 4) West of Ireland; 5) South-West Approaches.

Sample sizes were small for many species. The extraction of subsets of data to eliminate bias reduced sample sizes even further, so this was done only for the more frequently seen species. The non-parametric statistical tests employed were those appropriate for small sample sizes (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).

4. AN OVERVIEW OF MARINE MAMMAL SIGHTINGS AND SURVEY EFFORT

There were 480 sightings of cetaceans (13,376 individuals) and 21 sightings of seals (22 individuals) during 1999 seismic surveys (Table 1). 60% 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 1999

Species	*Number of sightings*	*Number of individuals*
Seal sp.	4	4
Grey seal	11	12
Common seal	6	6
Cetacean sp.	11	32
Whale sp.	19	79
Large whale sp.	27 [a]	68
Humpback whale	1	1
Fin whale	15 [b]	33
Sei whale	4	4
Fin/ blue whale	5	13
Fin/ sei whale	5	9
Fin/ sei/ blue whale	2	5
Fin/ sei/ humpback whale	6	8
Fin/ sei/ blue/ humpback whale	2	4
Minke whale	31	47
Sperm whale	39	79
Humpback/ sperm whale	2	2
Medium whale sp.	2	2
Beaked whale sp.	3	3
Pilot whale	13 [c]	639
Killer whale	25	197
Dolphin sp.	90 [a]	4,266
Dolphin sp. not porpoise	8	24
Risso's dolphin	1	7
Bottlenose dolphin	10 [d]	74
Unpatterned dolphin sp.*[1]	1	2
White-beaked dolphin	76 [d,e]	783
White-sided dolphin	55 [b,c,e]	6,416
Lagenorhynchus sp.*[2]	14	516
Striped dolphin	1	18
Harbour porpoise	19	45
Total	**501**	**13,398**

*1 unpatterned dolphin = Risso's/ bottlenose dolphin

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

a includes 2 sightings of large whale sp. associated with dolphin sp.

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

c includes 2 sightings of pilot whales associated with white-sided dolphins

d includes 1 sighting of bottlenose dolphins associated with white-beaked dolphins

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

The species seen most frequently was the white-beaked dolphin. White-sided dolphins, sperm whales, minke whales and killer whales were seen with moderate frequency, with lower numbers of sightings of other species. Dolphins, pilot whales and killer whales were usually seen in groups; these groups could at times be quite large (mean pod size = 49.15 for pilot whales, 7.88 for killer whales, 10.30 for white-beaked dolphins, 116.65 for white-sided dolphins). Baleen whales and sperm whales tended to occur either singly or in small groups (mean pod size = 2.20 for fin whales, 2.03 for sperm whales, 1.52 for minke whales). There was a peak in sightings of cetaceans during the month of August (Figure 2), when more time was spent watching for marine mammals.

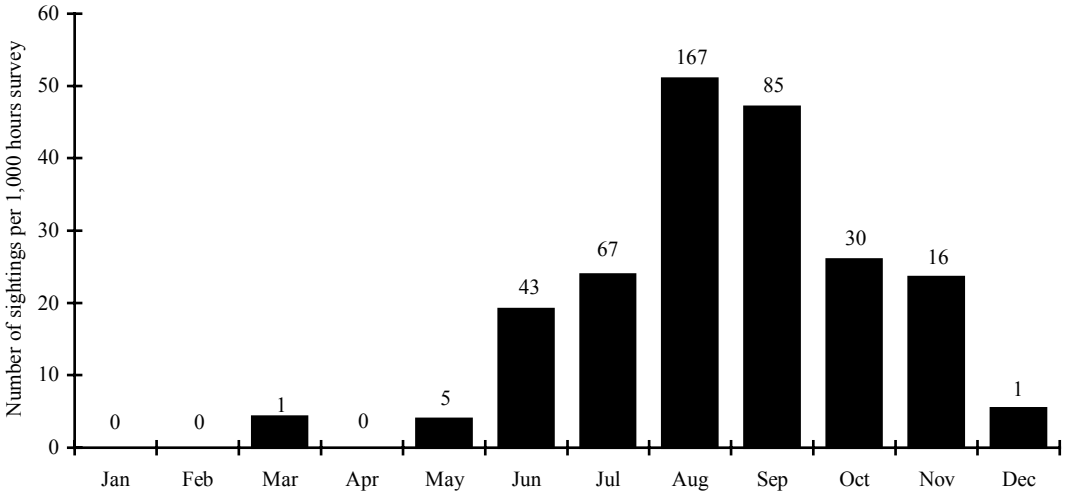


Figure 2 Sighting rates of marine mammals per month, with number of sightings (only includes surveys where effort was correctly recorded).

The length of time spent watching for marine mammals was summed using the surveys where 'Location and Effort' recording forms were completed correctly (35 of the 66 surveys). Excluding site surveys, 13,799 hrs 24 mins were spent watching for marine mammals, of which the airguns were firing for 5,944 hrs 11 mins (43% of the time on watch). 29 of the 66 surveys from which reports were received were site surveys, but effort was only recorded correctly during seven of these. During these site surveys 541 hrs 55 mins were recorded as watching for marine mammals, of which the airguns were firing for 181 hrs 19 mins (33% of the time on watch). The time spent watching for marine mammals during site surveys equated to approximately 4% of the total time spent watching during all surveys (14,341 hrs 19 mins). 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.

The overall time spent watching for marine mammals peaked in August, although the proportion of time spent shooting peaked in April and September (Figure 3). Most survey effort was concentrated in areas Northern North Sea and West of Shetland (Figure 4), although the proportion of time spent shooting was greatest in areas West of Ireland and Southern North Sea. A report was submitted from only one survey in the South-West Approaches, during which effort was not correctly recorded. Survey effort in the different areas varied throughout the year (Figure 5). Surveys in area West of Shetland did not commence until May, but then continued through to November, with an unusually high proportion of time spent shooting during the autumn months in this area. In the Southern North Sea surveys were undertaken from January through to October, while in the Northern North Sea there was little survey effort prior to May, but after this surveys continued until December. In both areas of the North Sea there was a peak in the proportion of time spent shooting in September; in the Northern North Sea there was another peak in January (although survey effort was low then), while in the Southern North Sea there was another peak in April. Surveys in area West of Ireland were restricted to June and July, but although survey effort was low a high proportion of time was spent shooting.

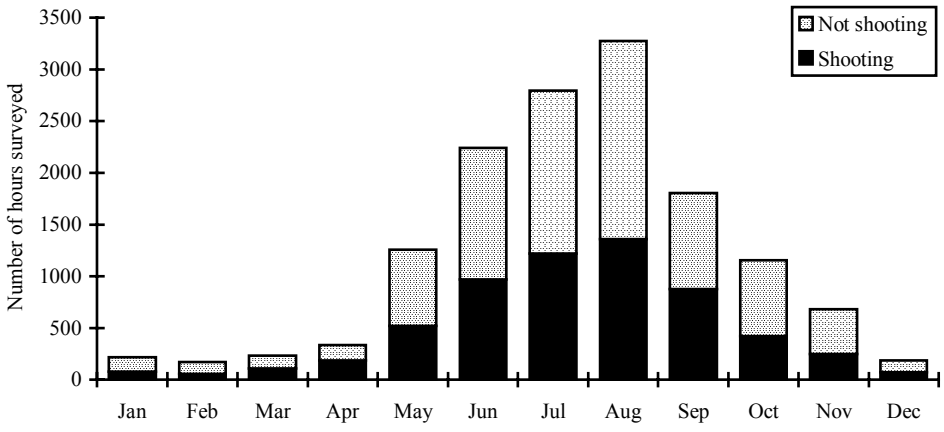


Figure 3 Length of time spent watching for marine mammals throughout 1999, and seismic activity during watches (all areas combined; only includes surveys where effort was correctly recorded).

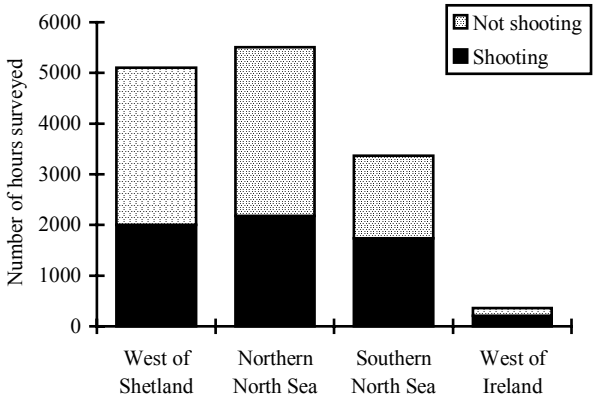


Figure 4 Length of time spent watching for marine mammals in each area, and seismic activity during watches (all months combined; only includes surveys where effort was correctly recorded).

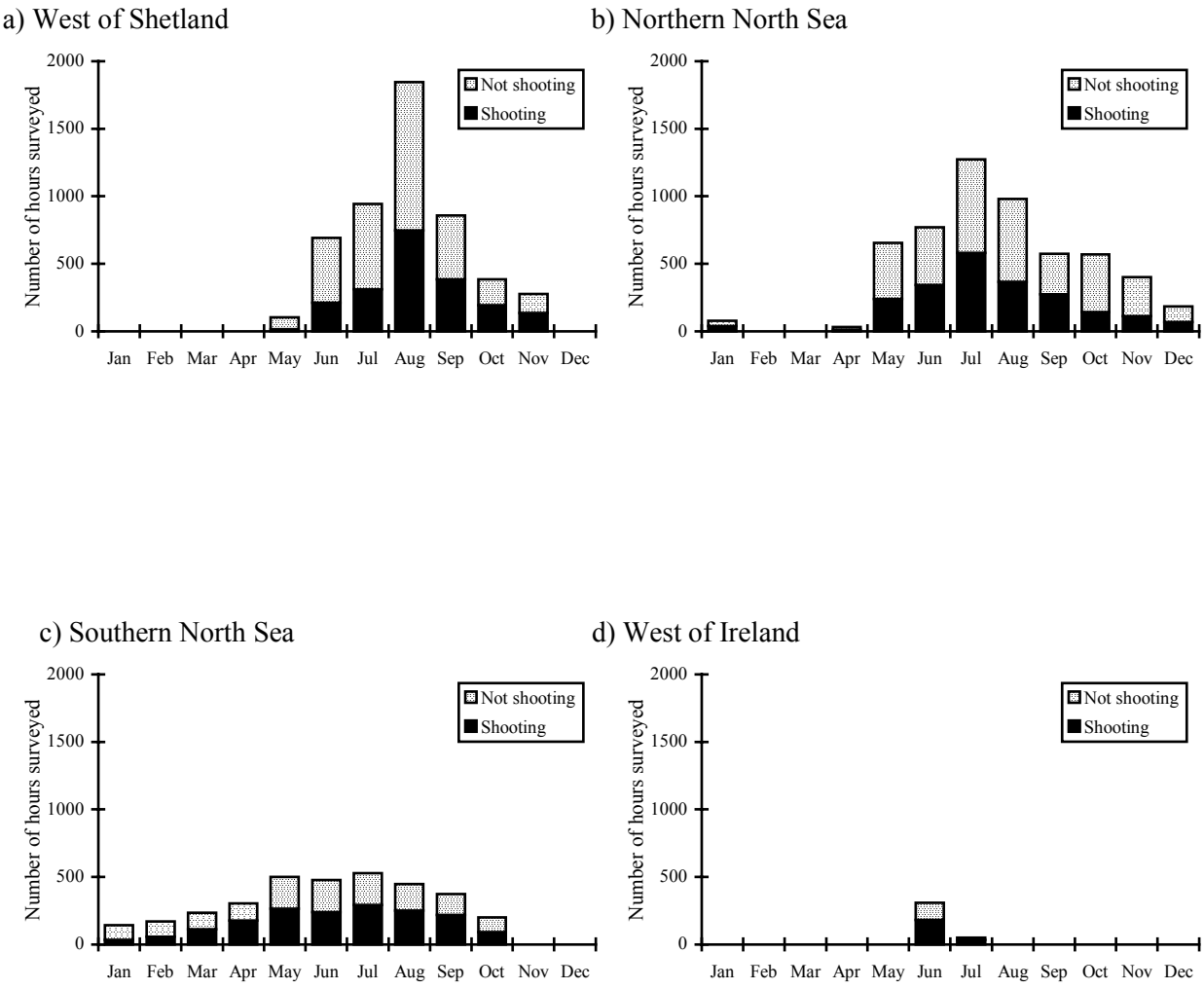


Figure 5 Comparison of survey effort throughout the year for the different survey areas (only includes surveys where effort was correctly recorded).

5. DISTRIBUTION OF MARINE MAMMALS

Sightings of marine mammals during seismic surveys in 1999 were concentrated in two main areas: north and west of Shetland and in the north-western part of the North Sea (Figure 6). To the north and west of Shetland there were many sightings in waters deeper than 1,000 m, but there were also a number of sightings in continental shelf waters. In the North Sea there was a cluster of sightings to the east of Aberdeen, near a deep trench known as the Devil's Hole, and a smaller cluster just beyond the outer Moray Firth. Scattered sightings occurred elsewhere off the east coast of Scotland and further offshore in the northern part of the North Sea. There were a few sightings in the southern part of the North Sea and a small cluster of sightings to the north-west of Ireland. There was just one sighting in the South-West Approaches.

Maps for cetaceans (Figures 7 - 22) showed that some species were only seen in relatively restricted geographical areas, while others were more widespread. Sei whales, sperm whales, beaked whales and pilot whales were concentrated in more northerly waters, with a preference for deeper waters beyond the 1,000 m isobath (Figures 10, 12, 13 & 14), although pilot whales were also seen on one occasion in deep waters in the South-West Approaches. Fin whales and white-sided dolphins were also found in northern waters (Figures 9 & 20), but were seen over the outer continental shelf and/or shelf slope as well as in deep waters. As well as occurring to the north-west of Shetland, white-sided dolphins were also seen in the North Sea (Figure 20).

Killer whales were also restricted to more northern waters, but occurred mainly over the continental shelf, with a few sightings in deeper waters (Figure 15). Some killer whales occurred relatively close inshore around Shetland. Risso's dolphins were also seen closer inshore, with one sighting to the north of Shetland (Figure 17). One humpback whale was seen close inshore off the east coast of Shetland (Figure 8).

In contrast to many species, striped dolphins were restricted to more southerly waters. The sole sighting of this species occurred in the southern North Sea (Figure 21).

Some species had a more widespread distribution. White-beaked dolphins were seen mostly in the northern North Sea (Figure 19), but were also seen close inshore around Shetland, over the continental shelf to the north of Shetland, and occasionally in deeper waters to the west of Shetland. There were occasional sightings of white-beaked dolphins in the southern North Sea. The distribution of harbour porpoises (Figure 22) also ranged from shallow waters in the southern North Sea to deep waters to the north-west of Shetland. Minke whales and bottlenose dolphins were seen in the northern North Sea, sometimes relatively close inshore, and also occasionally further offshore in deeper waters to the north-west of Shetland (Figures 11 & 18). All sightings of bottlenose dolphins offshore in the North Sea occurred within a 12 day period in late August/ early September.

Maps for seals (Figures 23 - 25) showed that most were seen in the North Sea. Most grey seals (Figure 24) were seen relatively close inshore off the east coast of Scotland, especially near the Firth of Forth, with one sighting near the Farne Islands. There was one sighting of a grey seal further offshore in the northern North Sea. Common seals were seen less often, but were seen close to the Farne Islands, close to Shetland and in the outer Moray Firth (Figure 25).

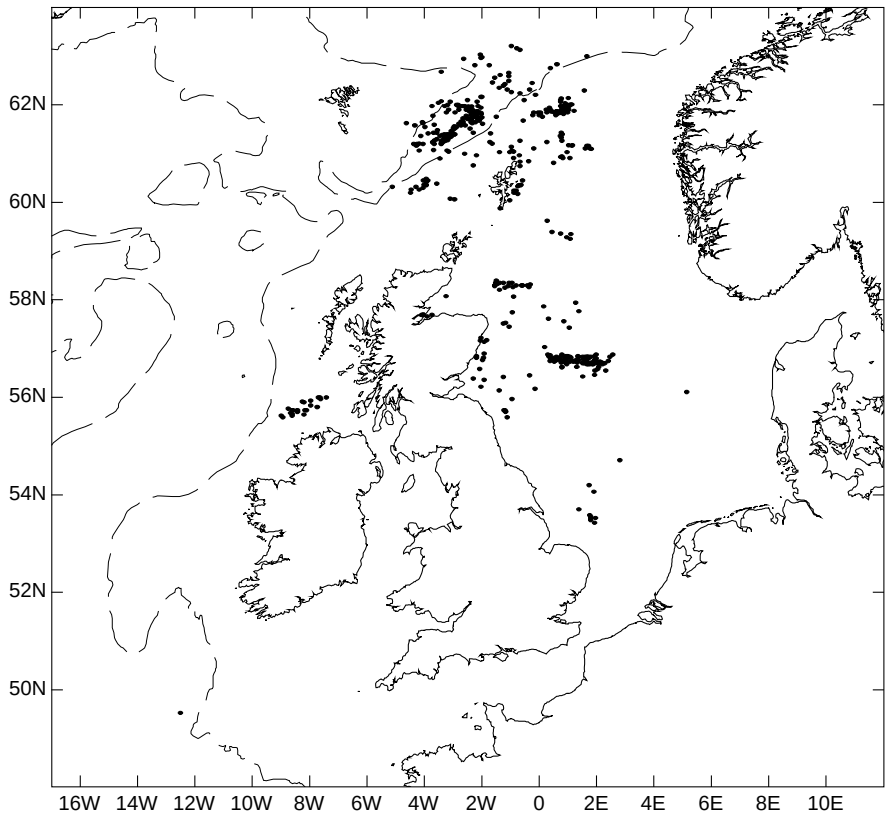


Figure 6 Marine mammal sightings (all species) from seismic survey vessels during 1999

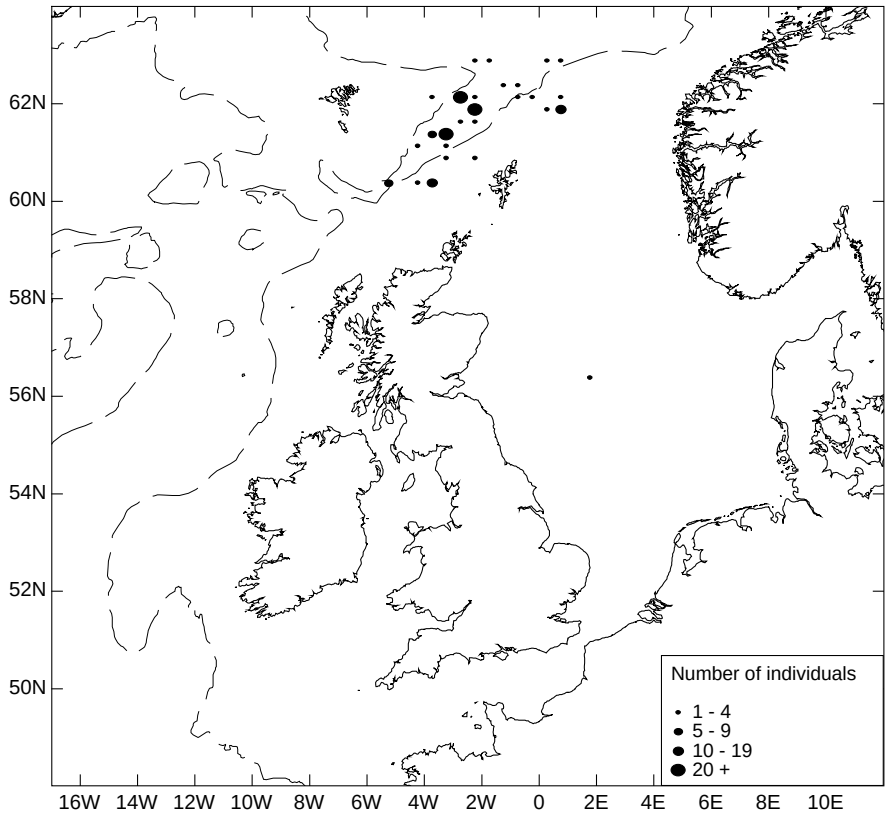


Figure 7 Distribution of unidentified whales during seismic surveys in 1999

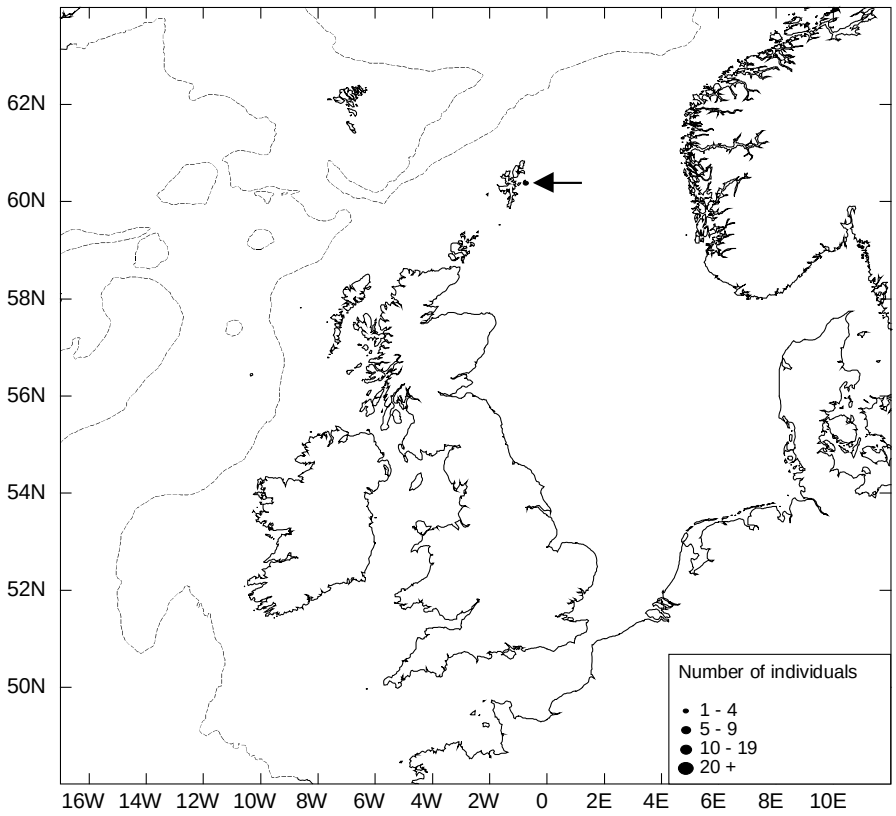


Figure 8 Distribution of humpback whales during seismic surveys in 1999

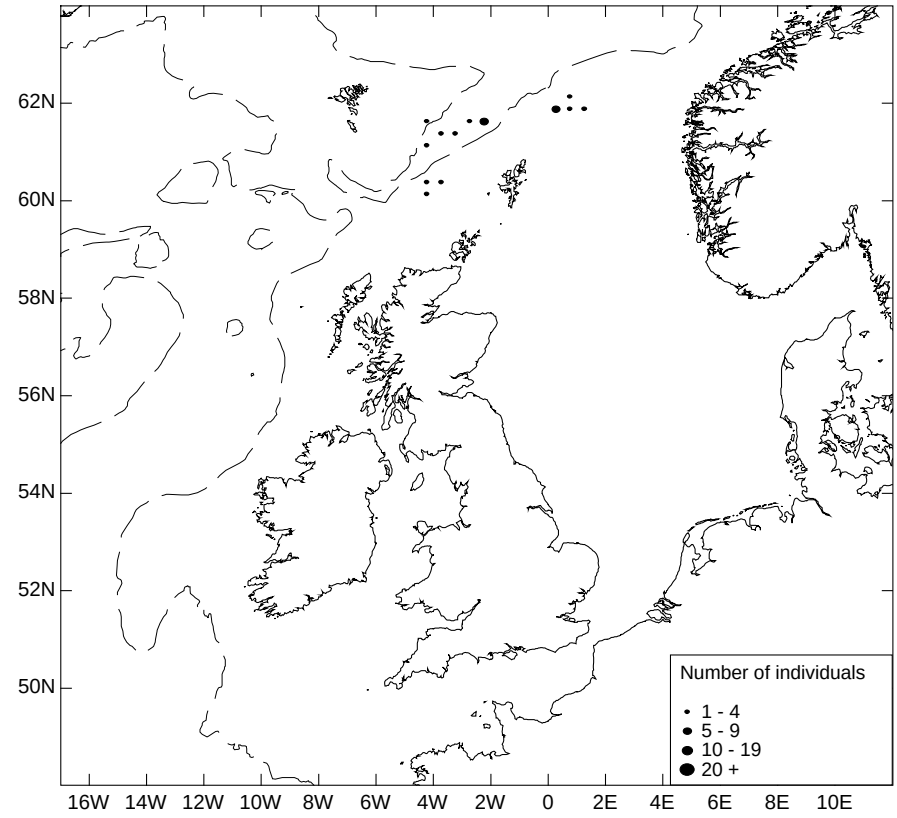


Figure 9 Distribution of fin whales during seismic surveys in 1999

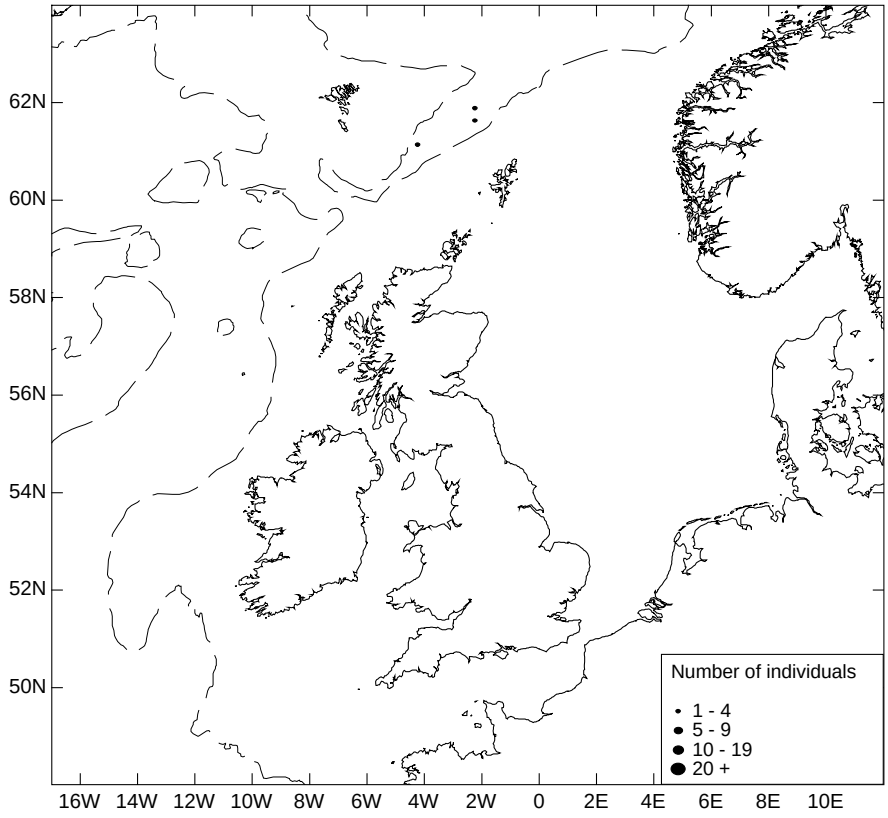


Figure 10 Distribution of sei whales during seismic surveys in 1999

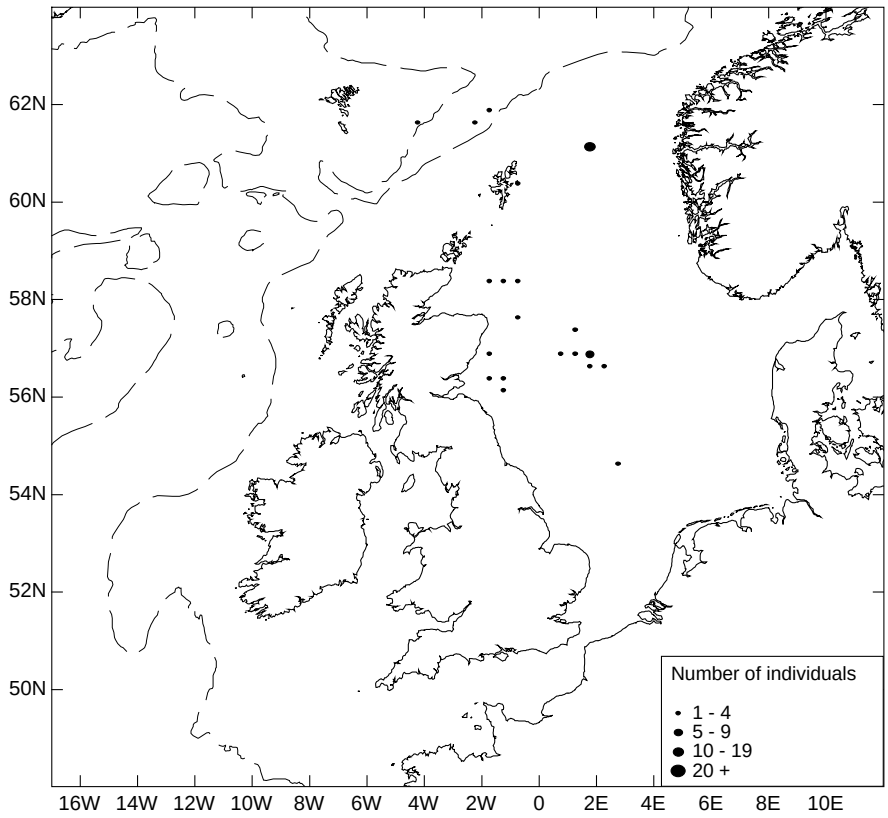


Figure 11 Distribution of minke whales during seismic surveys in 1999

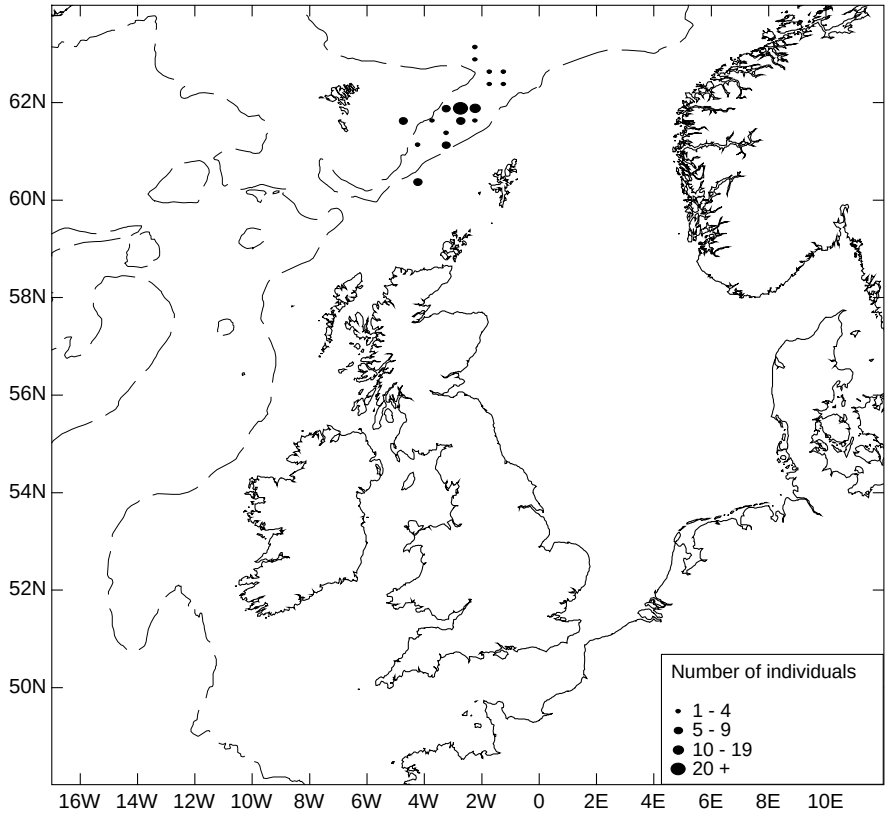


Figure 12 Distribution of sperm whales during seismic surveys in 1999

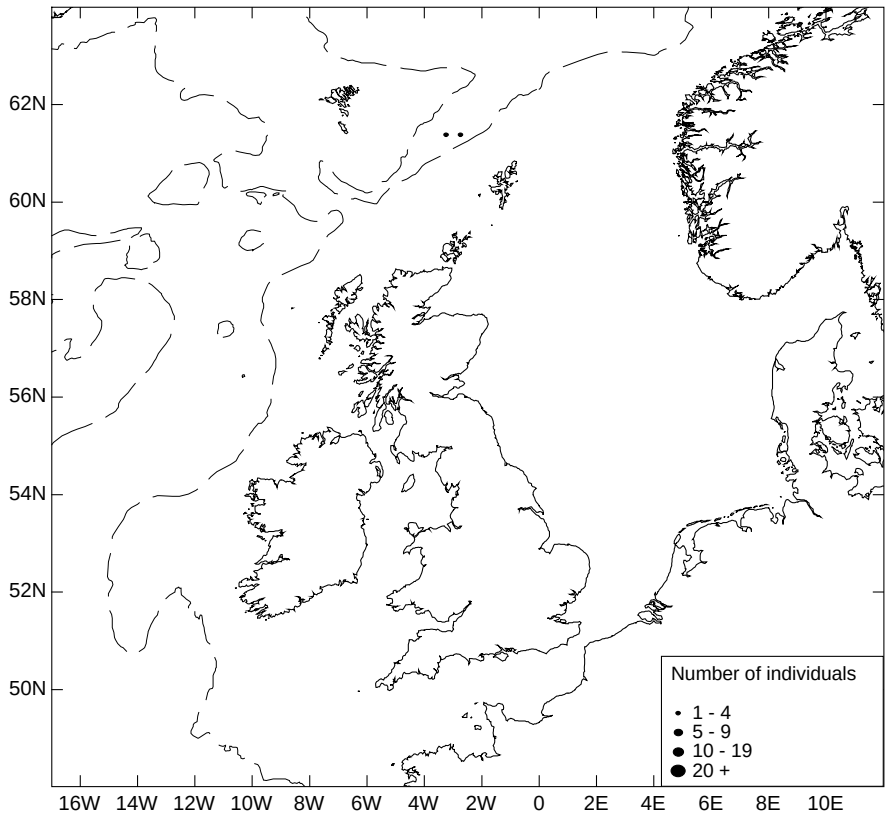


Figure 13 Distribution of unidentified beaked whales during seismic surveys in 1999

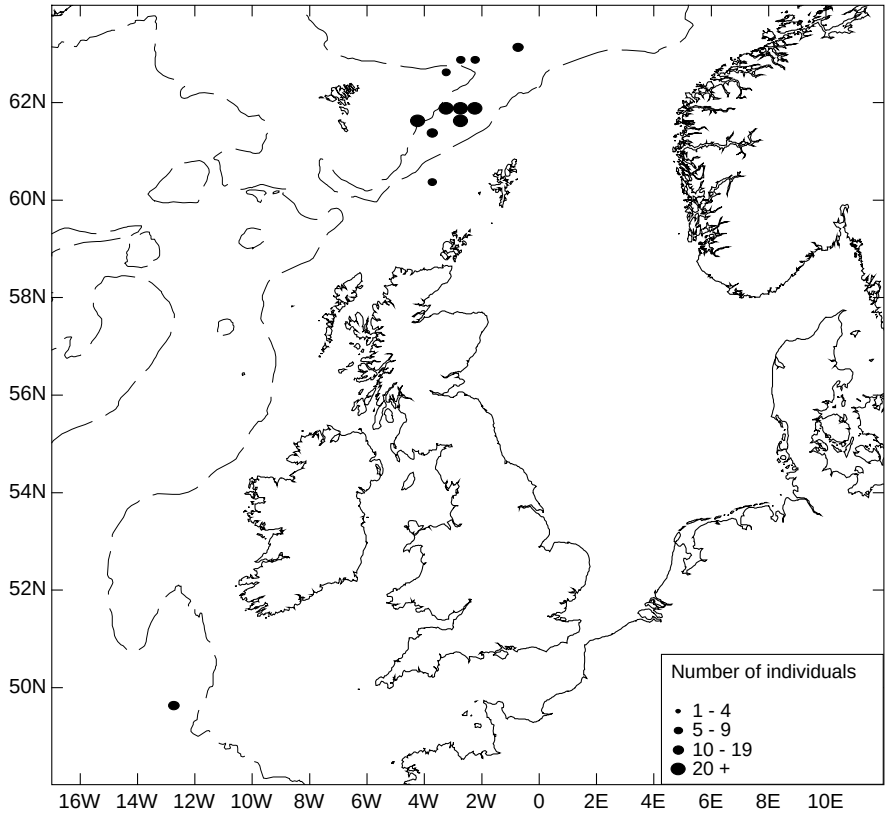


Figure 14 Distribution of pilot whales during seismic surveys in 1999

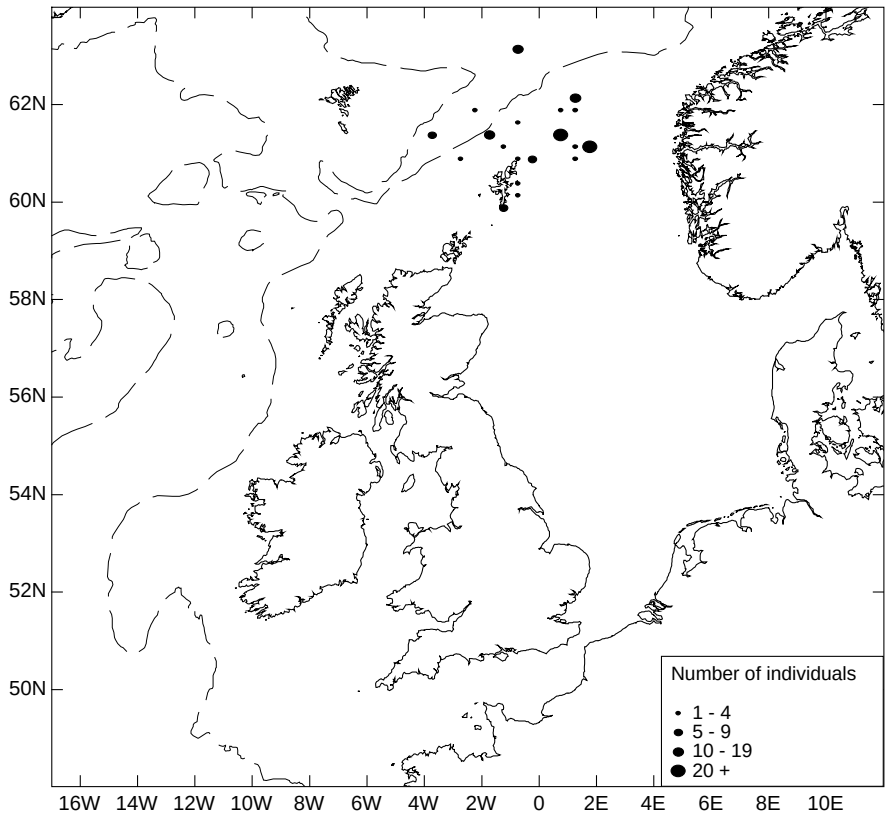


Figure 15 Distribution of killer whales during seismic surveys in 1999

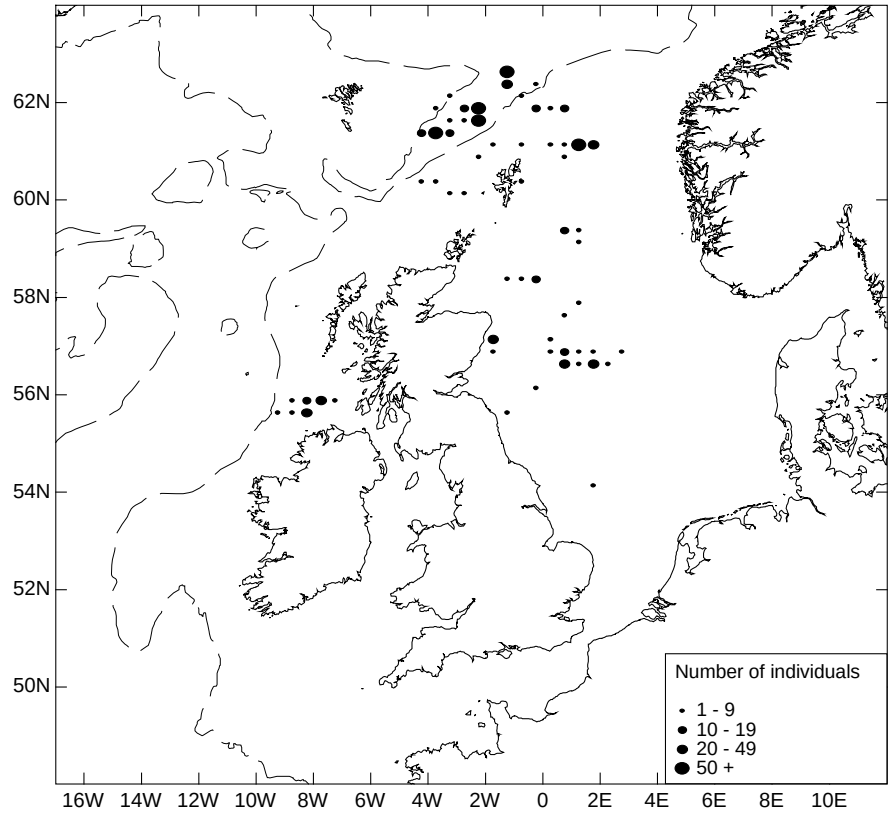


Figure 16 Distribution of unidentified dolphins during seismic surveys in 1999

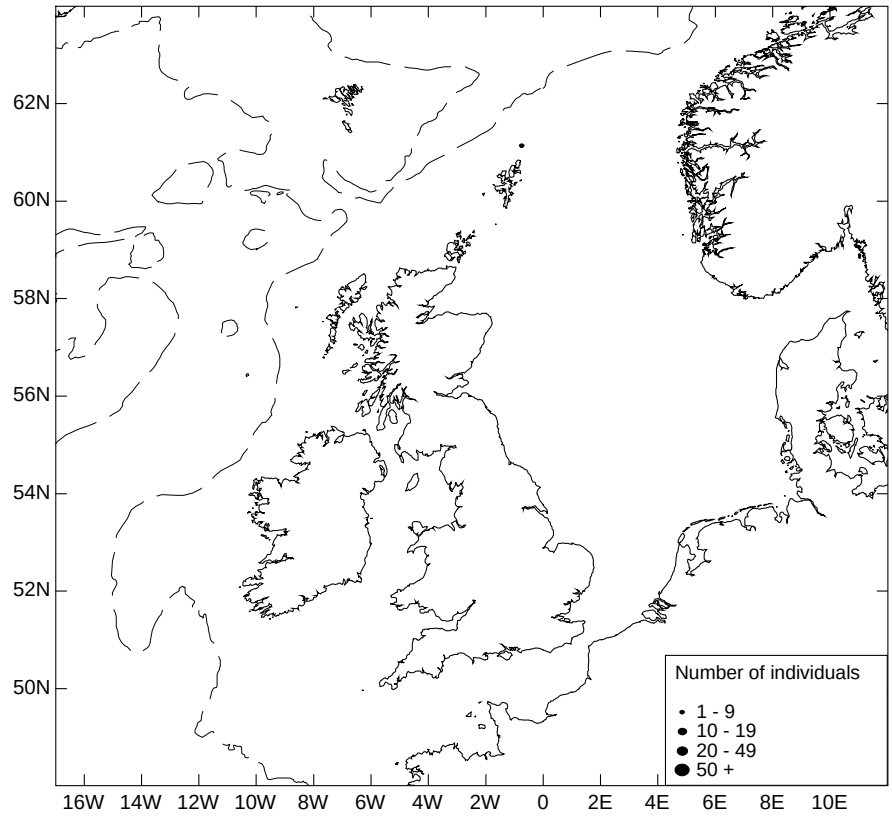


Figure 17 Distribution of Risso's dolphins during seismic surveys in 1999

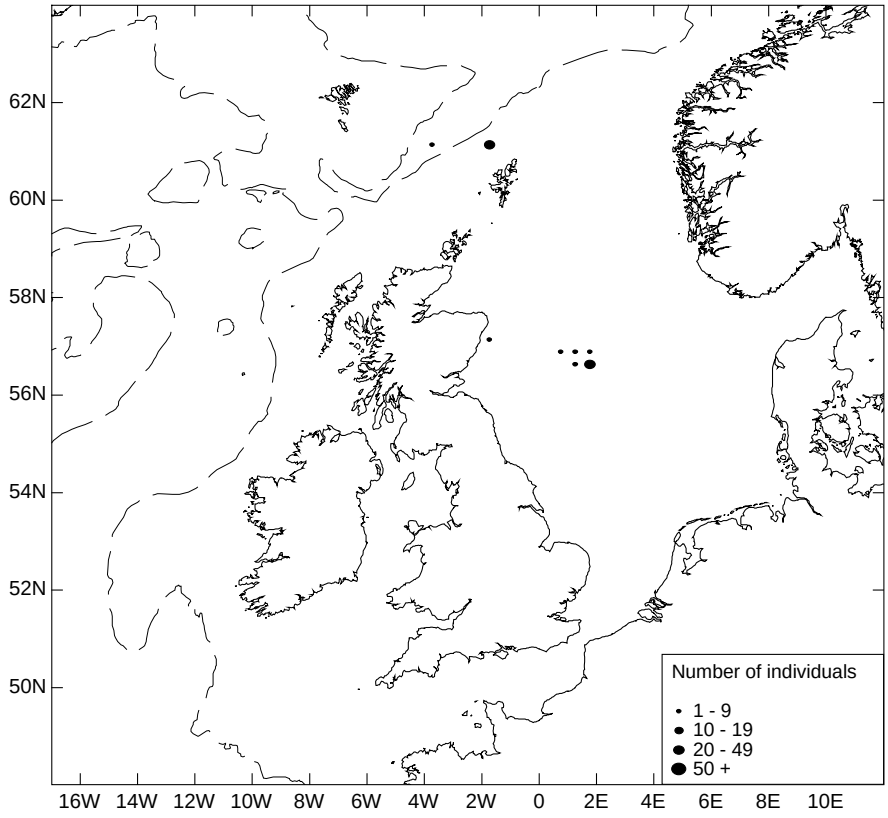


Figure 18 Distribution of bottlenose dolphins during seismic surveys in 1999

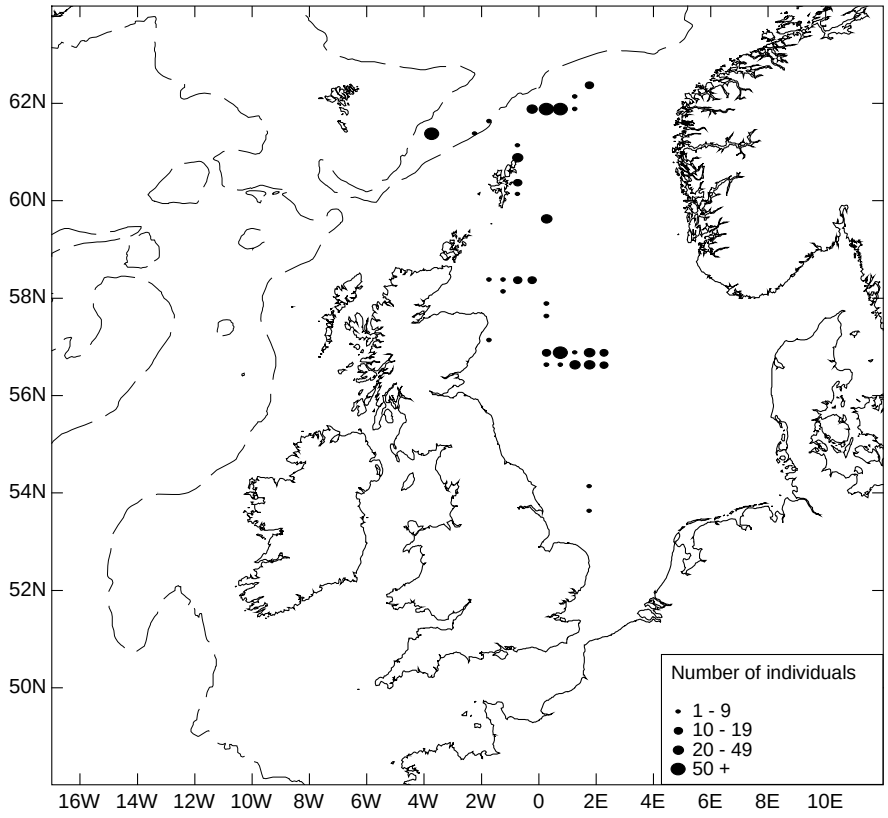


Figure 19 Distribution of white-beaked dolphins during seismic surveys in 1999

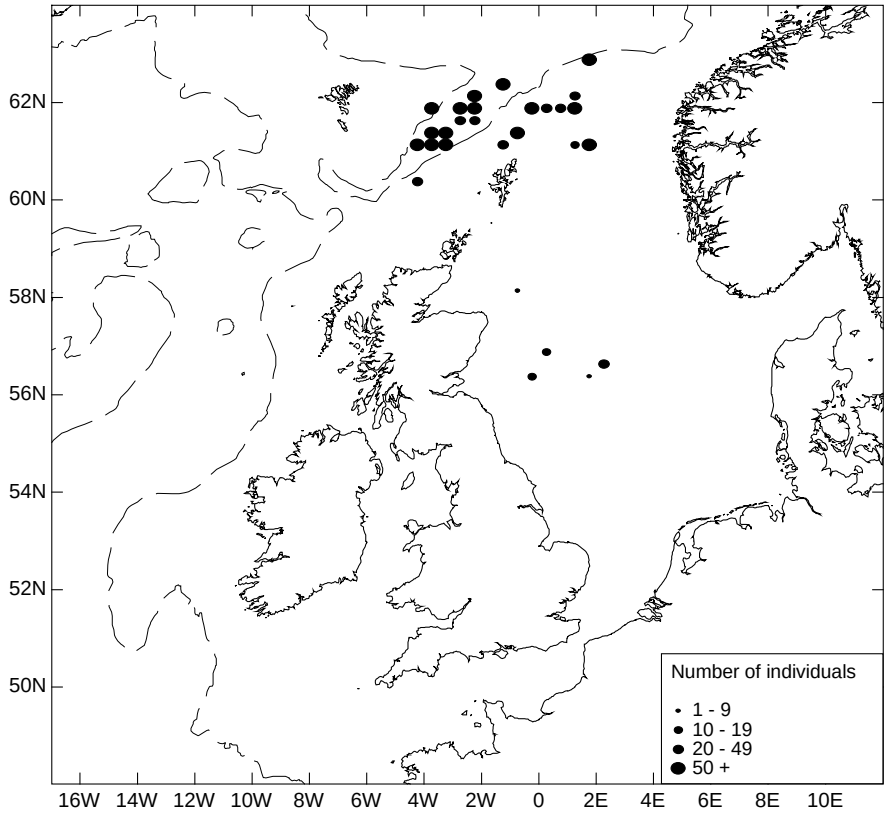


Figure 20 Distribution of white-sided dolphins during seismic surveys in 1999

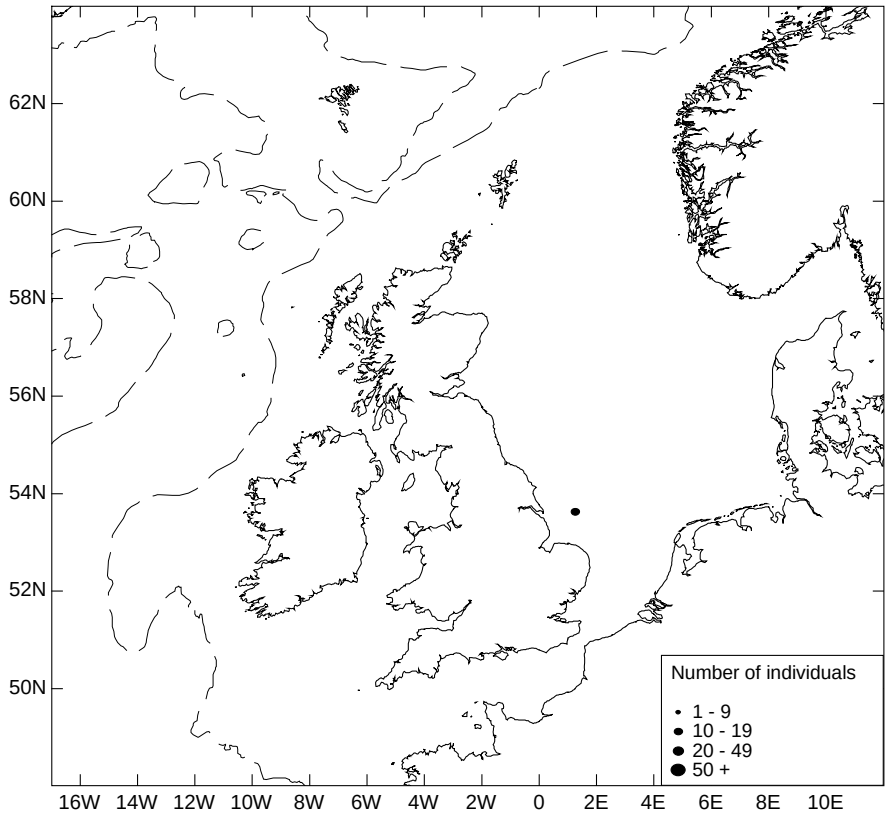


Figure 21 Distribution of striped dolphins during seismic surveys in 1999

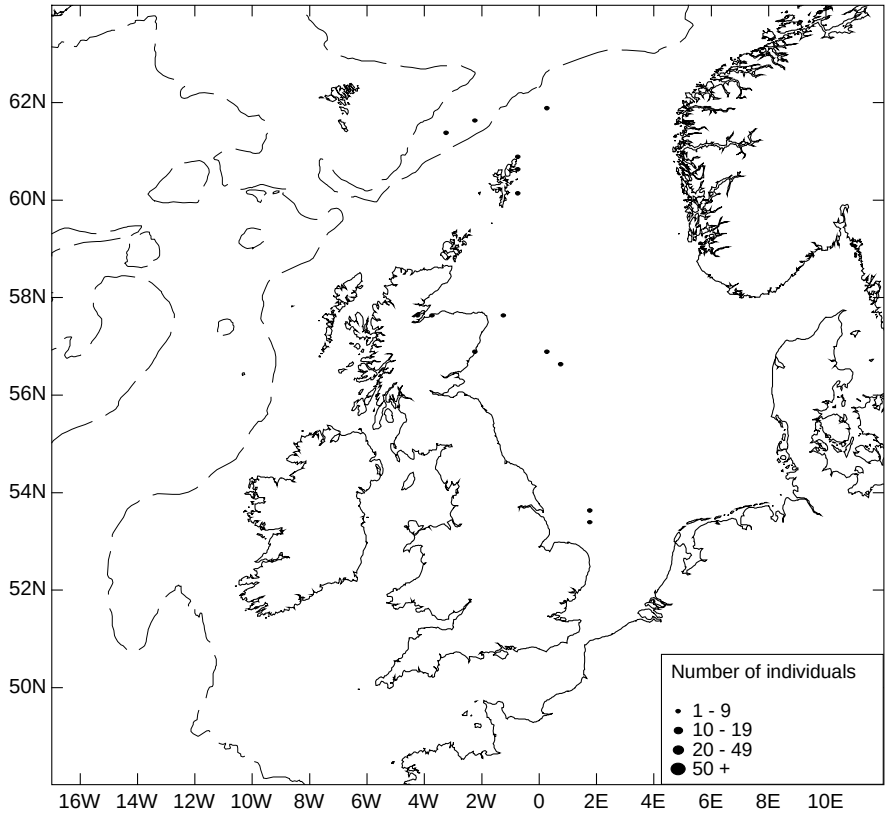


Figure 22 Distribution of harbour porpoises during seismic surveys in 1999

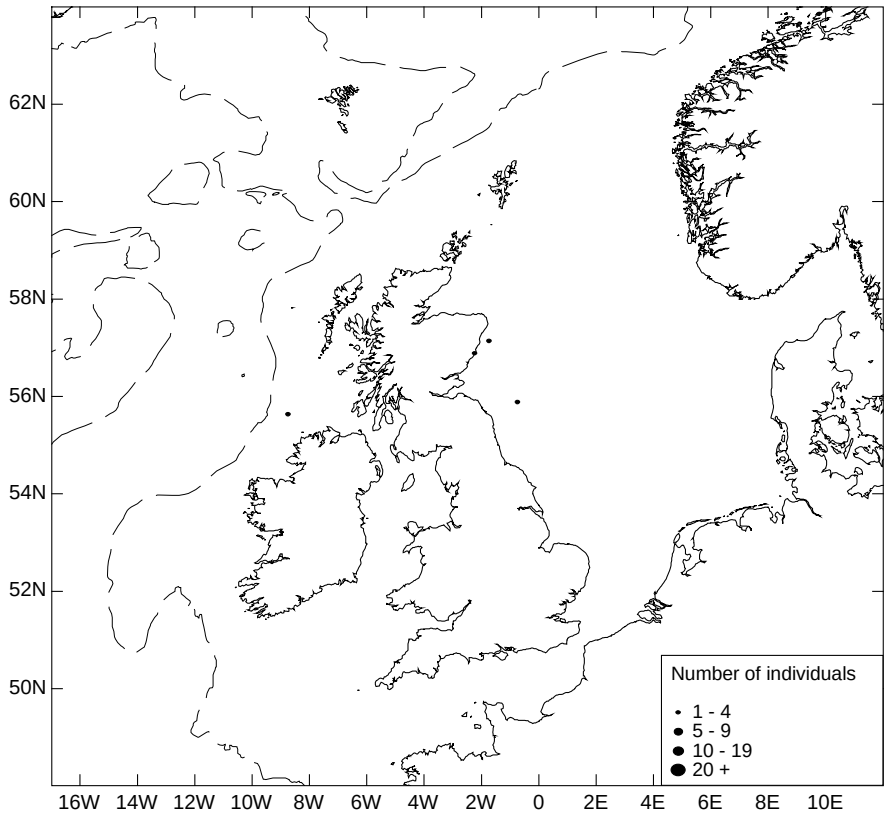


Figure 23 Distribution of unidentified seals during seismic surveys in 1999

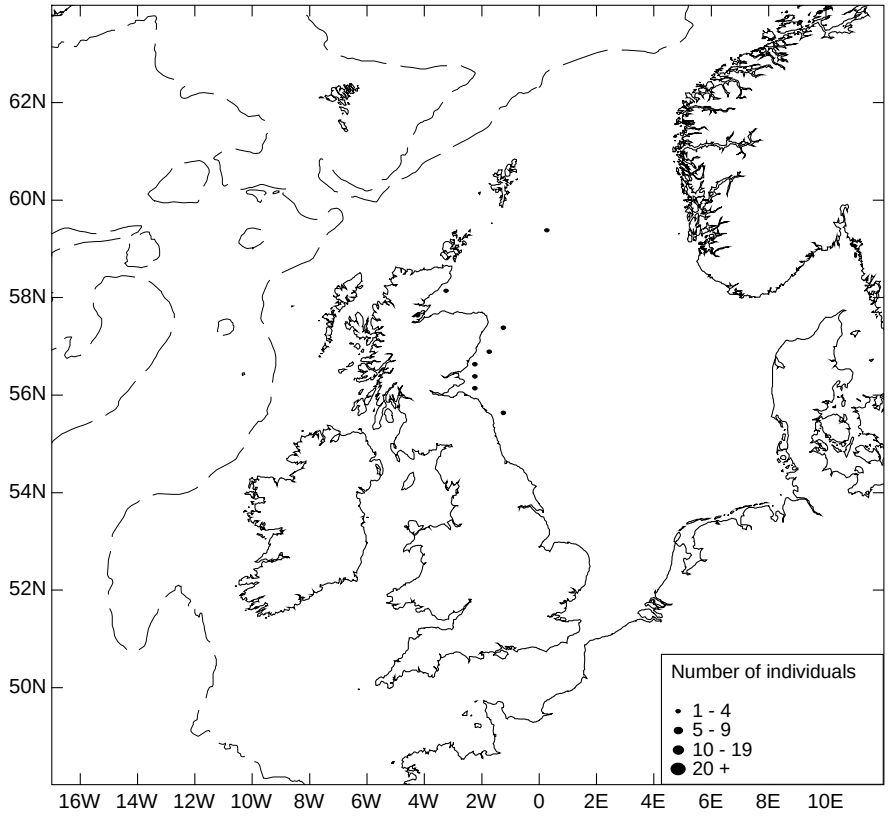


Figure 24 Distribution of grey seals during seismic surveys in 1999

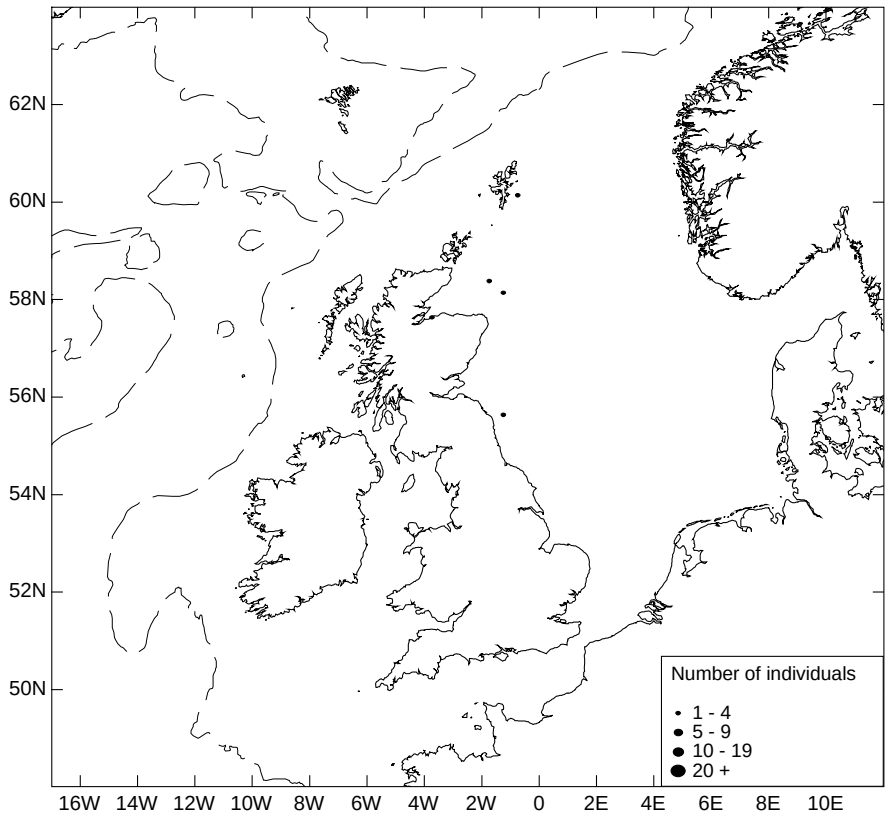


Figure 25 Distribution of common seals during seismic surveys in 1999

6. SEASONAL ABUNDANCE AND MIGRATION OF MARINE MAMMALS

There were no indications from the distribution or direction of travel of marine mammals of any migratory patterns in the species observed. However, there were seasonal peaks of occurrence for some species. The number of sightings of many species peaked in August, as might be expected as the time spent watching for marine mammals also peaked then (Figure 3). After allowing for the amount of time spent watching for marine mammals, some differences in the seasonal occurrence of the different species became apparent (Figure 26).

Sightings of fin whales, sperm whales and pilot whales occurred only during the summer and autumn months. Sighting rates of sperm whales reached moderate levels earlier in the summer than those of fin whales. Sightings of white-beaked and white-sided dolphins also occurred only during the summer and autumn months, but with a slightly more extended season than the large whales and pilot whales. Sighting rates of white-beaked and white-sided dolphins peaked in late summer/ early autumn, in August and September respectively. Harbour porpoises were also seen throughout the summer and autumn, with the sighting rate of this species peaking in October. Bottlenose dolphins only occurred offshore during late summer/ early autumn, but there was one additional sighting of this species close inshore near Aberdeen in November (while effort was not being recorded). Conversely, killer whales showed a peak of occurrence in early summer, during the month of June. Minke whales were seen in spring as well as throughout the summer and autumn; sighting rates of minke whales were constantly fluctuating.

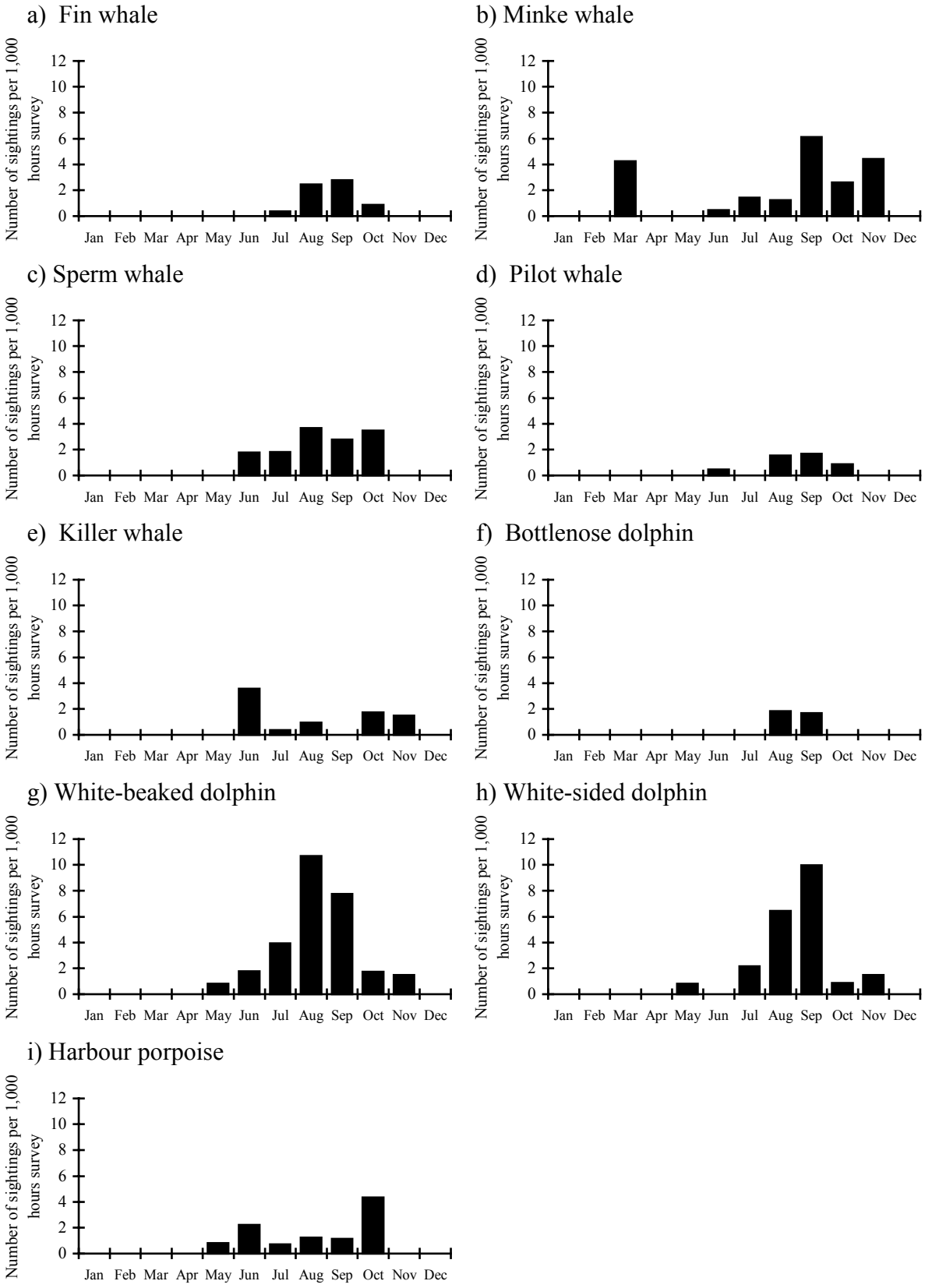


Figure 26 Sighting rates of cetaceans per month (only includes surveys where effort was correctly recorded).

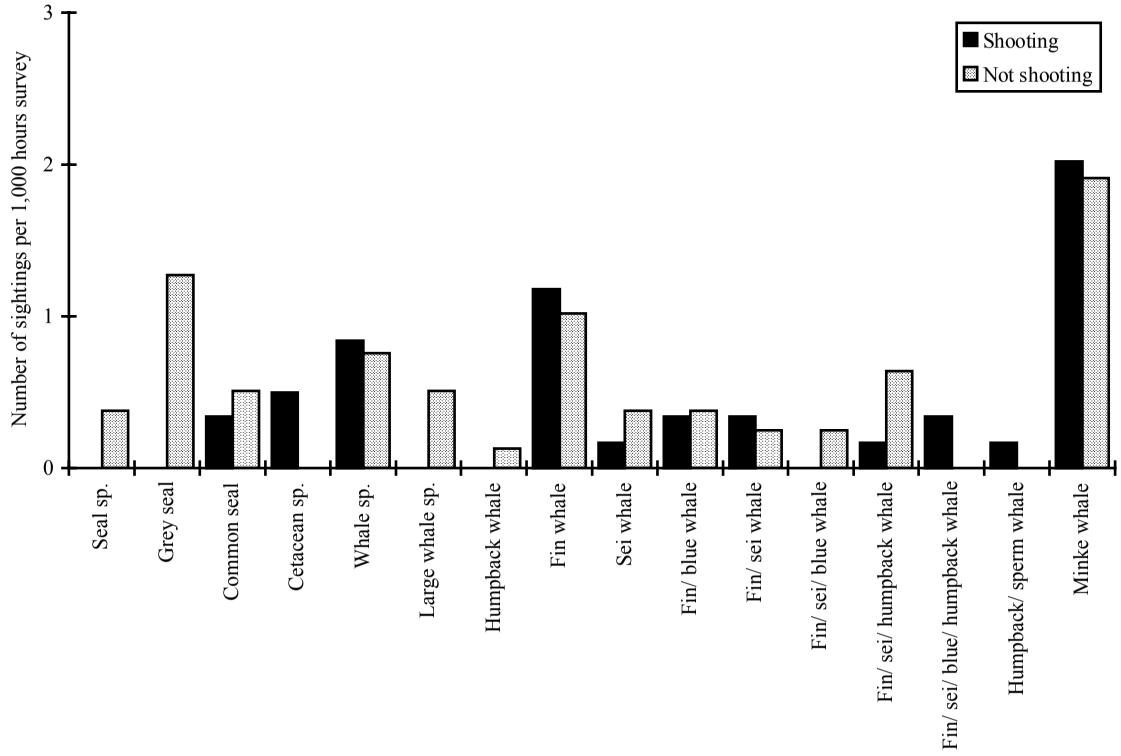
7. EFFECTS OF SEISMIC ACTIVITY ON MARINE MAMMALS

Reports were received from a number of different types of seismic surveys, some using large arrays of airguns and others with much smaller airgun configurations firing at relatively low power. The reports received did not always specify precise airgun parameters, but in most cases did state whether the survey was a 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. In general site surveys used airguns of relatively low power, that may have been less likely to cause disturbance to marine mammals. When considering the effects of seismic activity on marine mammals, site surveys were analysed separately from other surveys; 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 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 seals were highest when the airguns were not firing (Figure 27), while for cetaceans there were no clear patterns. Sighting rates of baleen whales were similar regardless of whether the airguns were firing or not. However, amongst the odontocetes, white-beaked dolphins and unidentified dolphins were seen more often during periods of shooting, while sperm whales, killer whales, white-sided dolphins and harbour porpoises were seen more often when the airguns were not firing. 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 killer whales, unidentified dolphins and white-sided dolphins (Table 2).

a) Seals and baleen whales



b) Odontocetes

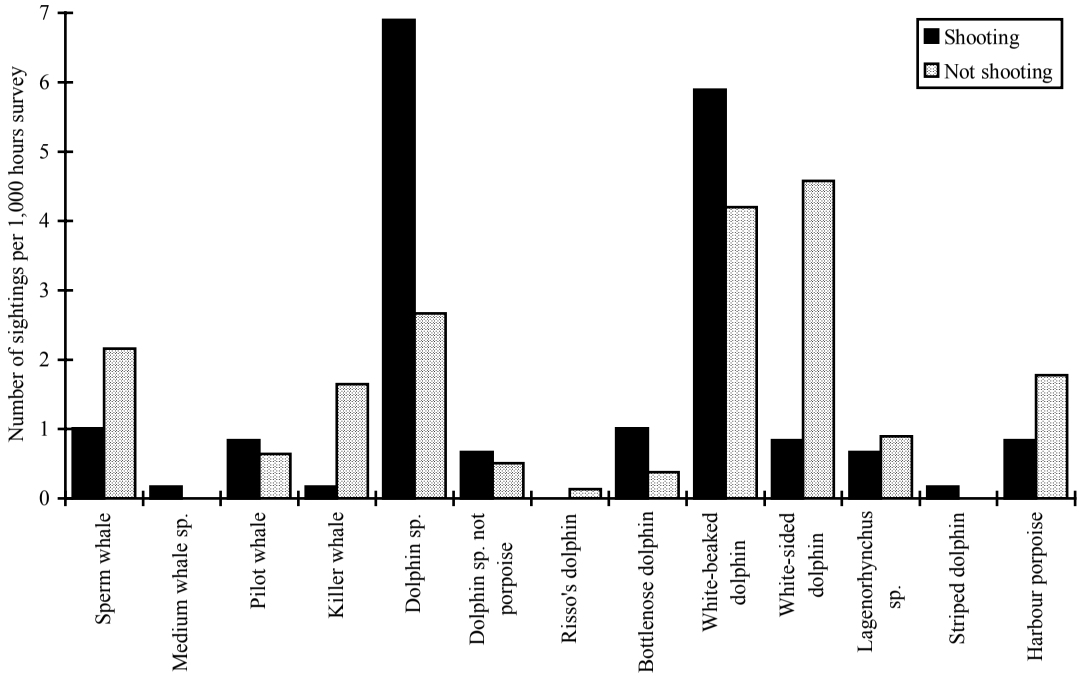


Figure 27 Sighting rates of marine mammals in relation to seismic activity (excluding site surveys, and not taking account of location, season or weather conditions).

Table 2 Statistical significance of difference in sighting rate of marine mammals in relation to seismic activity (excluding site surveys), not taking account of location, season or weather (d.f. = degrees of freedom; P = probability; n.s. = not significant).

Species	χ^2	*d.f.*	*P*
Fin whale	0.079	1	n.s.
Minke whale	0.021	1	n.s.
Sperm whale	2.711	1	n.s.
Killer whale	7.370	1	< 0.01
Dolphin sp.	13.432	1	< 0.001
White-beaked dolphin	1.955	1	n.s.
White-sided dolphin	15.942	1	< 0.001
Harbour porpoise	2.171	1	n.s.

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 particularly important to account for such factors if the proportion of time spent shooting also varies in relation to them. For example, including data from areas or seasons where marine mammal abundance is naturally low but where a high proportion of time was spent shooting could lead to the erroneous conclusion that sighting rates were reduced due to seismic activity, when the reduction could be adequately explained by natural factors. Similarly, observed effects on sighting rates could be related to weather conditions; 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 1999 the proportion of time spent engaged in seismic activity varied with location and season (Figures 3, 4 & 5), and was greatest in good weather conditions (Figure 28). Where sample size permitted it was important to re-calculate sighting rates of marine mammals to take account of these potential sources of bias.

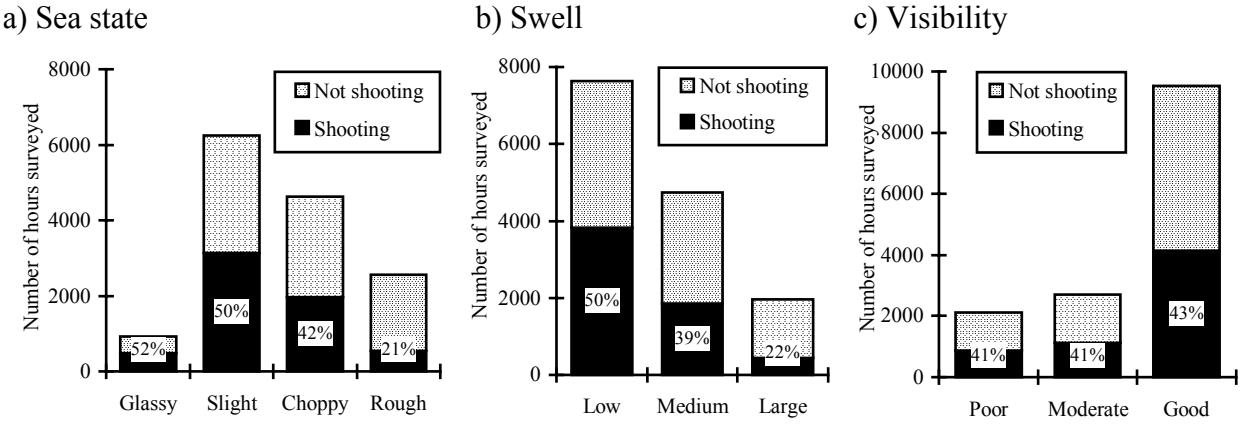


Figure 28 Length of time spent watching for marine mammals in different weather conditions in relation to seismic activity, with percentage of time spent shooting (only includes surveys where effort was correctly recorded).

When re-calculating 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; Northridge *et al.* 1995; Pollock *et al.* 1997, 2000; Skov *et al.* 1995). To reduce the influence of weather, data from periods of poor weather conditions were disregarded. There was apparently little effect of increasing sea state on the ability to detect large whales (Figure 29a), but as 'rough' sea states included conditions up to wind force 10 on the Beaufort scale it seemed inadvisable to include this category when re-calculating sighting rates. For the medium whales, dolphins and seals there was an obvious decline in sighting rate as sea states increased (Figure 29b). Although it would have been ideal to restrict analysis for these species to periods of 'glassy' sea states alone,

the reduction in sample size would have prevented meaningful analysis, so periods of 'slight' sea states were also included. Large whales were readily visible in 'low' or 'medium' swell, whereas medium whales, dolphins and seals were most easily detected in conditions of 'low' swell (Figure 30). However, when considering visibility, subsets of data had to be more restricted for large whales. Large whales were very often detected at considerable distances, where their conspicuous blows were still relatively easily seen. Any reduction in visibility below 'good' therefore hindered detection of these animals (Figure 31a). Conversely, most smaller species with less conspicuous or invisible blows were seen at relatively shorter distances, therefore a reduction of visibility from 'good' to 'moderate' had less effect on the ability to detect these species (Figure 31b).

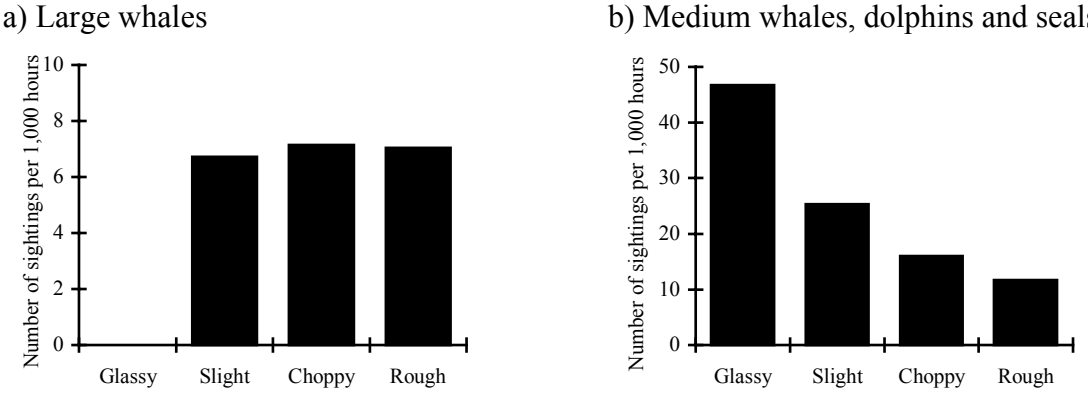


Figure 29 Frequency of marine mammal sightings in relation to sea state (large whales = fin/ sei/ blue/ humpback/ sperm whales i.e. whales over 10 m long with a conspicuous blow; medium whales = minke/ northern bottlenose/ beaked/ pilot/ killer whales).

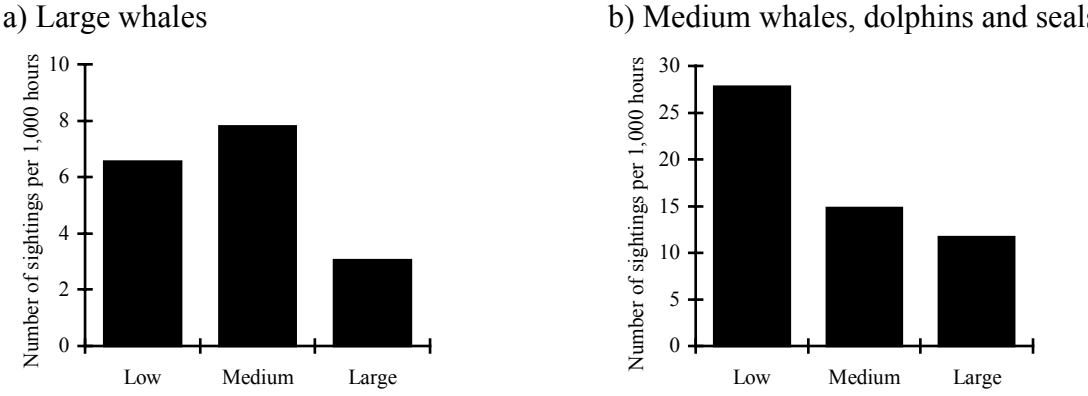


Figure 30 Frequency of marine mammal sightings in relation to swell (large whales = fin/ sei/ blue/ humpback/ sperm whales i.e. whales over 10 m long with a conspicuous blow; medium whales = minke/ northern bottlenose/ beaked/ pilot/ killer whales).

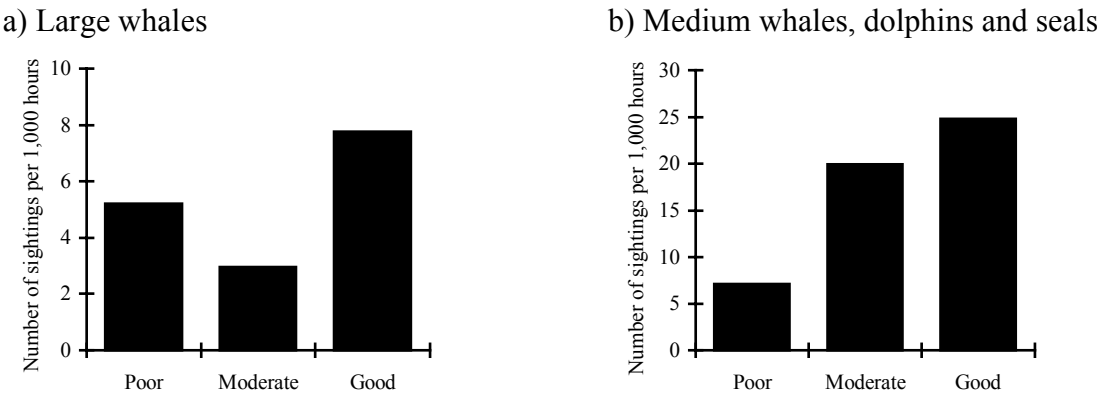


Figure 31 Frequency of marine mammal sightings in relation to visibility (large whales = fin/ sei/ blue/ humpback/ sperm whales i.e. whales over 10 m long with a conspicuous blow; medium whales = minke/ northern bottlenose/ beaked/ pilot/ killer whales).

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 West of Ireland	Glassy Slight	Low	Good
Fin whale	Jun - Sep	West of Shetland	Glassy Slight Choppy	Low Medium	Good
Minke whale	Jun - Sep	West of Shetland Northern North Sea West of Ireland	Glassy Slight	Low	Good Moderate
Sperm whale	May - Aug	West of Shetland West of Ireland	Glassy Slight Choppy	Low Medium	Good
Pilot whale	May - Sep	West of Shetland West of Ireland South-West Approaches	Glassy Slight	Low	Good Moderate
All dolphins combined	Jun - Sep	West of Shetland Northern North Sea West of Ireland South-West Approaches	Glassy Slight	Low	Good Moderate
White-beaked dolphin	Jun - Sep	West of Shetland Northern North Sea	Glassy Slight	Low	Good Moderate
White-sided dolphin	Jun - Sep	West of Shetland	Glassy Slight	Low	Good Moderate

The criteria used for selecting subsets of data are summarised in Table 3. Sample sizes were only sufficient to permit re-calculation of sighting rates for five 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 32; Table 4).

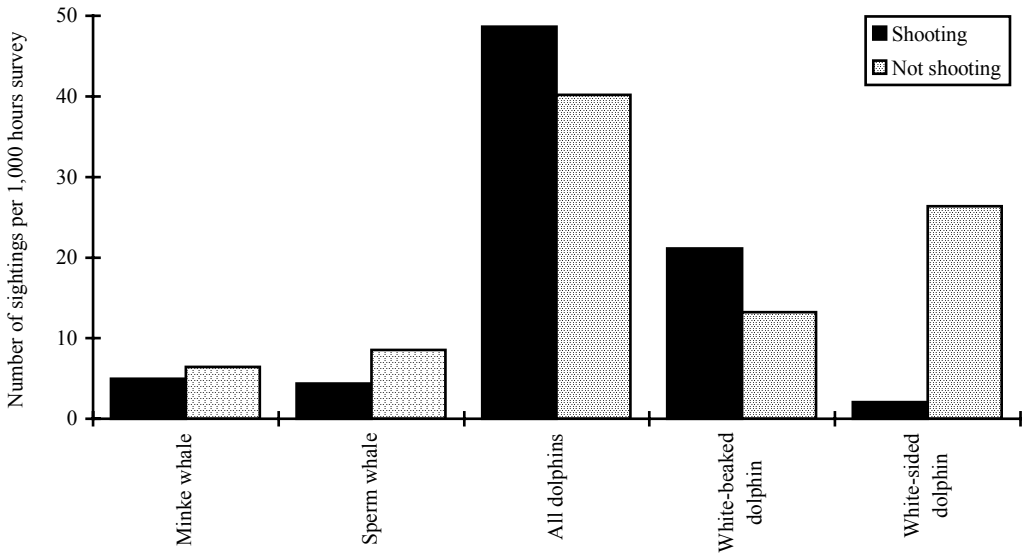


Figure 32 Sighting rates of marine mammals in relation to seismic activity (excluding site surveys), taking account of location, season and weather conditions.

Table 4 Statistical significance of difference in sighting rate of marine mammals in relation to seismic activity (excluding site surveys), taking account of location, season and weather (d.f. = degrees of freedom; P = probability; n.s. = not significant).

Species	χ^2	*d.f.*	*P*
Minke whale	0.262	1	n.s.
Sperm whale	1.299	1	n.s.
All dolphins combined	1.055	1	n.s.
White-beaked dolphin	2.259	1	n.s.
White-sided dolphin	10.079	1	< 0.01.

There were clearly fewer sightings of fin whales and pilot whales in 1999 than there had been in previous years. However, in previous years there had been substantial survey effort in the Rockall area, where these species were frequently seen. In order to ascertain whether there were significant differences in the numbers seen, sighting rates were compared for each year between 1997 and 1999. Data from 1996 were not used as daily weather conditions were not recorded then. To enable a fair comparison between years, the criteria specified in Table 3 were used, thus eliminating data from the Rockall area in previous years. However, swell was not routinely recorded during 1997 - although periods where large swell was noted could be disregarded, it was not possible to ensure that only periods of suitable swell conditions were used for this year. This comparison was carried out for all species where the number of sightings since the standard recording forms were first issued exceeds 100.

With data from the Rockall area excluded for previous years, it was apparent that there was not a real decrease in numbers of fin whales in 1999 (Figure 33). Sighting rates of fin whales were found to fluctuate between the years, but sample sizes were too small to determine whether these fluctuations were significant. The decrease in numbers of pilot whales seen in 1999 was still apparent, but this decrease was not significant. Sighting rates of sperm whales did not differ significantly between the years. More minke whales, white-beaked dolphins and white-sided dolphins were seen in 1999; for white-sided dolphins sample sizes were too small to test the statistical significance of this result, but the increase was found to be significant for both minke whales and white-beaked dolphins ($\chi^2 = 8.557$, d.f. = 2, $p < 0.05$ for minke whale; $\chi^2 = 44.576$, d.f. = 2, $p < 0.001$ for white-beaked dolphin).

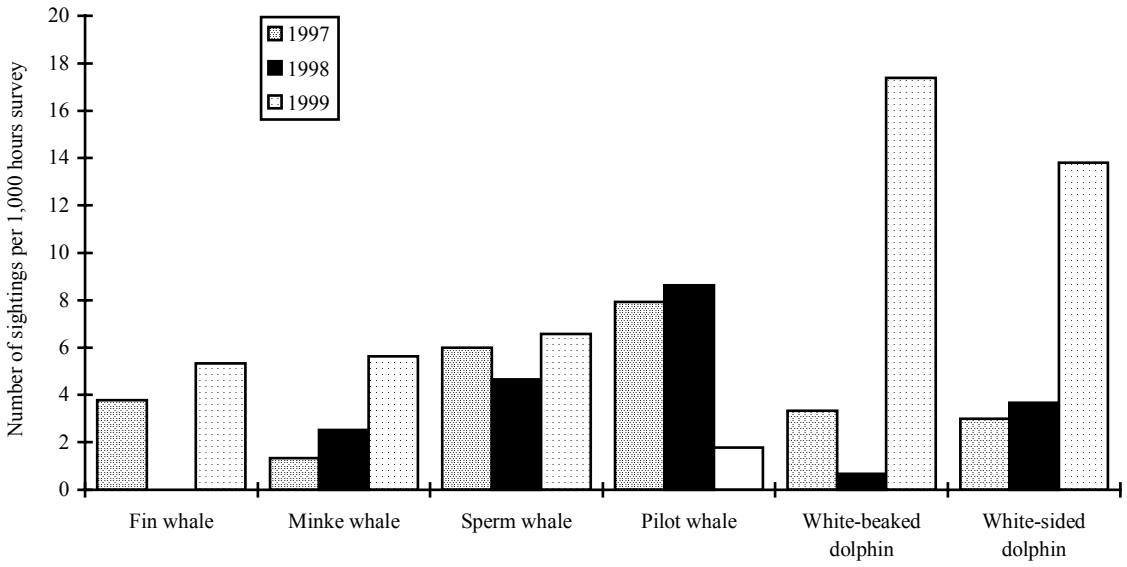


Figure 33 Sighting rates of marine mammals from 1997 to 1999 (excluding site surveys).

7.2 Distance of marine mammals from the airguns

The closest distance from the airguns at which marine mammals were observed was routinely recorded by observers. Median values were compared for those 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, so weather was taken into account 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 species except sperm whale were found to remain further from the airguns during periods of shooting (Figure 34). However, the differences were only significant for all baleen whales combined, all dolphins combined and white-beaked dolphins (Table 5).

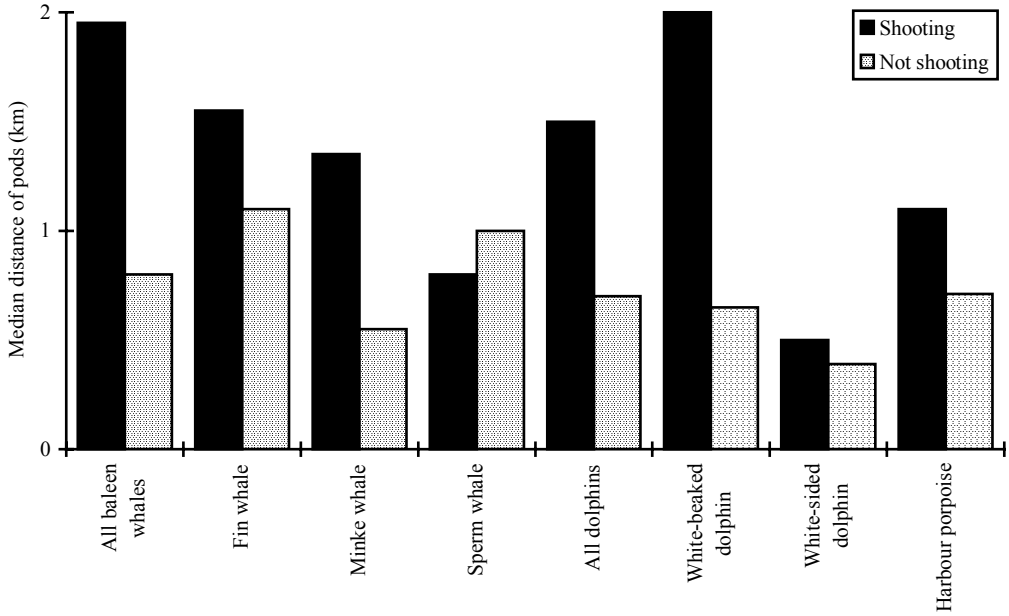


Figure 34 Median distance of marine mammals from the airguns in relation to seismic activity (excluding site surveys).

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

Species	*z*	*P*
All baleen whales combined	-2.861	0.0021
Fin whale	0.325	n.s.
Minke whale	-1.290	n.s.
Sperm whale	-0.050	n.s.
All dolphins combined	-2.847	0.0022
White-beaked dolphin	-1.929	0.0268
White-sided dolphin	0.595	n.s.
Harbour porpoise	1.098	n.s.

The proportion of sightings of marine mammals occurring within a given range of the airguns was reduced during periods of shooting for distances out to several kilometres from the source (Figure 35). This was particularly marked at ranges of less than 2 km. 45% of sightings of marine mammals during periods of shooting approached to within 1 km of the airguns and only 22% came within 500 m of the airguns. When the airguns were not firing, 66% of marine mammal sightings were within 1 km of the airguns, and 42% were within 500 m.

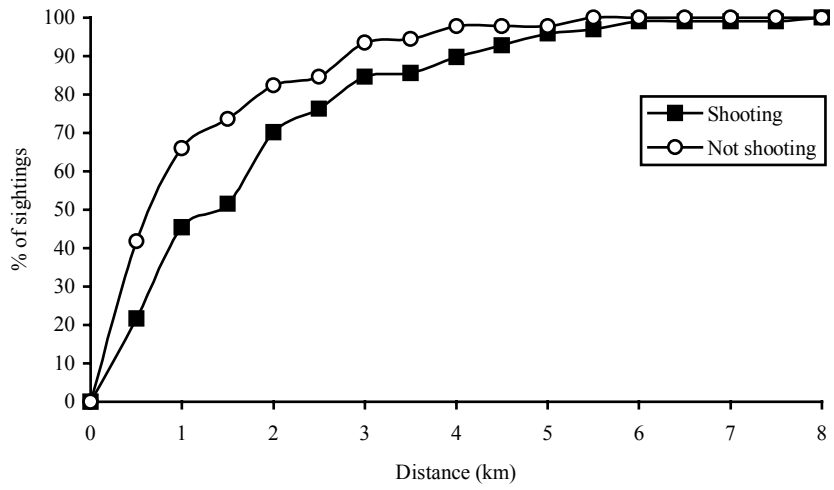


Figure 35 Proportion of marine mammal sightings occurring within specified distances of the airguns during good weather conditions, in relation to seismic activity (excluding site surveys).

7.3 Behaviour of marine mammals

Any types of behaviour that were apparent were recorded, with no limits to the types or number of behaviours that could be recorded for any one sighting. For 22% of encounters, nothing other than 'normal swimming' was recorded. In the remaining 78% of encounters 33 other types of behaviour were recorded, some being observed more frequently than others. Table 6 summarises the results for the more notable types of 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 (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	*P*
Feeding	All cetaceans combined	3.45	7.23	2.577	n.s.
	All dolphins combined	5.22	7.04	0.340	n.s.
+ve interactions	All cetaceans combined	3.45	10.44	6.617	< 0.05
	All dolphins combined	5.22	15.49	6.159	< 0.05
	White-beaked dolphin	2.56	24.32	-	-
-ve interactions	All cetaceans combined	4.02	1.61	-	-
Alteration of course	All cetaceans combined	2.30	1.20	-	-
Breaching, jumping or somersaulting	All cetaceans combined	28.74	19.28	3.957	< 0.05
	All dolphins combined	42.61	30.99	2.375	n.s.
	White-beaked dolphin	53.85	37.84	1.057	n.s.
	White-sided dolphin	55.56	51.28	-	-
Tail-slapping	All cetaceans combined	1.15	2.41	-	-
Fast swimming	All cetaceans combined	35.06	24.50	3.963	< 0.05
	All baleen whales	25.93	6.82	-	-
	All dolphins combined	44.35	33.80	1.834	n.s.
	White-beaked dolphin	51.28	27.03	2.836	n.s.
	White-sided dolphin	66.67	43.59	-	-
Slow swimming	All cetaceans combined	14.37	20.08	1.884	n.s.
	All baleen whales	14.81	38.64	3.216	n.s.
	All dolphins combined	14.78	14.08	0.021	n.s.
Surfacing infrequently	All cetaceans combined	12.64	10.84	0.285	n.s.
	All baleen whales	22.22	18.18	0.140	n.s.
	All dolphins combined	8.70	12.68	0.925	n.s.
Diving	All cetaceans combined	3.45	4.82	0.450	n.s.
	Sperm whale	40.00	38.10	-	-
	All seals combined	0.00	33.33	-	-
Logging/ resting	All cetaceans combined	4.02	2.81	0.454	n.s.
	Sperm whale	50.00	23.81	-	-
Bottling	All seals combined	100.00	33.33	-	-

Some 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. Cetaceans showed a greater tendency to swim at speed during periods of shooting, but this was only statistically significant when all species were combined. Conversely, swimming slowly was sometimes more prevalent when the airguns were not firing, but not significantly so. Sperm whales were much more likely to be logging at the surface during periods of shooting than when the airguns were not firing, but the sample size was too small to assess the significance of this.

Breaching, jumping or somersaulting by cetaceans were frequently observed. There was a much greater tendency to exhibit such behaviours during periods of shooting than when the airguns were not firing, and when all cetaceans were combined this difference was statistically significant. Tail-slapping was seen infrequently.

Alterations of course occurred infrequently, but were observed slightly more often during periods of shooting. Although sample sizes were small, it is interesting to note that all alterations of course during periods of shooting were away from the vessel, while only 33% were away from the vessel when the airguns were not firing.

Positive interactions of cetaceans with the survey vessel or its equipment (i.e. bow-riding, approaching close to the vessel, swimming alongside the vessel or its equipment, or following the vessel) occurred on a number of occasions when the airguns were not firing, but were relatively rare during periods of shooting.

Where sample sizes were sufficient to permit statistical testing, there was a significantly greater tendency to engage in positive interactions when the airguns were not firing. Negative interactions (i.e. avoidance) occurred infrequently, but were observed mostly during periods of shooting.

Cetaceans were observed feeding relatively infrequently. Although feeding was observed more often during periods when the airguns were not firing, the difference was not significant.

Although seals were seen relatively infrequently, all seals seen during periods of shooting were observed to be bottling (suspended vertically with the head above the surface of the water), but when the airguns were not firing some seals dived. However, sample sizes were too small to assess the significance of these differences in behaviour, and as very few seals were seen during periods of shooting this result should be treated with caution.

The median distance at which the behaviours were observed was calculated, using only sightings in better weather conditions, as defined in Table 3. Table 7 presents the median distance for all behaviours exhibited by species/ species groups where the sample size equalled or exceeded ten. Permutation tests were used to determine whether differences in the distance at which behaviours were observed were significant, but where sample sizes were larger the Wilcoxon test was used, which constitutes a good approximation to the permutation test (Siegel and Castellan 1988).

Table 7 Median distance (metres) at which behaviours exhibited by marine mammals were observed in relation to seismic activity (excluding site surveys), taking account of weather conditions (z = Wilcoxon statistic; * = probability calculated using permutation test; P = probability; n.s. = not significant).

Behaviour	*Species*	*Median distance when shooting*	*Median distance when not shooting*	*z*	*P*
+ve interactions	All cetaceans combined	200	230	-0.871	n.s.
	All dolphins combined	200	200	-0.803	n.s.
Breaching, jumping or somersaulting	All cetaceans combined	2,500	700	-2.809	0.0025
	All dolphins combined	2,500	800	-2.750	0.0030
	White-beaked dolphin	2,500	2,000	-0.994	n.s.
	White-sided dolphin	800	350	*	n.s.
Fast swimming	All cetaceans combined	1,950	675	-2.444	0.0073
	All dolphins combined	2,000	700	-2.386	0.0084
	White-beaked dolphin	2,250	700	-1.565	n.s.
	White-sided dolphin	500	400	*	n.s.
Slow swimming	All cetaceans combined	1,500	600	-1.365	n.s.
	All dolphins combined	1,600	500	-1.679	0.0465
Surfacing infrequently	All cetaceans combined	1,800	1,500	-0.369	n.s.
	All dolphins combined	1,900	1,650	0.312	n.s.

Breaching, jumping and somersaulting were observed at greater distances during periods of shooting than when the airguns were not firing. When all cetaceans or all dolphins were combined the differences in distance were statistically significant. Fast swimming, for the same species groups, was also observed at significantly greater distances during periods of shooting. The increased distance at which these behaviours were observed during periods of shooting may in part reflect a tendency to remain further from the source at these times. It is also possible, if animals remain further from the source when it is active, that the increased overall occurrence of these conspicuous behaviours during periods of shooting (Table 6) may be a result of the greater ease of detection of distant animals when they are behaving in a conspicuous manner. Further examination of the occurrence of such behaviours controlling for distance indicated that this was not the case (Table 8); if increased occurrence of these behaviours was a result of detection bias rather than an effect of seismic activity the proportion of animals displaying these behaviours would be expected to be the same in each distance band irrespective of seismic activity. Instead it seemed that there was a true increased tendency to display these behaviours as a result of seismic activity. Cetaceans showed an increased tendency to breach, jump or somersault during periods of shooting in all distance bands out to distances of 4 km or more from the source. Fast swimming was more prevalent during periods of shooting at distances of up to 3 km from the source.

Slow swimming in dolphins was also observed at significantly greater distances during periods of shooting (Table 7). However, the tendency of dolphins to swim slowly did not differ significantly with seismic activity (Table 6). In this case, the increased distance at which this behaviour was observed during periods of shooting probably wholly reflects the tendency of dolphins to be further away at these times.

Positive interactions with the vessel or its equipment, by definition, must occur at relatively close distances from the airguns. It is therefore not surprising that there was little difference in the distance at which positive interactions occurred regardless of seismic activity.

Table 8 Behaviour of marine mammals in relation to seismic activity (excluding site surveys) at various distance bands.

Behaviour	*Species*	*Distance band*	*% of encounters while shooting when behaviour was exhibited*	*% of encounters while not shooting when behaviour was exhibited*
Breaching, jumping or somersaulting	All cetaceans combined	0-1 km	18.39	17.71
		1.001-2 km	25.58	14.71
		2.001-3 km	55.56	28.57
		3.001-4 km	40.00	12.50
		> 4 km	64.29	50.00
Fast swimming	All cetaceans combined	0-1 km	29.89	24.57
		1.001-2 km	44.19	23.53
		2.001-3 km	55.56	14.29
		3.001-4 km	30.00	37.50
		> 4 km	14.29	37.50

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 9 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 in most cases where sample sizes were sufficient, the direction of travel differed significantly in relation to seismic activity. Partitioning was used to ascertain where the differences lay. For white-beaked dolphins, all dolphins combined and all cetaceans combined significantly fewer pods were found to be heading towards the vessel during periods of shooting. For all dolphins combined significantly 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 passing at close range would have been initially travelling towards the vessel, so the decrease in dolphins in this category during periods of shooting could have been linked to the decrease in dolphins heading towards the vessel. A significantly higher proportion of pods of baleen whales were heading away from the vessel during periods of shooting, and the same was true for all cetacean species combined. In addition, when all cetaceans were combined a significantly higher proportion were found to be milling or travelling in variable directions during periods of shooting.

Table 9 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*
All seals combined	Shooting		2					-	-	-
	Not shooting	1	1	2		6	7			
Grey seal	Shooting							-	-	-
	Not shooting	1	1	1		3	5			
Whale sp.	Shooting		2	2	1			-	-	-
	Not shooting		1	3		1				
All baleen whales combined	Shooting		7	2	4	10	2	8.835	2	< 0.05
	Not shooting	6	3	8	8	16	1			
Fin whale	Shooting		2		1	4		-	-	-
	Not shooting	1	2		1	4				
Minke whale	Shooting		3	2	1	4	2	-	-	-
	Not shooting	4		6	2	6	1			
Sperm whale	Shooting	2	3		2	2	1	-	-	-
	Not shooting	3	6	5	2	5				
Pilot whale	Shooting	1		1	1	4		-	-	-
	Not shooting	1		3		1				
Killer whale	Shooting			1		2		-	-	-
	Not shooting	3	1	4	2	8	2			
All dolphins combined	Shooting	8	30	35	10	16	15	26.204	5	< 0.001
	Not shooting	31	20	36	10	36	5			
Dolphin sp.	Shooting	2	12	14	4	8	6	5.443	4	n.s.
	Not shooting	5	5	6	4	8	1			
Bottlenose dolphin	Shooting		3	1		1	1	-	-	-
	Not shooting		1	1		1	1			
White-beaked dolphin	Shooting		10	12	4	7	6	15.808	4	< 0.01
	Not shooting	12	5	10	2	5	3			
White-sided dolphin	Shooting	4	1	4				-	-	-
	Not shooting	13	3	12	2	9				
Lagenorhynchus sp.	Shooting	2		1			1	-	-	-
	Not shooting	1	1	4	1	3				
Harbour porpoise	Shooting		3	2				-	-	-
	Not shooting		5			9				
All cetaceans combined	Shooting	11	43	41	18	36	18	28.325	5	< 0.001
	Not shooting	46	35	60	22	69	8			

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

Depth of water can influence the propagation of sound underwater, and therefore could influence the response of marine mammals to seismic activity. Seismic surveys in 1999 covered a range of depths, from the shallow waters of the southern North Sea to deep waters to the west of Shetland. Information on location was requested on the 'Location and Effort' form; for surveys where these forms were completed correctly each day was assigned 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). The proportion of time spent shooting was very similar in all three depth categories (Table 10).

Table 10 Proportion of time spent shooting at different depths (excluding site surveys).

Depth	*Proportion of time spent shooting*
0-200 m	43.51%
200-1,000 m	41.05%
> 1,000 m	42.38%

The depth of water was normally recorded whenever marine mammals were seen. Median, minimum and maximum depths are presented in Table 11. Seals were only seen in shallow waters, but many cetacean species were seen in a range of depths. Sperm whales, sei whales, pilot whales and beaked whales were seen predominantly or exclusively in deep waters. Fin whales also occurred in deep waters, but were seen more often over the shallower regions of the shelf slope, resulting in a median depth that was shallower than that found in previous years for this species. Minke whales, killer whales, bottlenose dolphins and harbour porpoises were seen in a range of depths from continental shelf waters to deep waters, but most sightings of these species occurred over the continental shelf. White-beaked and white-sided dolphins were also seen ranging from shallow shelf waters to deep waters, but while white-beaked dolphins were predominantly in shallower waters, white-sided dolphins mostly occurred in deeper waters.

Table 11 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*
All seals combined	66	17	137	21
Seal sp.	50	17	100	4
Grey seal	59	38	137	11
Common seal	92.5	49	109	6
Cetacean sp.	140	28	1,548	11
Whale sp.	1,250	96	1,802	18
Large whale sp.	1,340.5	835	1,608	26
All baleen whales combined	254	16	1,778	71
Humpback whale	104	104	104	1
Fin whale	428	220	1,560	15
Sei whale	1,501.5	1,040	1,552	4
Fin/ blue whale	475	221	1,008	5
Fin/ sei whale	238	219	1,502	5
Fin/ sei/ blue whale	487	478	496	2
Fin/ sei/ humpback whale	1,301	320	1,778	6
Fin/ sei/ blue/ humpback whale	243	220	266	2
Minke whale	88	16	1,530	31
Sperm whale	1,560	267	1,999	39
Humpback/ sperm whale	1,222	930	1,514	2
Medium whale sp.	1,480	1,000	1,960	2
Beaked whale sp.	1,279	1,253	1,285	3
Pilot whale	1,526	351	1,864	13
Killer whale	167	10	1,777	25
All dolphins combined	107.5	5	1,702	270
Dolphin sp.	107	9	1,670	87
Dolphin sp. not porpoise	85	80	165	8
Risso's dolphin	144	144	144	1
Bottlenose dolphin	88.5	5	1,500	10
White-beaked dolphin	90	20	1,320	75
White-sided dolphin	1,170	76	1,702	55
Lagenorhynchus sp.	133.5	66	1,496	14
Striped dolphin	24	24	24	1
Harbour porpoise	79	19	1,537	19

There was no consistent pattern in the proportion of sightings occurring during periods of shooting in relation to depth of water (Table 12). Median tests showed that for unidentified whales relatively more pods were encountered during periods of shooting in deeper waters than was the case in shallower waters, but results were non-significant for all other species or species groups.

Table 12 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; 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	*d.f.*	*P*
All seals combined	0.00	20.00	*	1	n.s.
Whale sp.	25.00	100.00	*	1	0.03
All baleen whales combined	44.44	31.43	0.783	1	n.s.
Fin whale	50.00	42.86	*	1	n.s.
Minke whale	25.00	53.33	1.561	1	n.s.
Sperm whale	27.78	38.46	0.057	1	n.s.
Pilot whale	75.00	25.00	*	1	n.s.
Killer whale	6.67	22.22	0.229	1	n.s.
All dolphins combined	51.52	38.52	3.810	1	n.s.
Dolphin sp.	66.67	52.78	1.035	1	n.s.
Bottlenose dolphin	80.00	40.00	*	1	n.s.
White-beaked dolphin	44.74	59.46	1.092	1	n.s.
White-sided dolphin	14.81	23.81	0.176	1	n.s.
Lagenorhynchus sp.	28.57	28.57	*	1	n.s.
Harbour porpoise	30.00	22.22	*	1	n.s.

7.5 Sightings during the soft-start

There were eight sightings of marine mammals during the soft-start (Table 13); one was first seen prior to the soft-start commencing but was still present as the soft-start commenced, while the remainder were all first detected once the soft-start was underway.

Table 13 Sightings during the soft-start

Species	*Number of animals*	*Closest distance to airguns (metres)*	*Behaviour*	*Duration of soft-start (mins)*	*Time elapsed since commencement of soft-start when animals sighted (mins)*
Sei whale	1	400	Slow swimming; crossed bow	Four shots, then stopped, then 10 mins	Seen beforehand
Fin/ blue whale	5	5,000	Slow swimming	36	1
Dolphin sp.	1	2,000	Fast swimming	22	15
Dolphin sp.	1	3,500	Jumping, fast swimming	21	13
Dolphin sp. not porpoise	3	5,000	Breaching and jumping	22	9
White-beaked dolphin	8	1,600	Breaching, fast swimming	22	17
Lagenorhynchus sp.	2	1,000	Heading towards ship	17	0
Harbour porpoise	1	1,700	Slow swimming; heading away from ship	24	5

The one sighting that first occurred prior to the soft-start commencing was of a single sei whale. It was at a distance of 600 m from the airguns as the soft-start commenced, and showed no apparent reaction to the commencement of firing, although the soft-start was halted after just four shots when the whale came within 500 m of the airguns. It continued on its course, crossing ahead of the ship, and at its closest point of approach was 400 m from the airguns. The soft-start soon re-commenced, but as the whale was no longer visible it was not possible to observe any reactions (the events surrounding this sighting are discussed further in sections 8.4 and 9.4).

Of the seven sightings that were first seen during the soft-start, only one was heading towards the vessel; in this instance the sighting occurred as the soft-start commenced, so firing would have been at the lowest power level. A harbour porpoise reported at a distance of 1,700 m from the airguns (during calm conditions) was recorded as heading away from the vessel, but showing no obvious signs of disturbance, five minutes into a soft-start of 24 minutes duration, when the power level was presumably still relatively low. All dolphins occurring more than one-third of the way into the soft-start were swimming at speed, breaching or jumping.

7.6 The effects of site surveys on marine mammals

There were 65 sightings of marine mammals during site surveys in 1999, of which 14 occurred when the airguns were firing. Sperm whales and unidentified whales were seen more often when the airguns were not firing (Figure 36), but for these and most other species or species groups, sample sizes were insufficient to permit statistical testing of the results. The only species group where sample sizes were sufficient to determine the statistical significance of differences in sighting rates was unidentified large whales - in this case the difference was not significant ($\chi^2 = 0.000$, d.f. = 1). Sample sizes for all species were too small to permit further selection of subsets of data to minimise any bias due to effects of location, season or weather conditions, so these sources of bias remain.

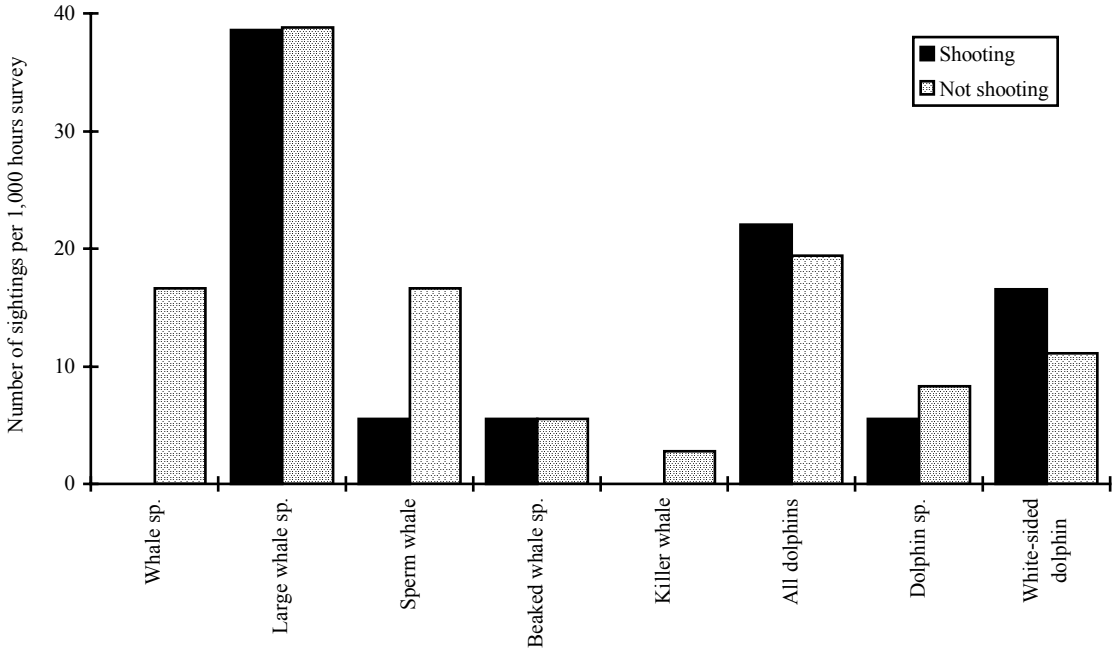


Figure 36 Sighting rates of marine mammals in relation to seismic activity during site surveys

Only two species groups were seen sufficiently frequently to permit comparison of their distance from the airguns in relation to seismic activity. Both unidentified large whales and all dolphins combined were observed to be further from the airguns during periods of shooting (Figure 37), but in both cases the differences were not statistically significant (Wilcoxon test: large whale sp. z = 0.438; all dolphins z = 0.591). Again, the effects of weather on the ability of observers to detect animals at greater distances were not taken into account for site surveys due to the small samples available.

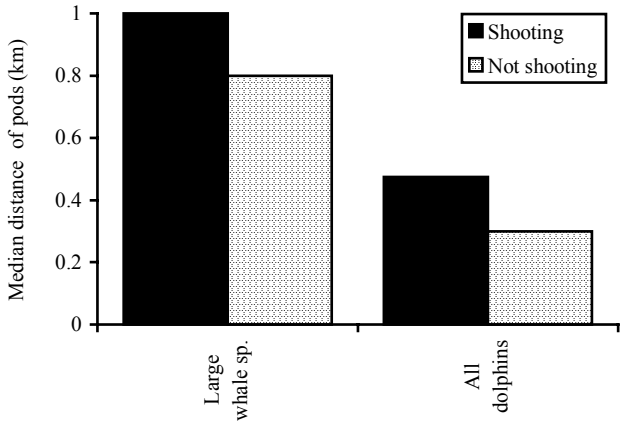


Figure 37 Median distance of marine mammals from the airguns in relation to seismic activity during site surveys

Trends in behaviour of marine mammals in relation to seismic activity during site surveys (Table 14) were similar to those during larger scale surveys, but sample sizes were too small to ascertain the statistical significance of these results. Feeding was observed more often when the airguns were not firing, and positive interactions of marine mammals with the vessel or its equipment were only seen at these times. There was a slightly increased tendency to breach or swim at speed during periods of shooting, while slow swimming was more prevalent while the airguns were not firing. Cetaceans were more likely to surface frequently during periods of shooting, while diving or surfacing infrequently was more prevalent when the airguns were not firing. There was a much greater tendency of cetaceans to head away from the survey vessel during periods of shooting, although the tendency to head towards the vessel was also slightly greater at these times.

Table 14 Behaviour of marine mammals in relation to seismic activity during site surveys

Behaviour	***Species***	***% of encounters while shooting when behaviour was exhibited***	***% of encounters while not shooting when behaviour was exhibited***
Feeding	All cetaceans combined	7.14	14.29
+ve interactions	All cetaceans combined	0.00	6.12
Breaching	All cetaceans combined	14.29	12.24
Fast swimming	All cetaceans combined	14.29	12.24
Slow swimming	All cetaceans combined	0.00	4.08
Surfacing infrequently	All cetaceans combined	0.00	2.04
Surfacing often	All cetaceans combined	7.14	2.04
Diving	All cetaceans combined	7.14	14.29
Heading away from vessel	All cetaceans combined	21.43	6.38
Heading towards vessel	All cetaceans combined	14.29	12.77

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 the necessary information - these forms were completed correctly for 54 surveys.

8.1 Notification and reporting of surveys

In total, JNCC received notification of and/or reports from 83 seismic surveys conducted in UK or adjacent waters during 1999. These 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 32 seismic surveys conducted during 1999 in blocks licensed in the 16th, 17th and 18th rounds of offshore licensing. For five of these surveys no report was received. In one case where a report was missing it had apparently been sent but was not received; as no copy of the report was kept a duplicate was not able to be issued. In another case the seismic contractor ceased trading, thus the missing report was not traceable. For the three remaining surveys where no report was received, no explanation was offered. JNCC knew of only one survey taking place in blocks licensed in the 16th, 17th and 18th rounds of offshore licensing which was not notified. Overall, the proportion of surveys that were both notified and reported had increased from levels in previous years (Table 15).

Table 15 Notification and reporting of seismic surveys in blocks subject to the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys*, 1996-1999.

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

JNCC received notification of and/or reports from 51 additional seismic surveys taking place in UK or adjacent waters in 1999. Notifications were received for 47 surveys taking place in UK waters in blocks licensed outside the 16th, 17th and 18th rounds of offshore licensing. All companies within the oil industry have indicated that they will comply with the guidelines in all areas of the UK continental shelf, but nevertheless there were no reports for 12 of these surveys (for two surveys no observations were carried out due to an oversight, while for the remaining ten no reason was given for the absence of a report). Reports were received from 39 surveys conducted in blocks licensed outside these rounds, either in UK or adjacent waters (Irish or Danish); no notification was received for two of these surveys (excluding those outside UK waters).

Reports were also received from two seismic surveys conducted outside European waters. A number of reports were also sent in from other vessels and platforms used by the oil industry, working both in UK or adjacent waters and further afield. Occasional reports were received from vessels outside the oil industry. 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

Increasing use has been made of dedicated marine mammal observers on seismic surveys in UK waters since the guidelines were first introduced in 1995 (Figure 38). However, the majority of surveys during 1999 still used fishery liaison officers or members of ships' crews to undertake the additional role of marine mammal observer.

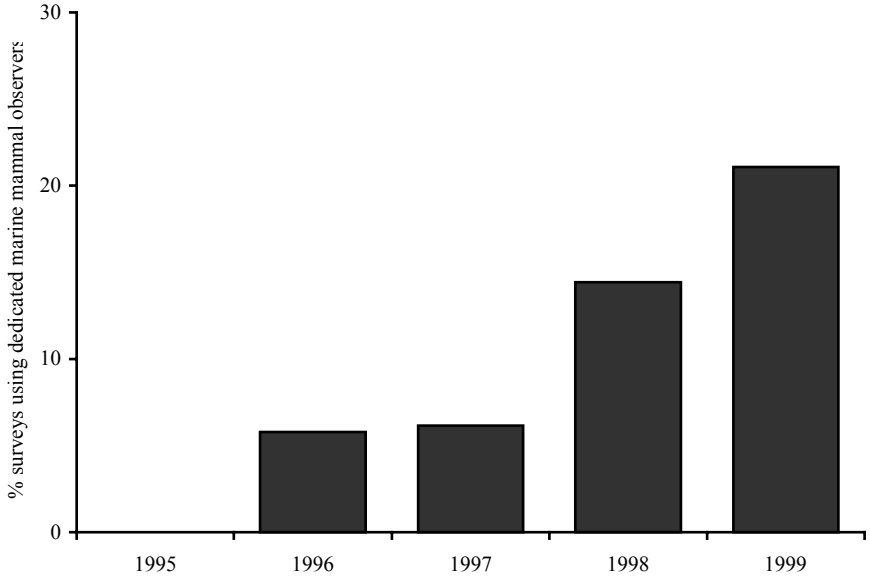


Figure 38 The proportion of seismic surveys in UK waters for which dedicated marine mammal observers were used

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. There were 20 surveys during 1999 that were conducted in areas that may be considered important for marine mammals. Dedicated marine mammal observers were used for the entire duration of six of these surveys, and for part of the time on one other survey. For two surveys no reports were received, thus it is assumed that no observations were carried out. For the remainder, fishery liaison officers or members of ships' crews acted as marine mammal observers. Untrained observers were used for eight of the 20 surveys.

On some occasions when notification was received of a survey in an area of importance for marine mammals, JNCC specifically requested the presence of dedicated marine mammal observers on board. For one such survey JNCC requested that two trained, competent, dedicated marine mammal observers were used, and provided the seismic contractor with four potential sources of marine mammal observers. The seismic contractor sought exemption from this request on the grounds of cost, but JNCC reiterated their request for high quality trained observers. Further correspondence regarding this survey indicates that JNCC later agreed to the use of a trained fishery liaison officer complemented by a member of the ship's crew to help cover the long daylight hours. It is not clear whether the fishery liaison officer had additional fishery liaison duties to perform. On several occasions throughout the correspondence regarding this survey JNCC emphasised the importance of the survey area for cetaceans and the need for strict adherence to the guidelines. The report from this survey (a 3D survey) clearly states that no soft-start was used at any time. There was no pre-shooting search on seven occasions when the airguns commenced firing during daylight hours. The fishery liaison officer had received training on marine mammal observations, but not since 1997;

he made an error, not discovered and therefore not addressed during training seminars prior to 1998, on the 'Location and Effort' form, and he also made mistakes on the 'Record of Operations' form (not included in training seminars prior to its introduction in 1998). As there were mistakes on the 'Record of Operations' form, it is not possible to be sure that no delays in shooting were necessary - there were two occasions when marine mammals occurred within 500 m of the airguns when the vessel's activity was recorded as "Turning for the next line", but the time that shooting commenced was not given.

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 1999 there were 3,341 recorded occasions when the guns were used, including two occasions when precise times were not noted. On 1,110 occasions use of the airguns commenced during hours of darkness, when a visual check for the presence of marine mammals was not possible. A pre-shooting search of adequate duration (at least 30 minutes) was carried out for the majority (82%) of occasions when use of the airguns commenced during daylight hours (Table 16). Nevertheless, there were still a number of occasions when the pre-shooting search was either absent or shorter than the required minimum duration.

Table 16 Duration of pre-shooting searches for marine mammals

Duration of search	*16th, 17th and 18th round blocks*	*Other blocks*	*All surveys combined*
No search	83 (5.80%)	48 (6.02%)	131 (5.88%)
Search stopped before firing commenced	17 (1.19%)	27 (3.38%)	44 (1.97%)
1-9 minutes	14 (0.98%)	16 (2.01%)	30 (1.35%)
10-19 minutes	42 (2.94%)	49 (6.14%)	91 (4.08%)
20-29 minutes	59 (4.12%)	41 (5.14%)	100 (4.49%)
30 minutes or more	1,216 (84.98%)	617 (77.32%)	1,833 (82.23%)

Short or absent searches were more common in blocks other than those licensed in the 16th, 17th and 18th rounds. Most short searches were between 10 and 29 minutes duration, but a small proportion 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 were stopped when conditions became too dark to enable detection of marine mammals); in a few cases the time at which the pre-shooting search was terminated coincided with a meal time. In approximately 6% of cases, there was no pre-shooting search prior to the commencement of firing.

Short, prematurely terminated or absent pre-shooting searches were more common when personnel with other duties were acting as marine mammal observer than when a dedicated marine mammal observer was on board (Table 17). Amongst those personnel with additional responsibilities, members of ships' crews provided inadequate or absent pre-shooting searches more often than fishery liaison officers.

Table 17 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	18 (2.63%)	90 (6.68%)	22 (12.94%)
Search stopped before firing commenced	6 (0.88%)	13 (0.96%)	23 (13.53%)
1-9 minutes	3 (0.44%)	24 (1.78%)	3 (1.76%)
10-19 minutes	6 (0.88%)	61 (4.53%)	24 (14.12%)
20-29 minutes	17 (2.49%)	74 (5.49%)	9 (5.29%)
30 minutes or more	634 (92.69%)	1,086 (80.56%)	89 (52.35%)

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 nine occasions during 1999 when marine mammals occurred within 500 m of the airguns when shooting was due to commence (Table 18). Two 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 18 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*
Seal sp.	80	None	15	36	Yes	Irish
Large whale sp.	400-500	None	14	0 (site survey)	No	17th round
Killer whale	25	None	11	21	Yes	16th round
Dolphin sp.	300	Delayed shooting	Still present, but at 3 km from guns	0 (site survey)	Yes	17th round
White-beaked dolphin	300	Delayed shooting	20	20	Yes	18th round
White-beaked dolphin	150	Delayed shooting	19	9	Yes	18th round
White-sided dolphin	50	Delayed shooting	33	0 (site survey)	Yes	17th round
White-sided dolphin	50	Delayed shooting	> 180	0 (site survey)	Yes	17th round
White-sided dolphin	200	"Extra watch"	10	40	Yes	Not 16th/17th/18th round

Correct procedures were put into effect on three of the seven occasions where licence conditions dictated that the guidelines should have been followed. On all three occasions dedicated marine mammal observers were used. In these instances shooting was delayed for a minimum of 20 minutes since the last sighting. One instance occurred on a 3D survey; after the delay a full soft-start of 20 minutes duration was employed. The other two delays occurred on a site survey, and after both shooting commenced without a soft-start (the guidelines state that the soft-start may be waived for some surveys where the seismic sources always remain at low power levels, e.g. some site surveys, although more recent guidance from JNCC states that site surveys should use a full soft-start unless a prior waiver has been agreed).

On another occasion in a 17th round block, shooting was delayed when dolphins were seen at a distance of 300 m from the airguns. Shooting commenced while the animals were still visible, but the observer recorded on the 'Record of Operations' form that by this time they were at a distance of approximately 3 km from the airguns. By the time shooting commenced these dolphins had been present for 1 hr 37 mins, but there was no indication of how long shooting had been delayed for. This instance also occurred on a site survey, and when shooting commenced there was no soft-start. The observer on this occasion was a dedicated marine mammal observer.

On one occasion when compliance with the guidelines was a licence condition, the action taken to minimise disturbance to the marine mammals was insufficient. Shooting was delayed but the delay was marginally shorter than the required minimum duration. This instance occurred during a 4C survey with a

large airgun array; the soft-start following the delay should have had a duration of at least 20 minutes, but instead was only nine minutes long. On this occasion a fishery liaison officer was acting as marine mammal observer.

On two occasions when compliance with the guidelines was a licence condition no action was taken to minimise disturbance to marine mammals which were close to the airguns shortly before shooting was due to commence. On one occasion killer whales were observed at a distance of just 25 m from the airguns; although the presence of marine mammals was noted on the 'Record of Operations' form the observer entered "n/a" in the column entitled 'What action was taken?'. The observer stopped watching for marine mammals immediately after this sighting occurred, at a time when it was probably getting dark. In spite of the close proximity of marine mammals, shooting commenced just 11 minutes after they were seen. It was not clear whether the observer in this case was a dedicated marine mammal observer or not. In the summary of his report, the observer stated that "The JNCC guidelines were known by the crew and were followed". On the other occasion when no action was taken, shooting commenced 14 minutes after a large whale had been observed within 500 m of the airguns; on this particular survey there were indications from the information provided on the recording forms that the observer (a dedicated marine mammal observer) may not have been fully aware of the timing of seismic activity as events happened. In the summary of the report in this case, the observer stated that "The guidelines were stringently followed and the shooting of lines was delayed when cetaceans were observed within 500 m of the vessel".

On the two occasions where compliance with the guidelines was not a licence condition, no appropriate action was taken to minimise disturbance to the marine mammals. It is not clear whether these surveys were intended to comply with the guidelines or not. On both surveys fishery liaison officers were carrying out marine mammal observations in addition to their fishery liaison duties. On the 'Record of Operations' form relating to one of these occasions the observer had entered "Extra watch" as the action taken, but it is unclear what this meant. Only ten minutes elapsed between the time of the sighting and shooting commencing, so either there was no delay or the delay was less than that specified in the guidelines.

As mentioned in section 7.5, there was one occasion when a soft-start legitimately commenced when a sei whale was at a distance of 600 m from the airguns. When the whale reached a distance of 500 m from the airguns the marine mammal observer, not realising that the soft-start had already commenced, advised the seismic crew not to start the airguns. The seismic crew halted the soft-start, with just four shots having been fired. The report accompanying this survey includes a detailed timetable of the ensuing events. The whale crossed ahead of the vessel and when last seen was at a distance of 400 m from the airguns and was heading away from the vessel. The marine mammal observer advised that there should then be a delay of at least 20 minutes before re-commencing the airguns, and then a soft-start of at least 20 minutes duration. However, the vessel was in a time-share situation and the party chief, aware that halting the soft-start was beyond the requirements of the guidelines and that the whale was now moving away from the vessel, decided that shooting should re-commence in time to start the line as planned. The party chief requested advice from the marine mammal observer as to whether, in order to minimise disturbance, the remaining time before the start of the line would best be spent on a delay in firing or on a soft-start. The marine mammal observer recommended the remaining time be used for a soft-start. Thus shooting re-commenced only eight minutes after the whale was seen at 400 m from the airguns, with a soft-start of just ten minutes duration.

On one survey the seismic contractor's 'Project Specific Safety and Environmental Plan' stated that during a line the airguns would be shut down if marine mammals were seen within a 1.5 km radius of the vessel. On two occasions when marine mammals occurred within 1.5 km of the vessel the airguns were instantly shut down. However, it was subsequently decided by the seismic contractor that the policy of shutting down the airguns when marine mammals were sighted within this radius was impractical on grounds of cost, and as this was not a requirement of the guidelines this policy was withdrawn. If this policy had been followed throughout the survey, there would have been eleven occasions when the airguns would have had to be shut down during a line, and substantial costs would have been involved.

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. during some testing or if shooting was aborted during the soft-start) were disregarded in the analysis, as were occasions when the soft-start was unusually protracted due to testing of the airguns.

The guidelines recognise that on some site surveys the seismic sources always remain at low power levels, and in these cases the soft-start may be waived (more recent guidance from JNCC states that site surveys should use a full soft-start unless a prior waiver has been agreed). The duration of soft-starts for site surveys was therefore analysed separately from other surveys. On most (60.5%) occasions when airguns were used during site surveys in 1999 there was no soft-start. Soft-starts were employed slightly more often (42.6% of occasions when airguns were used) for site surveys conducted in blocks licensed in the 16th, 17th and 18th rounds than in other blocks (38.4% of occasions when airguns were used). When soft-starts were used during site surveys, the mean duration was seven minutes.

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 24 minutes (Table 19). For these surveys, 84.2% of soft-starts were between 20 and 40 minutes duration. However, 13.5% of soft-starts on these surveys were either absent or shorter than the required minimum duration of 20 minutes. In other blocks the standard of soft-starts was lower - although the mean duration was 25 minutes, 27.3% were absent or shorter than 20 minutes, with 68.2% being between 20 and 40 minutes duration. Reasons for short soft-starts were not usually given, but on some occasions pressures caused by time-sharing were cited as the reason for a reduced duration. There were a small number of soft-starts that were rather long, with a maximum duration of 140 minutes.

Table 19 Soft-starts used during seismic surveys in 1999 (excluding site surveys).

Parameter	***16th/ 17th/ 18th round blocks***	***Other blocks***
Minimum duration (minutes)	0	0
Maximum duration (minutes)	140	115
Mean duration (minutes)	24	25
Sample size	1,952	701
Number of occasions when there was:		
no soft-start	36(1.84%)	14(2.00%)
soft-start < 20 minutes	227(11.63%)	177(25.25%)
soft-start > 1 hour	11(0.56%)	5(0.71%)

Soft-starts were short or absent more often when personnel with other duties were carrying out marine mammal observations than when dedicated marine mammal observers were used (Table 20). When fishery liaison officers were acting as marine mammal observers 21.1% of soft-starts were absent or shorter than 20 minutes, compared to 8.5% when dedicated marine mammal observers were used. Members of ships' crews were rarely used as marine mammal observers other than on site surveys, but where they were used a high proportion (83.3%) of soft-starts were shorter than 20 minutes.

Table 20 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	846	1,745	12
Number of occasions when there was:			
no soft-start	3 (0.35%)	47 (2.69%)	0 (0.00%)
soft-start < 20 minutes	69 (8.16%)	322 (18.45%)	10 (83.33%)

9. DISCUSSION

9.1 Distribution of marine mammals

Undoubtedly survey effort is a prime factor in determining the observed distribution patterns of marine mammals seen during seismic surveys. Survey effort varies both spatially and temporally, with intensive effort in some areas and some months, and little or no effort in other areas and months. This can be illustrated by the substantial increase in sightings of marine mammals in the northern North Sea in 1999 when compared to 1998. In 1998 many of the surveys in this area took place in spring and early summer, thereby missing the months of peak cetacean occurrence. In 1999, partly as a result of new acreage licensed in the 18th round of offshore licensing, there were many more seismic surveys in the northern North Sea during the mid-summer months, when many sightings occurred.

As survey effort was not recorded correctly for all surveys, it was not possible to allow for effort when plotting distribution maps. Because of the inequality of survey effort, the observed distribution of marine mammals seen during seismic surveys should not be taken as a true representation of their range or of their occurrence within that range. Nevertheless, despite the inequality of survey effort, broad patterns of distribution can be seen that mostly concur with previous knowledge.

Fin whales, sei whales, sperm whales, beaked whales, pilot whales and white-sided dolphins have previously been reported from deep waters in the Atlantic Frontier (Pollock *et al.* 2000; Stone 1997, 1998a, 2000a), so their occurrence in these waters was to be expected. However, not all of these species were confined exclusively to deep Atlantic Frontier waters. The additional sighting of pilot whales in the South-West Approaches was not unusual, as this species is known to occur beyond the continental shelf edge in this area (e.g. JNCC 1995). Similarly, the occurrence of white-sided dolphins in the northern North Sea was as expected, as this species has been recorded in these waters previously (e.g. Evans 1980; JNCC 1995). In 1999 more fin whales were seen over the shelf slope and outer continental shelf, as well as in deeper waters, than has been the case during seismic surveys in previous years. The median depth at which fin whales were seen in 1999 (428 m) was considerably less than in previous years, when the median depth was always approximately 1,000 m (Stone 1997, 1998a, 2000a).

Another species sometimes associated with deep waters is the humpback whale. This species has previously been recorded in deep offshore waters of the Atlantic Frontier (Pollock *et al.* 2000; Stone 1997, 1998a, 2000a), but there have been fairly frequent sightings of humpback whales in inshore waters around Shetland in recent years (Fisher 2000). The only sighting of a humpback whale during 1999 seismic surveys occurred close inshore near Shetland.

White-beaked dolphins, the most frequently seen species during 1999 seismic surveys, were seen both in the northern North Sea and around Shetland. Northridge *et al.* (1995) considered this species to be confined to shelf waters, with an increase in frequency of sightings towards land. There were few sightings of white-beaked dolphins from seismic survey vessels operating in deep waters. Pollock *et al.* (2000) consider that the distribution of white-beaked and white-sided dolphins is allopatric. While the main concentrations of sightings of these two species occurred in different areas, with the majority of white-sided dolphins in the deep waters of the Faroe-Shetland Channel and most white-beaked dolphins in the northern North Sea, there was clearly a considerable degree of overlap in their distribution, particularly over the outer continental shelf to the north of Shetland.

The distribution of sightings of other species also agreed with previous knowledge of their distribution. Killer whales are known to be most abundant in colder waters (Evans 1992), which concurs with their observed distribution in northern UK waters. Pollock *et al.* (2000) have recorded this species over both continental shelf and deeper waters, as was the case during 1999 seismic surveys. Risso's dolphins around the UK tend to occur in inshore waters, particularly around the Hebrides (Evans 1992; JNCC 1995). The only sighting of Risso's dolphins during seismic surveys in 1999 occurred in inshore waters, on this occasion near Shetland, where they have been regularly recorded inshore (Fisher 2000). Minke whales in UK waters are known to occur mostly around the Hebrides and in the northern North Sea, with an apparent preference for coastal waters (Northridge *et al.* 1995). There was no survey effort around the Hebrides in 1999, but minke whales were seen regularly in the northern North Sea, with a number of sightings occurring relatively close to the coast. Amongst the most widely distributed species was the harbour porpoise. This species has been recorded as being widespread in the northern and central North Sea, with other concentrations

elsewhere and even sightings in deep waters far offshore (Northridge *et al.* 1995), which again is a pattern reflected during 1999 seismic surveys.

There is a resident population of bottlenose dolphins in the Moray Firth. In recent years, some identifiable members of this population have been observed in coastal waters further south, particularly around St. Andrew's. While at first their appearance in these areas seemed seasonal, with increasing monitoring the seasonality is becoming less marked (Grellier, pers. comm.). It is not known whether the bottlenose dolphins observed further offshore in the northern North Sea were members of the same population. If they were, their occurrence may indicate a seasonal movement offshore as these sightings occurred within a short time span in the middle of a survey that lasted for four months. As well as mainly inshore populations of bottlenose dolphins such as those in the Moray Firth, this species is also known to occur in offshore waters (e.g. Skov *et al.* 1995), as demonstrated by the occasional sighting north-west of Shetland.

The only species that was seen in an area where it might not be expected was the striped dolphin. There was just one sighting of this species, in the southern North Sea. Striped dolphins in UK waters occur mostly in the South-West Approaches, 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). However, a sighting of this species in the southern North Sea is highly unusual. In this case the certainty of the identification was recorded as 'probable', but nevertheless the record of this sighting was accompanied by a reasonable description supporting the identification. Although this record should be treated with a degree of caution, it cannot be ruled out that the identification may have been correct.

There were some cetacean species that were not recorded at all during seismic surveys in 1999 that might have been expected to be seen. Marine mammal recording forms were first issued for use during seismic surveys in 1996, and common dolphins have been recorded every year until 1999 (Stone 1997, 1998a, 2000a), when none were seen. If there had been more survey effort in the South-West Approaches it is likely that common dolphins would have been recorded in 1999 also, as this species has a predominantly south-westerly distribution around the UK (JNCC 1995). However, common dolphins have also been recorded further north in deep waters to the west of Scotland (Pollock *et al.* 2000), and greater survey effort in waters around Rockall and to the west of Ireland contributed to the sightings of this species during seismic surveys in previous years. It is quite likely that some of the unidentified dolphins seen to the north-west of Ireland in 1999 were common dolphins. Blue whales have also been recorded during seismic surveys in each year from 1996 to 1998, albeit in low numbers, and this species has also been detected to the west of the UK by acoustic monitoring (Clark and Charif 1998). It is possible that some of the unidentified whales seen in deep waters of the Atlantic Frontier may have been blue whales.

Seals occurred mostly relatively close inshore, within range of haul-out sites or breeding areas. The sightings of grey seals in the outer reaches of the Firths of Forth and Tay may have been animals from the Isle of May, while the sighting further south was presumably an animal from the nearby Farne Islands. Common seals were mostly seen near their breeding areas, occurring in the outer Moray Firth and close inshore around Shetland. An additional sighting of a common seal near the Farne Islands was perhaps slightly more unusual as it is predominantly grey seals that occur there.

9.2 The effects of seismic activity on marine mammals

In previous years sample sizes have been greatest for species such as pilot whale and fin whale, enabling examination of the effects of seismic activity on these species. In 1999, sample sizes were greatest for white-beaked dolphins, while those of pilot whales and fin whales decreased. This was partly due to a shift in survey effort towards the northern North Sea as a consequence of the 18th round of offshore licensing, and partly due to increased detection of marine mammals in the northern North Sea as a result of the use of dedicated marine mammal observers on some surveys in this area.

In previous years significantly fewer white-beaked dolphins have been seen during periods of shooting (Stone 1997, 1998a). In 1999 there were no significant differences in sighting rates of white-beaked dolphins in relation to seismic activity. However, they were found to be significantly further from the airguns during periods of shooting, an effect which has not been noted in previous years. Significantly fewer were observed to be heading towards the vessel during periods of shooting.

White-sided dolphins also demonstrated some effects of seismic activity. In this case, sighting rates were significantly reduced during periods of shooting. In two of the three previous years for which data have been analysed, white-sided dolphins have shown some effect of seismic activity, with either a reduced sighting rate or a greater median distance during periods of shooting, or both (Stone 1997, 1998a).

It seems that both white-beaked dolphins and white-sided dolphins are demonstrating at least localised avoidance when the airguns are firing. These species, like other dolphins, use higher frequencies than those typically emitted by seismic airguns. For example, white-beaked dolphins emit squeals at 8-12 kHz and white-sided dolphins whistle at 6-15 kHz (Evans and Nice 1996, from various sources). Seismic exploration generally utilises frequencies up to 220 Hz, but noise of higher frequencies is emitted incidentally. 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 seismic emissions would be clearly audible to dolphins at a range of at least 8 km from the source.

Baleen whales use much lower frequencies. Although they may have clicks at higher frequencies (e.g. up to 31 kHz in fin whales; Evans and Nice 1996, from various sources), for other sounds such as moans, rumbles, grunts, calls and down sweeps they use frequencies that overlap with the dominant frequencies emitted by airguns (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). It might be expected that these species would be affected by seismic activity. Reduced sighting rates in response to seismic activity have not been observed for baleen whales in UK waters, but fin whales, unidentified fin/sei whales and minke whales have all at times been found to remain further from the source during periods of shooting (Stone 1997, 1998a, 2000a). Although fin whales and minke whales, when considered individually, were not found to remain significantly further from the airguns during periods of shooting in 1999, when all baleen whales were combined a significant difference was found. This may reflect the limits imposed by small sample sizes - generally, the power of a statistical test increases as the sample size increases (Siegel and Castellan 1988). Some avoidance of seismic activity by baleen whales is also indicated by the fact that more were observed to be heading away from the vessel during periods of shooting.

So far no marked effects of seismic activity have been apparent for sperm whales in UK waters. Although some differences in the tendency of sperm whales to dive have been noted in previous years (Stone 1998a, 2000a), sample sizes were too low to determine whether these differences were significant. In the Gulf of Mexico a decrease in abundance of sperm whales has been correlated with seismic activity (Mate *et al.* 1994) and possible negative effects on their communication and orientation behaviour have been noted (Rankin and Evans 1998).

Responses to seismic activity may take several forms. Avoidance may be indicated by reduced sighting rates or the tendency of animals to be at greater distances from the source; as noted above, avoidance has been indicated for white-beaked and white-sided dolphins, and perhaps also for baleen whales, although results for individual species of baleen whale have not consistently demonstrated avoidance. The reduction in positive interactions of cetaceans with the survey vessel or its equipment (e.g. bow-riding), and the increased proportion of cetaceans heading away from the vessel during periods of shooting may also be indicative of avoidance by cetaceans in general. However, there may also be other responses to seismic activity, such as behavioural responses, that may be apparent whether or not there is avoidance. The present results indicate that swimming at speed and breaching or jumping are examples of behavioural responses to seismic activity. Little is known about many marine mammal behaviours, and it can be difficult to interpret what certain behaviours may signify. Some behaviours may have different meanings in different circumstances. Roles as diverse as aggression, play and courtship have been offered as an explanation for breaching - underpinning many of the explanations is the assumption that breaching may serve as some form of non-vocal signalling. Whatever the meaning of such behaviours in the context of seismic activity, it is clear that breaching or jumping and fast swimming are incited by seismic activity even at distances of several kilometres from the source.

There was one other statistically significant behavioural response to seismic activity - an increased proportion of cetaceans were observed to be milling or travelling in various directions during periods of shooting. Again the reason for this is unclear, but it could possibly indicate some level of disorientation during periods of shooting.

It should be noted that some behaviours may make marine mammals more visible and thus increase detection rates. The tendency to breach during periods of shooting could mask effects of seismic activity on

sighting rates. Behavioural responses to seismic activity should be borne in mind when using sighting rate as an indicator of the presence or absence of disturbance.

As well as avoidance and short-term behavioural responses, there may be other effects of seismic activity that cannot be detected using these data. Effects on vocalisations will not be apparent from visual observations - cessation or reduction of vocalisation has sometimes been noted in response to acoustic disturbance (Bowles *et al.* 1994; Charif and Clark 2000; Richardson 1997). Physiological effects and physical damage may also not be apparent from visual observations. Observations from seismic survey vessels usually do not provide opportunities to track individual animals, so there is little opportunity to study surfacing and dive characteristics, such as blow intervals and dive durations. Effects on parameters such as these have often been found in species such as bowhead and gray whales in response to acoustic disturbance (e.g. Bowles *et al.* 1994; Ljungblad *et al.* 1988; Richardson *et al.* 1986, 1995). One study indicated that fin whales at distances of 1 km or less from the source had significantly shorter blow intervals during periods of shooting (Stone 1998b). Long-term effects, including any on breeding or migration, may not be apparent for many years. It should also be noted that while a detected response may indicate some level of disturbance, the lack of any detected response does not mean that there is no disturbance.

It is important that any information gained from observations during seismic surveys is used, wherever possible, to assess the effectiveness of the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys*. One question that may be addressed is whether 20 minutes is sufficient as the duration of the soft-start to allow animals to move to a distance at which they will tolerate firing at full power. Goold and Fish (1998) stated that their best estimate of a safe distance at which high source level sounds would be tolerable to cetaceans was 1 km for an airgun array of 2120 cu. in., but this is much smaller than a typical array used for a 3D survey. Other authors (e.g. Ljungblad *et al.* 1988; McCauley *et al.* 1998; Richardson *et al.* 1986, 1995) have demonstrated avoidance at ranges of 5 km or more. There is evidence from the present results that behavioural responses to seismic activity, such as fast swimming and breaching, are present even at distances of several kilometres from the source (up to 4 km or more for breaching or jumping), when the source is firing at full power. Although such behaviours in themselves may not be harmful, they may have energetic consequences or they may indicate stress that may in turn lead to harmful physiological effects. Although these behavioural responses are not fully understood, the precautionary principle on which the guidelines are based would suggest that they are treated as being possibly negative effects. The reduced proportion of marine mammals approaching within a given distance of the airguns during periods of shooting also indicates a reduced tolerance at distances up to several kilometres from the source.

It would seem reasonable, based on the present results, to allow animals time to move to a distance of 4 km from the source before full power is attained at the end of the soft-start. Evans (1987) quotes prolonged cruising speeds of 9-17 km hr^{-1} for dolphins and 4-30 km hr^{-1} for rorqual whales. At the lower end of these scales it would take dolphins 23 minutes and rorqual whales 52 minutes to reach a distance of 4 km from a starting point just beyond 500 m from the airguns (soft-starts are not permitted to commence with animals within 500 m of the airguns), assuming that they travel away from the source. The fact that the source itself is being towed at speeds of usually around 8 km hr^{-1} may serve to increase or decrease the speed at which marine mammals are travelling relative to the source, depending on their relative orientation. Given the lack of sightings during the soft-start, it is not even certain that animals travel away from the source to safer distances as power levels increase. However, from the limited information available, it would seem reasonable to assume that dolphins have the potential to reach a distance of approximately 4 km during the soft-start before full power is attained, but it is less certain that the slower rorqual whales could do so. There may be a case for increasing the minimum duration of the soft-start, although this would have to be balanced against the disadvantages of increasing the overall duration of acoustic input to the marine environment.

There is little information at present regarding the effects of firing at low power, either during the early stages of a soft-start or during site surveys (the volume of airguns used in site surveys is often similar to that used in the early stages of a soft-start). It would be useful to have more data to determine whether 500 m is an appropriate distance beyond which marine mammals may occur and the soft-start can still be allowed to commence. However, startle responses to the commencement of firing at low power have on occasions been observed in cetaceans at distances of 2 km or more (Stone 2000a, b). It seems likely that the minimum distance at which marine mammals may be present without necessitating a delay in firing at low power should not be less than 500 m. Any delays caused by the close proximity of marine mammals should allow sufficient time for animals to move to a safe distance at which the soft-start could commence without risk of

disturbance. Given that there is no certainty that 500 m is adequate as a safe distance, 20 minutes seems a reasonable minimum duration for a delay.

Increasing the threshold distance within which the presence of marine mammals would necessitate a delay in shooting would inevitably increase the frequency of delays, although not necessarily greatly. If the threshold distance had been 1 km in 1999 there would have been an additional eight occasions when a delay in shooting would have been required because of the presence of marine mammals within this radius shortly before shooting was due to commence.

In view of the low sample sizes for many species, it would be beneficial if the review of observations of marine mammals during seismic surveys in 2000 also included data from earlier years. It is recommended that data from 1998 to 2000 are combined. In 1996 weather conditions were not routinely recorded, and in 1997 swell was not routinely recorded, so no allowance can be made for any bias caused by these factors in these years. From 1998 until 2000 the standard recording forms have remained the same, providing an ideal opportunity to combine data over these years. As mentioned above, the power of a statistical test increases as sample size increases, so it is possible that previously undetected responses may become apparent. Sample sizes may become sufficient to examine the effects of seismic activity on some of the species that are seen in low to moderate numbers in most years e.g. killer whale, bottlenose dolphin, common dolphin, and harbour porpoise. As well as increasing sample sizes for individual species, the combination of data over several years may also increase sample sizes for site surveys sufficiently to enable some conclusions to be drawn regarding their effects, at least for the more common species. A preliminary examination of the data revealed that combining 1998 and 1999 data did not increase sample sizes to a sufficient level, but the additional inclusion of data from 2000 may help to achieve this.

9.3 Quality of observations

'Location and Effort' forms were completed correctly for 53% of surveys in 1999. This represents a decline in standards from previous years (60% in 1996, 72% in 1997 and 78% in 1998). However, dedicated marine mammal observers always completed these forms correctly - errors or missing forms were all attributable to fishery liaison officers or members of ships' crews. The forms were not completed for 14 (21%) surveys, of which 13 were using members of the ship's crew to act as marine mammal observers. These personnel were mostly untrained in this role, were possibly unaware of the existence of these forms, and probably had little time to devote to completing them. On one further survey the forms were lost. 'Location and Effort' forms were completed but were incorrect for 16 (24%) surveys. On 15 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 (one company actually changed the forms so that the incorrect duration was requested rather than the correct one). This was found to be a common error during 1997, so training seminars from 1998 onwards have specifically addressed this issue. On 9.5 of the 15 surveys where this error was made the observers were trained prior to 1998 and thus had not experienced this aspect of training, while on three surveys untrained ships' crew members were used. On a further two surveys the fishery liaison officers acting as observers were anonymous, so it is not known whether they had received any training (for this reason it would be helpful if observers were named on this form and on the 'Record of Sighting' form). Only on one half of a survey (where the survey continued at a later date with a different observer) was there an observer who had been trained since 1998 who nevertheless continued to make this mistake. The only other error encountered on the 'Location and Effort' forms was on one survey where the duration of the watch and the duration of shooting were omitted - the observer in this case was an untrained member of the ship's crew.

It appears that most of the instances where 'Location and Effort' forms were not completed or were completed incorrectly can be attributed to untrained or not recently trained fishery liaison officers or ships' crews. The same is true for the 'Record of Operations' forms, although a much higher proportion of these forms were completed correctly. Where dedicated marine mammal observers were used, on all but one survey these forms were completed correctly. Overall they were completed correctly for 82% of surveys, contained errors for 6% of surveys and were not completed for 12% of surveys. This form was first introduced in 1998 - observers trained since then were used on only 1.5 of the eight surveys where these forms were not completed, while untrained members of ships' crews accounted for six of these eight surveys. All observers completing the form but making mistakes were untrained or were trained prior to the

introduction of this form. Errors encountered on this form included not providing times when the airguns were firing overnight, merging survey lines together so that periods of airgun silence between lines were not apparent, not providing times of the pre-shooting search, and deleting columns of the form. Errors were correlated with individual observers - there were no consistent errors across observers on the 'Record of Operations' form.

While trained observers could benefit from attending refresher courses, it is not felt that these should be in any way a requirement. It is, however, important that observers keep themselves up to date with any developments, both in the guidelines and the recording forms, and are aware of any lessons learned. Companies supplying personnel to act as marine mammal observers, whether dedicated or not, should ensure that lessons learned from reports such as this one are passed on to their personnel. There are still many untrained observers - 30 (59%) of the 51 named observers used in 1999 had received no training.

As usual, there were a number of 'Record of Sighting' forms that either contained no description of the animals seen or gave a description that was insufficient to confirm the observer's identification, resulting in the identification being downgraded. The proportion of such forms declined from 35% in 1997 to 25% in 1998, and in 1999 there was a further slight improvement, with the proportion decreasing to 23%. There was a decline in the number of cases where downgrading was due to an inadequate description, and a corresponding increase in the number of cases where downgrading was due to the absence of a description. Whereas in 1998 only 3% of 'Record of Sighting' forms contained no descriptions, in 1999 this proportion rose to 10%. Training seminars stress the importance of good descriptions; for 82% of sightings for which there was no description, observers were untrained. Identification by trained observers was generally better than that by untrained observers; fewer identifications were downgraded for trained observers (13%, compared to 41% for untrained observers) and they used the broad categories of 'cetacean', 'whale', 'large whale', 'dolphin' or 'seal' less often (16% of sightings, compared to 41% for untrained observers). Overall there was only a small proportion (0.6%) of sightings where the identification was definitely wrong i.e. did not agree with the description given or was proved wrong by examining video footage of the sighting, which represents a continued improvement from previous years. The main difference between dedicated marine mammal observers and fishery liaison officers, irrespective of training, was that the broad identification categories were used more often by fishery liaison officers (41% of sightings, compared to 21% by dedicated marine mammal observers). Occasionally observers neglected to state whether the position at the time of the sighting was east or west of the Greenwich meridian.

For a minority of surveys where reports were received no standard recording forms were used. In these cases the report consisted only of a letter stating that no marine mammals had been seen, or giving brief details of a small number of sightings. This happened mostly when members of ships' crews were acting as marine mammal observers. This is inadequate as a report as very little can be learned from such limited information. Operators and contractors should ensure that as a minimum the standard recording forms are completed, recording effort and seismic activity even if no marine mammals are seen. Several reports were received using old versions of the forms and thus omitted some information that is requested on the current version.

The primary concern regarding the role of marine mammal observers is that they are efficient at detecting the presence of marine mammals and that they know the requirements of the guidelines and act as appropriate to enable the guidelines to be complied with. Recording full and accurate information is beneficial but does not, by itself, reduce disturbance to marine mammals. Dedicated marine mammal observers were much more efficient at detecting marine mammals than fishery liaison officers, whose 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 mean rate of sightings per 1,000 hours was 98.77 for dedicated marine mammal observers and 12.14 for fishery liaison officers (these figures exclude sightings brought to the observer's attention by other personnel). A comparable figure is not available for the ability of ships' crew members to detect marine mammals as these personnel rarely provided effort data, but on the 20 surveys where members of the ship's crew were relied on to monitor the presence of marine mammals there were just five sightings.

It is doubtful that relying solely on members of ships' crews to detect marine mammals is an adequate measure to ensure compliance with the guidelines. These personnel have many other matters to attend to and are usually fully occupied with their own duties. Although one aspect of their duties is to maintain a lookout for other marine traffic, there is a substantial difference between looking for vessels that remain at the surface of the water and looking for small marine mammals which may only surface briefly and infrequently. It is not reasonable or fair to expect them to search for marine mammals with the same level of concentration

as a dedicated marine mammal observer, whilst still attending to their normal duties. Furthermore, they have little time to devote to completing the recording forms. Nevertheless, ships' crews have a valuable contribution to make in alerting marine mammal observers to the presence of marine mammals which may have escaped detection by the latter (including occasions when the marine mammal observer is not on watch), and this role should be encouraged. There were 29 sightings acknowledged to have been detected by members of ships' crews (and probably a number of other sightings that they were not credited with) during surveys when they were not responsible for observations.

Reliance on ships' crews to carry out observations is particularly prevalent during site surveys, presumably because of the lack of available berths on some site survey vessels. Out of 29 site surveys during 1999 19 relied solely on ships' crews to fulfil the role of marine mammal observer, while only two used dedicated marine mammal observers. The remainder used fishery liaison officers to fulfil this role.

Clearly the ideal situation in terms of quality of observations is to use a dedicated marine mammal observer - they are more skilled at detecting marine mammals and their ability to provide accurate and useful data is greater than that of other personnel.

9.4 Compliance with guidelines

The procedure for notifying JNCC of forthcoming seismic surveys appears to be working well. However, there is a need for improvement in the procedures for submission of reports. While reports were received for the majority of surveys of which there was notification, there were still some outstanding. Moreover, figures such as those in Table 15 reflect the proportion of reports that were eventually received, rather than the proportion that were received promptly after completion of the survey.

The majority of pre-shooting searches for marine mammals were of acceptable duration. However, there is scope for improvement in this aspect of compliance with the guidelines. For every 20 instances where the airguns commenced shooting during daylight hours there was, on average, one instance when there was no pre-shooting search, and a further two instances when the pre-shooting search was shorter than the required minimum duration or terminated prematurely. There was no marked improvement in the standard of pre-shooting searches in 1999 from that of 1998. In some cases it was reported that the marine mammal observer was given insufficient advance warning of impending shooting, but in many cases the reasons for short or absent pre-shooting searches were not given. The standard of pre-shooting searches was higher when dedicated marine mammal observers were used, which may indicate that in some cases other duties prevented non-dedicated observers from carrying out an adequate pre-shooting search. An adequate pre-shooting search is essential for the operation of the guidelines, therefore the use of dedicated observers should be encouraged. It is also important that seismic crews routinely provide adequate advance warning of shooting to enable marine mammal observers to carry out their duties.

It is now becoming increasingly common to have two marine mammal observers on surveys during the summer months when daylight hours are long, particularly since this requirement was specified on the guidance note issued by JNCC in March 2000 (Appendix 1). Where only one dedicated marine mammal observer is used, there are difficulties in ensuring that the observer is available and sufficiently alert to carry out a pre-shooting search at any time during daylight hours. Some dedicated observers in these circumstances ensure that they carry out every pre-shooting search during daylight hours themselves regardless of what time of day it occurs, taking rests as necessary once shooting is underway or during long gaps in shooting. Others prefer to work a fixed 12 hour shift, leaving pre-shooting searches during daylight outside their shift to the fishery liaison officer or ship's officer of the watch. In light of the increased standard of pre-shooting searches by dedicated observers, it is recommended that where dedicated marine mammal observers are on board they should be responsible for carrying out all pre-shooting searches in daylight hours. This would be easy to achieve with two dedicated observers on board; where there is only one dedicated observer the observer should arrange their watch times to cover all pre-shooting searches. This would be aided by adequate advance warning of shooting from the seismic crew, particularly at times when the marine mammal observer is not on watch. The main difficulty would be during site surveys, where short lines and rapid turns result in frequent pre-shooting searches leaving little time for rest. On site surveys in sensitive areas during the summer months the use of a second dedicated observer is recommended.

As in 1998, the number of occasions when a delay in shooting was necessary in accordance with the guidelines was low. Out of a total of 501 sightings and 3,341 uses of the airguns, there were only nine

occasions when marine mammals occurred within 500 m of the airguns when shooting was due to commence, circumstances under which a delay would be required if the survey was being conducted in accordance with the guidelines. Seven of these occasions occurred in blocks where compliance with the guidelines was a licence condition, but on two of these occasions there was no action taken to minimise disturbance to marine mammals and on another occasion the action taken was insufficient. On both occasions where no action was taken the observers, according to their reports, believed that the guidelines had been followed during the survey. Their lack of awareness of any transgressions indicates that they may have been unaware of the impending shooting at the time of the sighting. Again this underlines the importance of adequate advance warning of shooting, but it also highlights the responsibility that marine mammal observers have to ensure that they are fully aware of events on board.

On one of the occasions when the required delay did not happen the observer stopped watching (presumably because darkness fell) before the airguns commenced firing, and it is conceivable that if there was no advance warning of shooting he may have been unaware of the situation as he finished his watch for that day. However, lack of advance warning does not relieve observers of their responsibilities. In a situation where the watch ends when marine mammals have recently been close to the airguns it would be advisable for observers to inform the seismic crew of the presence of marine mammals and check whether firing is due to commence in the near future. The apparent lack of awareness that there had been any transgressions of the guidelines indicates that the observer in this case probably did not do this. On the other survey where a required delay did not happen there were indications that the observer was not fully aware of the timing of seismic activity as events happened. This was a site survey when, as is typical of site surveys, lines were short and line changes could be relatively rapid. The frequency with which shooting commences during site surveys requires particular vigilance by marine mammal observers. Good communication is extremely beneficial in these circumstances, with the seismic crew providing adequate advance warning of shooting and the marine mammal observer informing the seismic crew of any sightings within 500 m of the airguns. Again, the lack of awareness of any transgressions of the guidelines on this survey indicates that communication between parties may have been poor.

The importance of good communication is also highlighted by the instance when a soft-start was halted when a sei whale approached within 500 m of the airguns but then re-commenced after only a short delay, with insufficient time remaining to complete a full soft-start before the start of the line, which was given priority. It appears from the report of this incident that there was considerable confusion and poor communication - the seismic crew did not inform the marine mammal observer that the soft-start had commenced, the marine mammal observer thus assumed that the soft-start had not commenced but did not request confirmation that this was the case, and the party chief was not informed of the correct sequence of events initially.

In this instance the soft-start had legitimately commenced when the whale was more than 500 m from the airguns, and could have continued as there is no requirement in the current version of the guidelines to terminate the soft-start. It is not clear why firing ceased, whether it was a purely voluntary action in an attempt to minimise disturbance, or whether it resulted from a misunderstanding of the guidelines. However, regardless of the reason for firing having ceased, the crew were now in a situation of having had a marine mammal within 500 m of the airguns shortly before firing was due to commence (in this case re-commence); the fact that the airguns had been firing previously did not remove the requirement for a full delay and then a full soft-start under the guidelines. Undoubtedly it was extremely frustrating for the crew to have acted beyond the requirements of the guidelines, whether voluntarily or due to a misunderstanding, and then found themselves in a penalising situation, especially given the pressures of time-sharing that they were experiencing at the time.

It is felt that this situation could have been avoided by better communication. If the seismic crew had informed the marine mammal observer that the soft-start had commenced, the marine mammal observer presumably would not have given the rather confusing advice not to start the airguns after they had already been started. His advice was appropriate based on the information he had, which was that firing was due to start but, as far as he knew, had not already started. However, rather than relying on information being volunteered, the marine mammal observer could have requested the information he needed; when he was informing the seismic crew that the whale had approached to 500 m from the airguns he could have asked whether the soft-start had already commenced, and on finding that it had he could have made it clear to the seismic crew that they could continue shooting. It seems that all parties involved in this incident must bear some responsibility for the events leading up to it, but this does not detract from the fact that once in the

situation correct procedures were not followed, responsibility for which lies with the party chief, who took the decision to re-commence shooting.

As there were only a small number of occasions when a delay in shooting was necessary to comply with the guidelines, it is not possible to make a reliable comparison of compliance with this requirement according to the type of observer employed. However, it is interesting to note that of the five occasions when dedicated marine mammal observers were present, there was only one occasion when insufficient or no action was taken. Conversely, correct procedures were not followed on any of the three occasions when fishery liaison officers were used (although two of these occasions occurred in blocks where compliance with the guidelines was not a licence condition).

The proportion of short or absent soft-starts during 1999 was very similar to that found in 1998. Although the majority of soft-starts were of acceptable duration, this aspect of compliance with the guidelines could also be improved. Almost one in seven soft-starts in blocks where compliance with the guidelines was a licence condition were absent or shorter than the required minimum duration, and in other blocks the proportion of short or absent soft-starts was doubled. Again the benefits of using dedicated marine mammal observers was apparent, with fewer soft-starts being short or absent when these personnel were employed. As mentioned previously (Stone 2000a), this may reflect the commitment to the guidelines that is demonstrated when an operator or contractor requests the presence of a dedicated marine mammal observer on board; this demonstration of commitment encourages the crew to comply with the guidelines and gives the observer confidence to ensure that the guidelines are followed. Assignment of marine mammal observations to other personnel as a secondary duty may give the impression that marine mammals are of secondary importance, thus creating a reluctance to 'interfere' with seismic operations by such personnel and a more complacent attitude amongst the crew.

In order to ensure compliance with the guidelines, it is important that operators should provide the most appropriately qualified and experienced personnel to act as marine mammal observers, especially in areas of importance for marine mammals. It is still only a minority of surveys for which dedicated, experienced marine mammal observers are used, although it is pleasing to note that this proportion is increasing. A high proportion of surveys during 1999 that were conducted in areas that may be considered important for marine mammals did not use appropriately skilled personnel. Whilst it is acknowledged that it can at times be difficult to locate an available dedicated marine mammal observer, particularly during the summer months when demand can be high, operators are encouraged to provide qualified and experienced marine mammal observers for more of the surveys taking place in areas of importance for marine mammals.

The instance where JNCC originally requested the presence of two trained, dedicated, competent observers and eventually agreed to the use of a fishery liaison officer and a member of the ship's crew, serves to illustrate the importance of providing high quality experienced personnel in areas of importance for marine mammals. The observers used on this survey did not ensure that the seismic contractor complied with the guidelines - there were no soft-starts and on some occasions there were no pre-shooting searches. Although the seismic contractor originally sought exemption from JNCC's request for dedicated observers on the grounds of cost, it is now known that at least one of the four suggested sources of observers had not been approached to ascertain cost and availability.

Although the industry has agreed to adopt the guidelines throughout UK waters, the level of compliance with the guidelines was generally lower outside those blocks where compliance was a licence condition (i.e. outside 16th, 17th and 18th round blocks). More than one third (36%) of seismic surveys (excluding site surveys) in UK waters in 1999 were conducted outside 16th, 17th and 18th round blocks, while for site surveys a high proportion (89%) were outside these blocks. Many blocks licensed prior to the 16th round and many unlicensed blocks are in areas of importance for marine mammals, therefore there needs to be a high level of compliance with the guidelines throughout all UK waters, regardless their licence status.

9.5 Recommendations for revisions to recording forms

Some observers have made comments and suggestions for improvements to the marine mammal recording forms. In general the forms are well understood and record the necessary information, but there is scope for improving them to increase the quality of the data obtained. Some minor modifications are proposed to achieve this (revised forms are included in Appendix 3). It should be remembered that the forms must provide a means of obtaining standard information from all observers, and thus must be suitable for those whose primary responsibility is to perform other duties (e.g. fishery liaison officers, ships' crews) and who

may not have a particular expertise in this field nor much time to devote to completing the forms, as well as for dedicated and experienced marine mammal observers. The recording forms should be regarded as the minimum information to be recorded - observers should be encouraged to provide any further information they feel is appropriate. However, observers are requested not to alter the recording forms - any further information should be appended at an appropriate point within the standard format or presented on a separate additional sheet.

All three recording forms now have a space for the JNCC seismic survey reference number (JNCC SS ref. no.). This is a unique reference for each survey, using a combination of year and survey number. In order to ensure that these references remain unique, they should only be assigned by one person dealing with all the data, and not by individual observers. Observers should obtain this reference number from JNCC prior to the survey commencing and include it on all forms.

Several observers have suggested that recording weather conditions at the time of a sighting would be beneficial. When the recording forms were originally issued, weather conditions were included on the 'Record of Sighting' form, but this was found to be of limited use when analysing the data. Instead, it was found to be necessary to have a record of weather conditions throughout the watch for marine mammals, and then link this to the sightings as appropriate. As a result, weather information was moved to the 'Location and Effort' form. However, at present only one entry per day is required on the 'Location and Effort' form, and weather conditions can change considerably throughout any given day. Although changing weather conditions can be summarised daily on the 'Location and Effort' form, this severely limits sample sizes when performing aspects of the analysis that are influenced by weather conditions, as whole days have to be disregarded even if the weather was poor for only part of the day.

Recording weather conditions at more frequent intervals throughout the day would clearly be beneficial, but is only of use if the duration of the watch, and the length of time spent shooting during the watch, are recorded at the same intervals. Several observers have recorded weather conditions more frequently than once a day, but most have not realised the importance of providing this other information at the same intervals. It is recommended that in future these observers should complete several entries on the 'Location and Effort' form per day, filling in all columns on the form each time. In order to link the weather conditions to the relevant sightings during each day, the time of the watch has been added to the 'Location and Effort' form. Those observers who, perhaps because they have other duties to perform, do not wish to fill in more than one entry per day on this form will still be able to summarise information daily as before, but those who are keen to provide more detailed information will be able to record entries as often as they feel appropriate.

Occasionally observers have commented that the categories used for weather conditions are vague and imprecise. Although the categories are defined both in the *Guide to using marine mammal recording forms* and during training seminars, definitions have been included on the 'Location and Effort' form to ensure their correct usage by all observers.

It is becoming increasingly common to use two observers on surveys in higher latitudes during the summer months, to provide adequate cover during the long daylight hours. In recognition of this, the facility to record which observer carried out any particular watch has been added to the 'Location and Effort' form.

A small number of observers have commented that there is no facility on the current 'Location and Effort' form for recording location when the vessel is not in production and thus may be in areas outside the prospect. In fact this is not the case - most observers record their location in the form of quadrant in the 'Block number' column when outside the prospect, or give latitude and longitude, while a few observers work out exactly which blocks they have transited. Although it is only a minority of observers who feel that the form does not allow them to provide this information, the title of the 'Block number' column has been amended to make this facility more apparent.

Two small modifications have been made to the 'Location and Effort' form to attempt to minimise errors on this form. The column entitled 'Length of time seismic guns were shooting during the watch' has been changed to 'Length of time airguns were shooting while you were looking for marine mammals' to try to minimise the number of occasions on which observers misinterpret this as meaning the length of time the airguns were shooting during a 24 hour period. In this and the previous column, it has been specified that duration should be in hours and minutes - some observers have recorded this using decimals rather than minutes.

The 'Record of Operations' form is intended to assess how well a survey has complied with the *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys*. Thus it is necessary to record the times of all uses of the airguns (including the times of soft-starts), including those

during hours of darkness. One observer in 1999 omitted to record the times when the airguns were firing overnight, so a note to remind observers to include these times has been added to this form.

Some observers feel that they need to include every watch for marine mammals on the 'Record of Operations' form, even when seismic activity is neither taking place nor imminent. In fact it is only those watches that constitute a pre-shooting search that are required on this form. In an attempt to help observers comprehend the purpose of this form, the columns containing the times of airgun activity have been moved to the front end of the form, and columns have been grouped under several main headings: 'Airgun activity', 'Pre-shooting search' and 'Action necessary'.

Some observers have misinterpreted 'Contractor' at the head of the 'Record of Operations' form, providing the name of the agency supplying marine mammal observers, rather than the seismic company conducting the survey. The identities of both the client (i.e. operating oil/ gas company) and the seismic contractor are useful for maintaining an overview of their adherence to the guidelines and for matching reports to notifications of surveys. To clarify the meaning, 'Contractor' has been changed to 'Seismic contractor'.

There are also a few minor changes to the 'Record of Sighting' form. Some observers like to assign a reference number to each sighting, and have suggested that a combination of observer's initials, date, sighting number and possibly the initials of the ship's name would be an appropriate method of providing a standardised reference. However, such a method would not provide a unique reference. There are currently 166 named observers in the database, so it is highly probable that there are several who share the same initials as others, and there are numerous ships sharing the same initials. Furthermore, many surveys are conducted concurrently, so many sightings would share the same date. A system of providing unique references for each sighting has actually been in place since the recording forms were first introduced; this referencing system has now been added to the 'Record of Sighting' form for use by observers. The reference comprises two parts - a survey reference number (the JNCC SS ref. no.) and a sighting number. As with the other forms, observers should obtain the survey reference number from JNCC prior to the survey commencing. The sighting number should simply be a sequential number starting at "1" for the first sighting of each survey. This will ensure that all observers have a standardised means of referencing their sightings.

Some more experienced marine mammal observers have commented that a more accurate position for the sighting could be determined if a range and bearing to the animals was recorded, particularly for those animals which are some distance from the vessel. However, this level of accuracy of an animal's position is not necessary for the effective operation of the guidelines (although it should be remembered that an accurate assessment of the closest distance of the animal from the airguns is required), nor does it aid assessment of any effects of seismic activity. Requesting such information could lead to confusion amongst less experienced observers using the forms, so no changes have been made in this respect. Nevertheless, experienced observers wishing to record range and bearing may do so by appending these to the 'Ship's position' box on the 'Record of Sighting' form.

A small minority of observers have commented that there is no space on the 'Record of Sighting' form to record more than one time and position of a sighting when animals are present for some time. However, the majority of observers simply append this information to the time and position when the animals are first sighted, using the existing boxes for time and position. As many as four times and positions for one sighting have been recorded in this way. This seems an adequate solution, so no changes have been made in this respect.

At present the only options under the 'Airguns firing' section of the 'Record of Sighting' form are 'Yes' or 'No'. Although it is possible to answer 'Yes' and append a note to indicate if the sighting occurred during the soft-start, the majority of observers do not differentiate between firing during the soft-start and firing at full power. Therefore a third option, 'Soft-start', has been added to encourage observers to make such distinctions.

The *Guide to using marine mammal recording forms* has been updated to take account of the above amendments to the forms, and to provide further clarification. It is strongly recommended that observers read this guide (included in Appendix 3) before using the recording forms.

9.6 Considerations for future revisions to guidelines

A previous report 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 summarised below, followed by further items for consideration. For a fuller consideration of items discussed previously refer to Stone (2000a).

(1) *(Discussed previously)*. The guidelines should perhaps specify a maximum duration of the soft-start as well as a minimum duration, to avoid very lengthy soft-starts and unnecessary excess noise production.

(2) *(Discussed previously)*. There should perhaps be a requirement to cease further increases of power if marine mammals appear close to the airguns during the soft-start. The circumstances under which power should be maintained at a constant level without further increases, and the circumstances under which the build-up of power levels could re-commence, would need to be defined. However, this may act as an incentive for operators or contractors to begin the soft-start well in advance of a line and make it as short as possible, thereafter continuing to fire at full power until the start of line, thus increasing the overall amount of acoustic input to the marine environment. Careful consideration should therefore be given if the guidelines are to include any requirement for action during the soft-start.

(3) *(Discussed previously)*. The guidelines should include a requirement that there should be no shooting which is not necessary for the normal operations of a seismic survey or for a soft-start, thus closing the loophole whereby if shooting is continued between lines, the requirement for a delay is avoided. Although this item has been mentioned in the guidance note issued by JNCC in March 2000 (Appendix 1), it needs to be incorporated into the guidelines at their next revision.

(4) *(Discussed previously)*. Consideration should be given to the consequences of time-sharing, where the potential for continuous man-made noise over large areas of the sea, and thus the potential for acoustic disturbance, is great. In addition to previous comments on this item (Stone 2000a), it should be noted that on some occasions during 1999 soft-starts shorter than the required minimum duration occurred because of a time-share situation. Some crews believe that if another seismic vessel is shooting nearby this is an adequate substitute for their own soft-start. The purpose of the soft-start is to avoid injury or excessive disturbance to mammals that may be in the vicinity of the airguns, allowing them time to move to a safer distance before full power is reached. This is of particular importance for those animals which may be very close by but are undetected (i.e. animals for which there would have been a delay if they had been detected). Clearly, if mammals are in the vicinity of the airguns of one vessel, the impact of the commencement of shooting will not be reduced by the firing of airguns on another vessel several kilometres away. The guidance note issued by JNCC in March 2000 stated that a soft-start with a minimum duration of 20 minutes should occur in time-share situations. This should be incorporated into the next revision of the guidelines, even if no other aspect of time-sharing is addressed.

(5) *(Discussed previously)*. The guidelines could encourage operators or contractors to consider whether extra protection (e.g. cessation of firing) could be given to species which are endangered, such as the northern right whale.

The following items were not discussed in the previous report:

(6) A number of observers during 1999 commented on the difficulties of providing adequate cover during the long daylight hours in the summer months in higher latitudes. The guidance note issued in early 2000 stated that in these cases two marine mammal observers would be required, and that in sensitive areas both observers should be trained cetacean biologists. It was also stated that the use of a second crew member with other onboard responsibilities would not be considered an adequate substitute. There was only one survey during 1999 that used two dedicated observers throughout the

entire survey (one other used two observers during the first ten days), but the use of two dedicated observers has increased since the issue of the guidance note. This has undoubtedly improved observers' ability to ensure compliance with the guidelines at all times, and provide high quality data. Again, this item from the guidance note should be incorporated into the guidelines at their next revision. It should be noted that this may also be important in sensitive areas for site surveys where lines and line changes are short, resulting in very frequent pre-shooting searches.

(7) The guidelines should include a requirement that the marine mammal observer is on board the source (= airgun) vessel. On some surveys more than one vessel is used, but usually only one vessel deploys the source. The marine mammal observer clearly needs to be on board the source vessel to be able to check for the presence of marine mammals in the vicinity of the source prior to shooting commencing. In some cases the source vessel and the receiving vessel may be several kilometres apart, for example in surveys where the streamer is laid on the sea bed and the source vessel shoots over the entire length of the streamer. In such cases it is inappropriate to expect fishery liaison officers to act also as marine mammal observers, as they are usually posted on board the receiving vessel where they are best placed to ensure that fishing vessels keep clear of the streamer(s). During 1999 there were six dual-vessel surveys, and in five cases the fishery liaison officer acted as marine mammal observer. In three cases the fishery liaison officer/ marine mammal observer was on the receiving vessel for either the entire survey or the majority of it, while in another case it was not specified which vessel the observer was on; there were only two cases where the observer was known to be on the source vessel for the entire survey, one being when a dedicated marine mammal observer was used. There should be a clear requirement within the guidelines for marine mammal observers to be on board the source vessel for the entire duration of dual/multi-vessel surveys. For the same reasons, there should be a requirement that the observer is on the seismic vessel and not on the chase vessel.

(8) The current version of the guidelines applies the same measures to any uses of the airguns; although this is intended to include test firing this activity is not specifically mentioned. Although the guidance note addresses this specific issue, some crews still need to be reminded of the need for a pre-shooting search, a soft-start, and a delay if necessary when testing the airguns. It would be appropriate to specifically mention test firing within the guidelines.

(9) The guidelines state that any required delay in shooting should allow "adequate time after the last sighting (at least 20 minutes) for the animals to move well out of range". Several observers have questioned what should happen when animals which have caused a delay in shooting are still visible once they have moved some distance away. Clearly it would seem reasonable for the soft-start to be allowed to commence once the animals are well out of range, even if they are still visible, but there is no definition of what constitutes "well out of range". Present knowledge is insufficient to define this distance with any degree of confidence (see section 9.2), but in spite of this it would seem appropriate to clarify this issue by stating a distance at which the soft-start could commence. Unless a distance is specified, there is a danger that individual observers will develop their own differing definitions of what constitutes "well out of range". The original intention in specifying a minimum 20 minute delay was to allow animals time to move at least a couple of kilometres away; it would be advisable for any distance specified to reflect this original intention.

(10) There are indications that marine mammals may be affected by seismic activity (at full power) out to distances of at least 4 km from the source. Consideration should be given to whether the level of disturbance at this distance is such that sufficient time should be allowed during the soft-start to enable animals that may be just beyond 500 m to move to this distance before full power is attained (see section 9.2). However, any suggestions for lengthening the soft-start should be balanced with the need to minimise overall acoustic input to the environment.

(11) It would be worth considering whether the proportion of inadequate soft-starts would decrease if the soft-start was measured in terms of distance rather than time. This would not compromise the intended purpose of the soft-start (allowing animals to move away from the source before full power

levels are attained) so long as an adequate distance (e.g. 4 km) is chosen. By using this approach the starting point of the soft-start could be accurately entered into the instrumentation on board, which may make it easier for seismic crews to comply with the guidelines. Normally there is a short run-in to a line, usually with the guns firing at full power, and at present crews have to estimate at what point they will be 20 minutes ahead of the run-in, taking into account the effect of currents on the vessel's speed. Even allowing some extra leeway, at times currents can increase the speed of the vessel beyond that anticipated, resulting in insufficient time for a full soft-start. Measuring the soft-start in terms of distance would remove this uncertainty and may result in fewer inadequate soft-starts. However, one clear disadvantage is that it would be much harder for marine mammal observers to check that the soft-start has lasted for a specified minimum distance than it is to check that it has lasted a specified minimum time. Consequently it would be more difficult for JNCC to measure the level of compliance with the guidelines and thus determine whether they are serving their purpose.

(12) The current version of the guidelines indicates that the requirement for a soft-start may be waived for surveys where the sources always remain at low power e.g. some site surveys. However, the guidance note issued by JNCC in March 2000 stated that a soft-start of minimum 20 minutes duration should occur for site surveys, except for a minority where a waiver has been agreed with JNCC prior to the start of the survey. Although this report does not cover surveys conducted since the issue of this guidance note, it is known that this has caused problems for some seismic contractors. Most soft-starts are achieved by commencing firing with one or several small volume airguns, and then adding in other airguns until the whole complement is firing. This is easily achieved on surveys such as 3D surveys, where there are many airguns arranged in several strings. However, many site surveys use a small number of airguns (e.g. four) and these may be arranged on a frame - firing the guns individually can damage this frame. Some seismic contractors have not sought to agree a waiver with JNCC prior to the survey, which consequently causes difficulties for the marine mammal observer, who is then put in the position of informing the crew that they should be carrying out a procedure that may damage their equipment. This situation needs to be addressed; several possible solutions are outlined below.

(a) The guidelines could state that site surveys using airguns with a total volume below a specified level would be exempt from the soft-start. It should be borne in mind that for many site surveys the total volume of all the airguns approximates to the starting volume of a soft-start on a typical 3D survey.

(b) The guidelines could concur with the guidance note and state that all site surveys should use a soft-start and that those contractors who wish to be exempted from this requirement will have to consult JNCC prior to each survey commencing to determine whether an exemption will be granted. In this case it would be advisable if those seismic contractors who routinely carry out site surveys were made fully aware that they are not automatically exempt from the soft-start but need to apply for exemptions.

(c) The guidelines could contain an alternative means of achieving the soft-start for site surveys where the total volume of the airguns is below a specified level. Alternatives to be considered could perhaps include building up the pressure, or firing at decreasing shot-point intervals, or firing a single warning shot at a fixed interval in advance of normal firing. When considering suitable alternatives it should be remembered that line changes on site surveys are often of short duration. It would be advisable to consult seismic contractors when considering alternatives, to ensure that any alternative adopted would both minimise the impact for marine mammals and be practical to achieve.

(13) Several people have commented that acoustic methods should be used to aid detection of marine mammals. This would increase detection of small and inconspicuous species such as the harbour porpoise, and would provide a means of monitoring the presence of marine mammals during the hours of darkness. However, it is important to realise that this is not a substitute for visual

observation, but should be additional to it. Rates of vocalisations may be highly variable, some species do not vocalise at certain times of year, and some studies have shown that there may be a cessation or reduction in vocalisations in response to acoustic disturbance (Bowles *et al.* 1994; Charif and Clark 2000; Richardson 1997), therefore it is essential that visual monitoring continues. Until acoustic monitoring is sufficiently automated, the use of this means of detection will require additional personnel with appropriate expertise. It would not be possible for visual observers to deploy hydrophones, set up associated equipment, monitor it for detection of marine mammals and deal with any problems encountered without detracting significantly from their visual observations. Further development of acoustic monitoring should be encouraged, with the aim of progressing it to the stage where a wide range of species can be detected and range can be determined, and where the system is sufficiently automated that it requires minimum input from marine mammal observers. Until then, it would not be appropriate for the guidelines to require that acoustic monitoring is used routinely on all seismic survey vessels, although the current recommendation that hydrophones should be used whenever possible should remain (there were no surveys during 1999 where hydrophones were used). It would be particularly useful if acoustic monitoring were used in deep water areas where deep-diving cetaceans (that spend a high proportion of their time underwater) are commonest.

(14) Knowledge of the guidelines is now widespread amongst companies and crews involved in seismic exploration in UK waters from ships. However, on occasions there are also seismic operations, such as vertical seismic profiling, on drilling rigs, and personnel involved in drilling operations are sometimes (possibly mostly) unaware of the existence of the guidelines. It would be advisable to circulate the guidelines amongst those involved in such operations.

(15) The word 'guidelines' is often misinterpreted by seismic crews to mean that the document is merely a guide and that the measures contained therein are optional rather than a requirement, and can be adapted or ignored as they wish. It would be worth considering whether the guidelines should be renamed, substituting the word 'guidelines' with a less ambiguous alternative, e.g. 'procedures'.

10. Acknowledgements

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12. 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 1999

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

Appendix 4 Additional reports received by JNCC during 1999

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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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.

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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.

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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.

Zoe Crutchfield
Joint Nature Conservation Committee
Dunnet House
7, Thistle Place
Aberdeen AB10 1UZ

Telephone 01224 655716
Fax 01224 621488
E-mail seismic@jncc.gov.uk

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 tasker_m@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

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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 colspan="2">Airguns firing

Yes / No</td><td>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 mark.tasker@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)

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

MARINE MAMMAL RECORDING FORM - RECORD OF SIGHTING

Options in italics should be circled or underlined as appropriate

<table>
<tr><td>Date</td><td>Time (GMT)</td><td>JNCC SS ref. no.</td><td>Sighting no.</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
(when animals first seen)

Yes / No / Soft-start</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 mark.tasker@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 1999

Seismic survey vessels and associated guard vessels operating outside Europe:

Western Wave	Makran/ Indus
Western Legend	Angola
Lamnalco 22	Indus

Other vessels and platforms operating outside Europe:

Toisa Panther (supply vessel)	Angola

Other vessels and platforms operating in UK and adjacent waters:

Beryl Bravo (production platform)	Northern North Sea
Henry Goodrich	West of Shetland
Highland Spirit (standby vessel)	West of Shetland
Iolair (semi-submersible vessel)	West of Shetland, Hebrides
Jack Bates (drilling rig)	Norwegian Sea
Jean Charcot (submarine cable survey vessel)	Celtic Sea
Schiehallion (FPSO)	West of Shetland
Seaspring (oil pollution control vessel)	Moray Firth
Transcend (fishing vessel)	Caithness
Transocean Nordic (drilling rig)	Outer Moray Firth

Appendix 5

Scientific names of species mentioned in the text

Common seal	*Phoca vitulina*
Grey seal	*Halichoerus grypus*
Bowhead whale	*Balaena mysticetus*
Gray whale	*Eschrichtius robustus*
Humpback whale	*Megaptera novaeangliae*
Blue whale	*Balaenoptera musculus*
Fin whale	*Balaenoptera physalus*
Sei whale	*Balaenoptera borealis*
Minke whale	*Balaenoptera acutorostrata*
Sperm whale	*Physeter macrocephalus*
Beaked whales	*Mesoplodon/ Ziphius/ Hyperoodon* spp.
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*