

CETACEANS IN THE VICINITY OF THE PROPOSED BARRA FERRY TERMINAL

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INTRODUCTION The waters around the Western Isles are probably the richest of any coastal region in the UK for whales, dolphins, and porpoises, and are one of the most important regions in north-west Europe (Evans, 1998). Twenty species of cetaceans have been recorded since 1980 in nearshore waters (within 60 km of the coast). Of these, eleven species are either present throughout the year or recorded annually as seasonal visitors. Some of these are pelagic species that normally live along or west of the continental shelf edge, and they rarely come close to the coasts of the Western Isles. In and immediately around the Sound of Barra (including Eriskay Sound), a total of eight species have been recorded live since 1980.

STATUS & ECOLOGY The status, seasonal occurrence and ecology of the eight species of cetaceans recorded in recent years in the locality are given below:

Minke Whale (*Balaenoptera acutorostrata*) Worldwide distribution in tropical, temperate and polar seas of both hemispheres. In the North Atlantic, the minke whale occurs from Baffin Bay in the west and the Greenland & Barents Seas in the east, south to the Lesser Antilles in the west and the Iberian Peninsula and Mediterranean in the east.

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix III (can be exploited so long as regulation keeps populations out of danger) of BERN Convention on the Conservation of European Wildlife and Natural Habitats (1982); and Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and is treated by the European Community as if it is on CITES Appendix I (trade strictly controlled, and not for primarily commercial purposes, with exception of West Greenland); one of the species managed by the International Whaling Commission. Status listed by IUCN (1991) as vulnerable. In UK, it receives protection under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985).

The minke whale is widely distributed along the Atlantic seaboard of Britain and Ireland but also occurs regularly in the northern and central North Sea as far south as the Yorkshire coast. It is seen in small numbers in the Irish Sea but is rare in the Channel and southernmost North Sea, as well as south of here in the Bay of Biscay.

There is some indication of an increase since the 1980's, with populations concentrated in the northern North Sea, and around North and West Scotland. Indeed, in the Minches and Sea of Hebrides, it has become the second most frequently observed species in summer months.

Most sightings occur in July-August although the species can be seen anytime between May and October, and at least small numbers remain in coastal waters year-round (Evans, 1980, 1992; Evans *et al.*, 1986; Northridge *et al.*, 1995). In the autumn there appears to be a general offshore movement, possibly associated with breeding which occurs sometime between autumn and spring, although breeding locations are unknown. There is no information on whether any extensive migration takes place.

It occurs regularly in coastal waters of South Uist, Eriskay, and Barra, and in the Sound of Barra, but we have no records of it from within the Sound of Eriskay where the waters are probably too shallow for the species to favour this area although it probably does enter here on occasions. Although most commonly seen singly or in loose groups of up to three, in late summer the species may form feeding aggregations numbering between 5 and 15 individuals.

The Sea of Hebrides provides a rich feeding ground for minke whales, which prey upon a variety of fish species, notably herring, sandeel, cod, haddock, saithe, as well as euphausiids and pteropods. Feeding occurs often in areas of upwelling or strong currents around headlands and small islands, primarily during the summer. Feeding minke whales in late summer are commonly associated with flocks of manx shearwater, northern gannet, kittiwake and various *Larus* gulls.

Vocalisations involve intense, low frequency, broadband (0.5-1 kHz bandwidth) and harmonic down-sweeps with maximum source level of 165 dB re 1 μ Pa. These include short broadband down-sweeps (mainly 0.13-0.06 kHz lasting 200-300 msec); 'grunts' (mainly between 0.08-0.14 kHz, but up to 2 kHz, lasting 165-320 msec); and thumps (often down-sweeps; mainly 0.1-0.2 kHz, lasting 50-70 msec) (Schevill & Watkins, 1972; Winn & Perkins, 1976; Thompson *et al.*, 1979; Edds, 1988).

Killer Whale or Orca (*Orcinus orca*) Worldwide distribution in tropical, temperate and polar seas in both hemispheres (with greatest abundance at higher latitudes).

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats (applied to this species, from 1987); and Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation). Status listed by IUCN (1991) as insufficiently known. In UK, it receives protection under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985). One of the species for which the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.

Although killer whale numbers in the North Atlantic appear to be greatest in subarctic and arctic waters, the distribution of the species extends south to the Caribbean, Azores, Madeira, Canaries and occasionally the western Mediterranean. The species is widely distributed in the North Atlantic and in coastal northern European waters particularly around Iceland and western Norway. In UK, it is most common in northern and western Scotland, but rare in the Irish, central and southern North Seas, and the English Channel (Evans, 1988, 1992).

Although uncommon, killer whales are regularly observed in the Sea of Hebrides where several recognisable individuals have been seen repeatedly in the same region over a period of at least ten years. They are mostly seen in West Scotland between May and October. Like the minke whale, the species may be seen anywhere in coastal waters of South Uist, Eriskay, and Barra, but we have no records of it from within the Sound of Eriskay. On the other hand, killer whales may come into shallow coastal waters in pursuit of seals, which form part of their diet, along with a wide variety of fish species (particularly herring, cod, and mackerel) and other marine vertebrates (such as porpoises and sharks). Group size varies between 1 and 16, though usually between two and eight are seen, with groups (termed pods) having very stable membership. Breeding occurs between October and March, possibly between October and December.

Vocalisations have been well studied and include a variety of whistles of variable duration mainly of 6-12 kHz frequency, a pulsed call primarily in the frequency range 1-6 kHz, and very short echolocation clicks mainly of 12-40 kHz (Hoelzel & Osborne, 1986; Bowles *et al.*, 1988; Moore *et al.*, 1988; Ford, 1989). Stereotyped, discrete calls have been found to vary between groups and appear

to represent group-specific dialects (Ford & Fisher, 1982, 1983; Ford, 1984; Bowles *et al.*, 1988; Ford, 1989, 1991; Strager, 1995).

Risso's Dolphin (*Grampus griseus*) Worldwide distribution in tropical and temperate seas in both hemispheres.

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats (applied to this species, from 1987); and Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation). Status listed by IUCN (1991) as insufficiently known. In UK, it receives protection under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985). One of the species for which the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.

In the North Atlantic, it occurs from Newfoundland to the Lesser Antilles in the west; and from the Shetland Islands to the Mediterranean in the east. The species also occurs around oceanic islands like the Azores, Canaries and Cape Verde Islands.

The major populations in UK occur in the Hebrides but the species is regular also in the Northern Isles, and in the Irish Sea, and in Western Ireland (Evans, 1992). It is rare or absent in the central and southern North Sea and eastern portion of the Channel. Elsewhere, it is present in Northwest France, the Bay of Biscay, around the Iberian Peninsula, and in the Mediterranean.

The species is nowhere common but is seen most frequently between May and September, particularly the latter three months of July, August and September. The largest populations are reported from the Minches and Sea of Hebrides. Although more common in the north of this region (particularly around the Eye Peninsula), the species occurs regularly in coastal waters of South Uist, Eriskay, and Barra. We have no reports of it within the Sound of Eriskay, although elsewhere in the Hebrides, the species has been seen entering very shallow sounds.

Risso's dolphins feed mainly upon cephalopods (octopus, cuttlefish and small squid), and the area is important both for feeding and breeding (calving occurring mainly between April and September). Groups usually comprise 5-20 individuals although sometimes aggregations of 50-100 individuals have been recorded. Photo-ID studies indicate that groups can be stable over the longterm with individuals associating from one year to the next (Evans, 1987; Atkinson *et al.*, 1997, 1999; Evans, unpubl. data).

Vocalisations include a variety of clicks, whistles, and pulsed calls. Whistles are rarely heard, but range over 2.5-20 kHz, usually 8-12 kHz, average duration 0.67 secs, and maximum source level of 170 dB re 1 μ Pa @ 1 m (Watkins, *pers. comm.*). Clicks have peak frequency at 65 kHz and durations of 40-100 secs (Au, 1993). Click frequencies are between 0.2-over 100 kHz, with repetition rates of 4-200 per sec. Click-bursts last from 0.2-1.5 secs. Maximum source level is 175 dB re 1 μ Pa @ 1 m (Watkins, *pers. comm.*). Eight different kinds of sounds in three main categories were recognised in Hebridean Risso's dolphins: clicks in discrete series (echolocation clicks, creaks, grunts) with repetition rates of 37-167 pulses per sec., fast sequences of pulses (buzzes, squeaks, squeals, moans) with high repetition rates of 187-3,750 pulses per sec, resulting in harmonics; and whistles of 9-13.2 kHz (Benoldi *et al.*, 1997, 1998).

Bottlenose Dolphin (*Tursiops truncatus*) Worldwide distribution in tropical and temperate seas in both hemispheres.

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats (applied to this species, from 1987); and Annex II of the EC Habitats Directive (1992) (prohibiting all forms of deliberate capture, killing or disturbance, especially during breeding, rearing or migration; bans the keeping, sale, or exchange of such species; and requiring that member states monitor the incidental capture and killing of all cetaceans, and carries out research on conservation measures to prevent such accidents). Like all cetacean species, it is also listed on Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and, since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation). Status listed by IUCN (1991) as insufficiently known. In UK, it receives special protection in respect of particular methods of killing or taking under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985). One of the species for which the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.

Along the Atlantic seaboard of Europe, the species is locally fairly common nearshore off the coasts of Spain, Portugal, north-west France, western Ireland, north-east Scotland, in the Irish Sea, particularly Cardigan Bay and south-east Ireland, and in the Channel. All those localities receive influence from the Gulf Stream. The species also occurs offshore in the North Atlantic (often in association with long-finned pilot whales) as far north as the Faroe Islands. In coastal waters, bottlenose dolphins often favour river estuaries, headlands or sandbanks where there is uneven bottom relief and/or strong tidal currents (Lewis & Evans, 1993; Liret *et al.*, 1994; Wilson *et al.*, 1997).

Essentially an inshore species, in British and Irish waters the bottlenose dolphin is most frequently sighted within 10 km of land, although also occurs in offshore waters, often associated with other cetaceans such as long-finned pilot whales. Bottlenose dolphins are present throughout the year in various bays in Western Ireland; in the Irish Sea (particularly Cardigan Bay); and the Moray Firth. Elsewhere in Britain, the species has been scarce in the central and southern North Sea, but it occurs seasonally at particular localities along the south coast of England.

Although generally rare in Northwest Scotland and the Northern Isles, there is a small resident community of bottlenose dolphins that live in the Sound of Barra and these enter the Sound of Eriskay where they may occur in very shallow waters (probably making use of those shallows to capture fish). They have been seen in all months of the year though most frequently between April and September, with groups usually varying between two and ten individuals including young. Elsewhere in UK, group sizes tend to increase in late summer and may number tens of individuals. A small group also lives around Coll, Tiree and Mull, and offshore groups are sometimes seen west of the Outer Hebrides.

The species has an extended breeding season, but with births peaking between May and November (Evans 1980; Wilson, 1995). Bottlenose dolphins feed upon a variety of benthic (e.g. mullet, eels, flounder, dab, sole, turbot, haddock, hake, and cod) and pelagic fish (e.g. salmon, trout, bass, herring, blue whiting) as well as marine invertebrates (cephalopods and shellfish).

The bottlenose dolphin makes a wide range of vocalisations. Echolocation clicks (used for orientation and foraging) are composed of intense short duration broadband clicks (40-130 kHz) (Au, 1993). Clicks are broadcast in episodic trains that can continue for the duration of a dive and culminate in buzzes and whines as targets are approached. Burst pulse vocalisations (barks, yelps and donkey-like brays) may have a variety of social functions (0.2-16 kHz). Whistles are pure tone frequency modulated calls ranging from 2-20 kHz. Clicks and whistle vocalisations can be made simultaneously.

White-beaked Dolphin (*Lagenorhynchus albirostris*) Distribution restricted to temperate and subpolar seas of the North Atlantic.

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats (applied to this species, from 1987); and Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation). Status listed by IUCN (1991) as insufficiently known.

In UK, it receives protection under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985). One of the species for which the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.

The distribution of the white-beaked dolphin extends northwards to central W Greenland, the Greenland Sea and the southern Barents Sea and south to Newfoundland, Cape Cod and SW Ireland. It occurs over a large part of the northern European continental shelf and is common in British and Irish waters, with a similar distribution to the Atlantic white-sided dolphin though less pelagic and apparently more abundant at least in coastal waters. Its distribution is centred mainly upon the central and northern North Sea, but extending westwards to North and North-west Scotland, and southwards towards SW Britain and Ireland (Evans, 1990, 1992; Northridge *et al.*, 1995). It is occasionally observed in the western Channel south to the Bay of Biscay, in the Irish Sea, and southernmost parts of the North Sea.

White-beaked dolphins are common in the Hebrides, particularly in the north Minches, but they also occur regularly in the Little Minch and Sea of Hebrides (mainly along the east coast of the Western Isles). The species has been seen in coastal waters of South Uist, Eriskay, and Barra but not observed (according to our records) within the Sound of Eriskay itself where the waters are probably too shallow for them to occur more than occasionally. In UK waters, the species is most common between June and October) although present in northern Britain year-round (Evans, 1992; Northridge *et al.*, 1995).

White-beaked dolphins feed upon mackerel, herring, cod, poor-cod, sandeels, bib, whiting, haddock, and hake, as well as squid, octopus, and benthic crustaceans. The region is used both for feeding and breeding. They breed mainly between May and August, although some may occur also in September and October.

Vocalisations poorly known but include whistles of 6.5 to at least 15 khz frequency (often around 8 khz), with maximum source levels of 180 db re 1 μ pa @ 1 m, and echolocation clicks of up to at least 325 khz, with click bursts of 100-750 pulses per second, and maximum source levels of 207 db re 1 μ pa @ 1 m (Watkins, *pers. comm.*, Mitson & Morris, 1988; Mitson, 1990; Reeves *et al.*, 1999b).

Atlantic White-sided Dolphin (*Lagenorhynchus acutus*) Distribution restricted to temperate and subpolar seas of the North Atlantic.

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats (applied to this species, from 1987); and Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and, since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation). Status listed by IUCN (1991) as insufficiently known. In UK, it receives protection under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985). One

of the species for which the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.

This species is relatively abundant in mainly offshore waters from central West Greenland, Iceland and the southern Barents Sea south to Cape Cod (United States) and SW Ireland. In European waters, it is widely distributed mainly offshore from Iceland and the western Barents Sea south to the Bay of Biscay. It is less common on the continental shelf than on the slope and in deeper waters, and is more abundant north of 56°N than south of this latitude. In coastal waters of Britain and Ireland, it is less commonly recorded than the closely related white-beaked dolphin, where its distribution is concentrated around the Hebrides, Northern Isles and northern North Sea. It also occurs regularly off western Ireland, and in the southwest approaches to the Channel and in the central North Sea, but is rare in the Irish Sea, the eastern Channel, and southernmost North Sea.

Although less commonly encountered in the Sea of Hebrides than the white-beaked dolphin, white-sided dolphins usually occur in large schools numbering in the tens up to around 500 individuals. Most sightings occur at the southern end in July and August.

The diet reflects its more oceanic ecology, with species like blue whiting, herring, mackerel, horse mackerel, cod, hake, and silvery pout being important. Squid are also taken. Breeding occurs between February and September, probably mainly between May and August.

Vocalisations include whistles of 7-16 kHz frequency, with mean peak frequencies of 8-12 kHz, and mean duration 0.5 sec, and broadband echolocation clicks at 0.2-180 kHz with peak frequencies of 60-80 kHz and single pulse duration 0.25-1 msec (Watkins, *pers comm.*).

Common Dolphin (*Delphinus delphis*) Worldwide distribution in tropical, subtropical and temperate seas in both hemispheres.

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats (applied to this species, from 1987); and Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation). Status listed by IUCN (1991) as insufficiently known. In UK, it receives protection in respect of particular methods of killing or taking under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985). One of the species for which the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.

The common dolphin is widely distributed in the eastern North Atlantic, mainly in deeper waters from the Iberian Peninsula north to west Scotland. In British and Irish coastal waters, its distribution has a mainly western and southern component. It is common in the western approaches to the Channel and the southern Irish Sea, off the west coast of Ireland, and around the Inner Hebrides north to the Isle of Skye (Evans, 1992; Northridge *et al.*, 1995). In some years, the species occurs further north and east, around Shetland and Orkney, and in the northern North Sea. It is generally rare in the southern North Sea and the eastern portion of the English Channel. In recent years, there have been a number of sightings of common dolphins off Northern Scotland, in the Northern Isles, and well into the North Sea.

Common dolphins have been seen off the east coast of South Uist in June and July, with group sizes numbering up to 200 animals. The species has not been recorded in the Sound of Eriskay itself, and since it favours deep waters, this is unlikely to be used to any extent.

The diet of the common dolphin includes a wide variety of fish and squid. Pelagic fish species are most common - blue whiting, mackerel, poor cod, hake, sardine, anchovy, silvery pout, scad, hake,

and whiting, as well as small squid, octopus, cuttlefish, and crustaceans. The region is used both for feeding and breeding, with calves born mainly between June and September.

Vocalisations vary from whistles of 1-50 kHz frequency (mainly 6-12 kHz, max. source level 172 dB) to echolocation clicks which have not been adequately described but may reach 150 kHz (max. source levels 170 dB) at repetition rates of 30-200 clicks/sec. and pulsed calls such as “buzzes” and “barks” (Evans, 1973; Watkins, pers. comm.; Sturtivant *et al.*, 1994; Moore & Ridgway, 1995). Clicks and whistles may be given simultaneously.

Harbour Porpoise (*Phocoena phocoena*) Distribution restricted to temperate and subarctic seas of the northern hemisphere.

International protection includes Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983); Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats (applied to this species, from 1987); and Annex II of the EC Habitats Directive (1992) (prohibiting all forms of deliberate capture, killing or disturbance, especially during breeding, rearing or migration; banning the keeping, sale, or exchange of such species; and requiring that member states monitor the incidental capture and killing of all cetaceans, and carries out research on conservation measures to prevent such accidents). Like all cetacean species, it is also listed on Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992). It is listed on List C1 of Council Regulation and, since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation). Status listed by IUCN (1991) as insufficiently known. In UK, it receives special protection in respect of particular methods of killing or taking under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985). One of the species for which the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.

In the eastern North Atlantic, the harbour porpoise is widely distributed on the continental shelf from the Barents Sea south to the coast of France and Spain, although in the last thirty years, it has become scarce in the southernmost North Sea, English Channel, and Bay of Biscay. Nevertheless, it is the commonest cetacean recorded in British and Irish waters, though most abundant along the south and west coasts of Ireland, western and northern Scotland including the Hebrides and Northern Isles, in East Scotland and Northeast England, and in some coastal areas within the Irish Sea (mainly off SW Wales). Only small numbers occur in Southwest England, and the species becomes scarce eastwards along the south coast of England, in the Thames estuary and off East Anglia. General declines were noted in coastal areas of the southern North Sea during the 1970's, extending and including some more northern and Atlantic sites during the early 1980's, with some indication of a reversal in this trend in the late 1980's to the present (Evans, 1992; Sea Watch unpubl. data).

Porpoises are common all along the eastern (and western) seaboard of the Outer Hebrides including South Uist, Eriskay, and Barra, and the species occurs in Barra Sound and has been recorded in the Sound of Eriskay. As elsewhere, porpoises can be found sometimes in very shallow waters. The species is apparently resident throughout the year in the region, although peak numbers are recorded between July and September. The area is used both for feeding and breeding.

The main diet of porpoises is small fish (usually less than 40cm length) such as young herring, sprats, sand-eels, whiting, saithe, and pollack, although particularly in winter months, prey such as dab, flounder, sole, and cod are taken. Breeding occurs mainly between May and August, with a peak in June, though some can be as early as March.

Harbour porpoises produce high-frequency sounds used for echolocation and communication, but do not make frequency-modulated whistles typical of many delphinids. The high frequency sounds are comprised entirely of click trains, produced in two narrow band frequency components, one weaker one of longer duration (c. 0.2 msec) at between 1-20 kHz (Schevill *et al.*, 1969; Goodson *et al.*,

1995) and the other between 120-160 kHz (peaking around 130 kHz) of shorter duration (c. 0.02 msec) (Mohl & Andersen, 1973; Kamminga, 1990; Amundin, 1991; Goodson *et al.*, 1995). Repetition rates of pulses range between 0.5-1,000 clicks per sec (Amundin, 1991). Maximum source level is estimated at between 149 and 177 dB re 1 μ Pa at 1 m (Akamatsu *et al.*, 1992). The contexts in which these click trains are used are not well understood.

EFFECTS OF ANTHROPOGENIC SOUND UPON CETACEANS

Sound characteristics produced by human activities Animals such as cetaceans which live entirely within an aquatic environment rely heavily on sound both to acquire information about their environment and for communication (Evans, 1987; Richardson *et al.*, 1995). Additional sounds may therefore cause disruptions to the lives of cetaceans, distracting, annoying or even frightening them, as well as providing the potential for causing behavioural and physiological upset.

Since the industrial era, humans have developed a number of highly intense sources of sound (Ross, 1976; Urick, 1983, 1986). Indeed, Ross (1976) estimated that between 1950 and 1975, ambient noise had risen by 10 dB in areas where shipping noise dominates, and he predicted it would rise a further 5 dB by the end of the 20th century as shipping traffic increased. The more powerful the engine that a vessel possesses, the greater the amount of sound (at least at low frequencies) it will produce. Supertankers, in particular, produce sound intensities of between 187 dB (at 50 Hz) and 232 dB (at 2 Hz) re 1 μ Pa, at very low (particularly <10 Hz) frequencies (Cybulski, 1977; Leggat, *et al.*, 1981).

Besides propeller and engine sound generated by vessels during commercial, military and recreational activities, surface vessels and submarines employ active sonar which uses sonic or ultrasonic waves to locate submerged objects, at the same time introducing brief, high-intensity pulses into the marine environment that sometimes may be transmitted over great distances. Source levels of sound are c. 200-250 dB re 1 μ Pa at frequencies up to 200 kHz. High resolution sidescan sonar (generally below 14 kHz) is also used in geophysical seismic surveys particularly during oil and gas exploration, along with lower resolution explosive techniques (airguns, sleeve exploders, etc.) mainly at frequencies below 500 Hz (Richardson *et al.*, 1995; Evans & Nice, 1996).

Most of the sounds generated from maritime activities referred to above (with the exception of sonar) are produced at frequencies lower than 1 kHz. However, when a surface vessel travels at high speed, the propeller may cavitate and produce much higher frequency sound (between 2 and 20 kHz) (Evans *et al.*, 1992). Measurements of various small craft (up to 15 m length, 240 hp engine) indicated source levels ranging from 100-125 dB re μ Pa at 2 kHz and 60-105 dB re μ Pa at 20 kHz. Cavitation is also more likely to occur when the propeller is damaged.

Cetacean Sound Production and Hearing The auditory sensitivities of porpoises, dolphins and the smaller toothed whales are greatest at very high frequencies - between 10 and 150 kHz, with a hearing threshold of about 40 dB at those frequencies, increasing to around 100 dB at 1 kHz and 120 dB at 100 Hz, at least for those species for which data are available (Richardson *et al.*, 1995). Although there is no quantitative information on the auditory sensitivities of baleen whales (such as the minke whale), results of recent investigations suggest that greatest hearing sensitivities occur between 100 Hz and 5 kHz, on the assumption that whales will hear approximately over the same frequency range as the sounds they produce. Using this argument, we would expect minke whales to be most sensitive to frequencies of between 60-140 Hz.

The sounds produced by toothed whales and dolphins may conveniently be divided into: (1) pure tone whistles generally in the frequency range 500 Hz - 20 kHz, used mainly for communication; and (2) pulsed sounds or clicks varying from 500 Hz to 150 kHz, used mainly for echolocation. Source levels for both types of sound are estimated usually to be between 150 and 200 decibels, although pulsed sounds for non-echolocatory purposes may be produced at source levels of 115 dB, mainly in the frequency range below 20 kHz. Most of these measurements were made in captivity and it should

be noted that animals can modify their sound production (particularly its intensity) in confined situations, and indeed do so also in open water.

The sounds produced by baleen whales may be classified into four types: (1) low-frequency moans, typically with frequencies of 12-500 Hz and of 0.4 to 36 seconds duration; (2) gruntlike thumps and knocks with most sound energy concentrated between 40 and 200 Hz; (3) chirps, cries and whistles at frequencies between 1 and 10 kHz; and (4) clicks or pulses at frequencies up to 20-30 kHz and lasting from 0.5 to 5 msec. Sound source levels range between 150 and 200 decibels, at frequencies of 500 Hz or less.

To summarise, most toothed whales, dolphins and porpoises can hear sounds over a wide range of frequencies from 75 Hz to 150 kHz, with greatest sensitivity around 20 kHz (although low frequency hearing has not been fully investigated), whereas the hearing of baleen whales probably ranges from frequencies of 10 Hz to 10 kHz, with greatest sensitivity usually below 1 kHz (this is based on sound production levels since no audiograms exist). Major differences in hearing between baleen and toothed whales are further supported by anatomical differences between the hearing organs of these two groups.

Sounds generated within the hearing range of cetacean species tend to elicit specific responses: the animal or animals move away from the sound source; they increase their dive times, remaining underwater for longer periods (possibly as a result of a rapid flee response; and social groups may bunch together. Sometimes, a cetacean species can shift the sound frequency at which it is communicating, and thus avoid or at least reduce interference with human made sounds. Longterm effects upon survival and reproduction of cetaceans have scarcely ever been demonstrated. However, because of the extreme difficulty of distinguishing from other anthropogenic factors and natural environmental changes, it is almost impossible to say whether these occur.

IMPLICATIONS FOR CETACEANS OF A FERRYPORT ON THE ISLAND OF ERISKAY

Ferry facilities for the Sound of Barra are proposed by Comhairle nan Eilean Siar in association with the Eriskay Causeway. The scheme involves construction of an approach road approximately 550m long, a marshalling area, a 60m long concrete slipway, and two protective breakwaters. The proposal is for construction to involve material excavated from the rock extraction site at Luday, South Uist, which will be developed to provide rock for the whole works. Bearing in mind that the ferry terminal will only go ahead in combination with the proposed Eriskay Causeway, these developments have a number of implications for cetacean species living in the area. They are:

(1) the construction of the ferry terminal and adjacent causeway is likely to cause sound disturbance to local cetacean populations in the immediate vicinity through blasting & dredging activities and increased heavy transport;

(2) the terminal will presumably bring to the area increased ship traffic at least with respect to the proposed ferry, and this will generate local underwater sound disturbance which could also affect cetaceans further afield;

(3) the causeway linked to the scheme will serve as a land barrier preventing movement of animals between the western and eastern sides of the northern Sound of Barra.

From the systematic list of eight species of whales and dolphin regularly occurring in the area, detailed above, it is clear that four species are most likely to be affected to any great extent in the immediate area by this scheme. These are minke whale, Risso's dolphin, bottlenose dolphin, and harbour porpoise. Both bottlenose dolphin and harbour porpoise are listed in Annex II of the EU Habitats Directive as species whose conservation requires the designation of Special Areas of Conservation. Both species are found regularly in the Sound of Barra and on occasions enter the Sound of Eriskay. They occur in the area throughout the year, and use it for giving birth and nursing their calves, for socialising, mating and feeding. Minke whales and Risso's dolphins occur regularly in the Sound of Barra and adjacent waters, and although most common during summer months, they

are found in the area most months of the year, using it for feeding, socialising, and as nursery areas for their calves.

The development of a ferryport on the west side of Eriskay will introduce at least one large vessel into this area, in this case using the deeper waters of the Sound of Barra as the route between the terminal and the island of Barra (as well as the Sound of Hellisay).

In general, all vessels produce noise in the same ways (Richardson *et al.*, 1995). Propeller cavitation produces most of the broadband noise, with dominant tones arising from the propeller blade rate. Propellers create more noise if damaged, operating asynchronously, or operating without nozzles. Propulsion and auxiliary machinery can also radiate significant noise. Radiated noise is roughly related to ship size, speed, and mode of operation. Large ships tend to be noisier than small ones, and ships underway with a full load produce more noise than unladen vessels. Noise also increases with ship speed.

The ferry proposed for the route between Eriskay and Barra is to be the “Loch Brushda”, which currently operates between Leverburgh, Isle of Lewis, and Otternish, North Uist. It is 44m long, 11.2m wide, 80 tonnes (dead weight) and 246 tonnes (gross) with a capacity to carry 18 cars and 150 passengers. The vessel operates by “shuttle propulsion” and has a top speed of 9 knots.

Although direct measurements of sound source levels from ferries in the region have not been made, most vessels of similar size produce sounds of c. 180-190 dB re 1 μ Pa at 1 metre for sound frequencies of 30-60 Hz (Richardson *et al.*, 1995: 116; Evans, 1996). As noted above, the size of the propeller affects the dominant frequencies at which sound is generated. Strong broadband components caused by propeller cavitation were centred at 40-50 Hz for a vessel with a propeller 6.3 m in diameter, and near 100 Hz for another with a 9-m propeller. Although such sounds will be heard by any cetacean species, there is greatest overlap with the frequencies used by baleen whales like the minke whale, and should traffic of vessels in the Sound of Barra exceed around ten movements per day, it may deter this species from using the area.

Whereas local conditions of propagation will affect the actual sound levels that cetaceans are exposed to from any particular vessel, as a general rule behavioural avoidance tends to occur at sound levels of 160-170 dB re 1 μ Pa at 1 metre in the frequency range of greatest sensitivity to the species (Evans & Nice, 1996). For comparison, ambient noise in the ocean tends to be c. 60-100 dB re 1 μ Pa at 1 metre (usually nearer to the upper value of 100 dB) (Richardson *et al.*, 1995: 88-98).

Assuming spherical spreading of sound according to the equation STL (sound transmission loss) = $20 \log R$ + linear range term, where R = range (a reasonable assumption in this area), the zone of negative influence (resulting in direct avoidance) is unlikely to be more than 100 metres from the vessel, although there is potential for acoustic masking at distances of a few kilometres.

Two species, the bottlenose dolphin and harbour porpoise, which are known to enter the Sound of Eriskay, are most likely to be affected by the scheme to build a causeway from South Uist to Eriskay. As part of the causeway project, there is a plan to construct culverts of about 10 metres width under the road to assist animals to pass either side of this land barrier.

There have been no instances of a comparable construction being made in the vicinity of a resident population of either bottlenose dolphins or harbour porpoises so it is difficult to predict with any confidence how successful this may be for either species. Both species are known to enter very shallow waters, and bottlenose dolphins will in some parts of the world actually beach themselves on banks of sand or mud in pursuit of fish prey. Once driven ashore, the fish are then captured by the dolphins. There are no observations of the species doing this in the UK but there are few comparable situations for this to occur. Although both species occur in fairly narrow channels, these are generally at least 100 metres wide. It is therefore likely that both species will be deterred from crossing from one side of the causeway to the other, and are more likely to move around the island of Eriskay if

they wish to travel any distance. On the other hand, this will not necessarily cause a serious interference for either species since they frequently travel adjacent to coastlines.

Harbour porpoises do not have any strong social structure, usually feeding and travelling either singly or in loose groups of 2-4 animals. A newly-formed land barrier is therefore unlikely to disrupt their behaviour in any sustained manner. Bottlenose dolphins do live in social units, however, and have preferred home ranges which they use on a longterm basis. From our current knowledge of the local population, bottlenose dolphin individuals mainly use the waters west and south of Eriskay. They are occasionally seen in the Sea of Hebrides east of South Uist and Eriskay, but are more commonly seen off the north-east corner of Barra and particularly in the western portion of the Sound of Barra. It is therefore likely that the population will concentrate its activities west of the causeway and within the main part of Barra Sound. Although we have no information on preferred habitats in the area, since it is the Sound of Barra which is mainly used by the local population, the creation of a land barrier in the very shallow waters of Eriskay Sound (maximum depths 10 metres) in itself is not likely to lead to a population decline for any cetacean species.

The other possible impact of the ferry terminal and causeway is through sound disturbance and local habitat modification during their construction. The building material for the causeway is being extracted from a site about one kilometre inland on South Uist. Thus it is unlikely that the blasting operations will cause much sound disturbance underwater in the Sound of Eriskay. Materials will then be taken by heavy vehicle and end-tipped so that again there does not appear to be much danger of sounds being generated underwater except as a result of the actual construction (and then subsequent use) of the carriageway. Presumably, although use of the causeway will increase over time, it will probably never receive heavy traffic unless the ferry terminal becomes specially active. Elsewhere in Britain, both bottlenose dolphins and harbour porpoises frequently pass under bridges which take quite large volumes of traffic (e.g. the bridge across the Inverness Firth at Kessock) and show no obvious signs of disturbance (indeed, they are disturbed more by speedboats in the vicinity).

If dredging or marine explosives are used in the ferry terminal construction, then there is potential for disturbance in the area during the period of activity. Source levels for explosions at 60 m depth gave peak values of 267 dB re 1 μ Pa at 1 metre for 0.5 kg TNT, 271 dB for 2 kg TNT, and 279 dB for 20 kg TNT (Richardson *et al.*, 1995: 156-157), likely to cause physical hearing damage at distances of up to one kilometre, and behavioural avoidance to c. 10 km. Dredging activities produce sounds varying from 172-185 dB re 1 μ Pa at 1 metre over the broadband range 45 Hz to 7 kHz, which by their continuous nature, elicit negative responses at lower levels than intermittent sounds. Strong behaviour changes in migrating bowhead whales have been noted at received levels of 124 dB from a drilling platform (Richardson *et al.*, 1995: 286), and avoidance was recorded in bowheads exposed received sound levels of 122-131 dB from a suction dredge (Richardson *et al.*, 1995: 279). They stopped feeding and moved from within 0.8 km of the sound projector to locations more than 2 km away.

MITIGATION MEASURES THAT COULD BE ADOPTED TO MINIMISE POTENTIALLY ADVERSE IMPACTS

There are three main measures that could be taken to mitigate the potentially adverse effects of this scheme:

- 1) The construction of both the causeway and ferry terminal would be best conducted between November and April when cetaceans are least in evidence in the region;
- 2) Where possible, blasting should be confined to terrestrial situations so as to minimise waterborne sound transmission which have potentially dangerous effects on cetaceans;

3) Any large vessel like a ferry or tanker using the proposed terminal would cause least disturbance to cetaceans if it was routed through shallow waters close to the west coast of Eriskay, and avoided straying far out into the Sound of Barra which is frequented by a variety of cetacean species.

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