

Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae)

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ABSTRACT

Information regarding beaked whales is so sparse that even the most basic aspects of their biology, such as their distribution, remain poorly defined for some species. We have reviewed the known distribution of each beaked whale species and where possible, used this information to infer its global distribution. While for some species, such as the relatively commonly recorded Cuvier's beaked whale, the inferred distribution is likely to be an accurate reflection of the species' actual distribution, for other lesser known species, such as the spade-toothed whale, the inferred distribution is more tentative. However, even such limited distribution information is essential when assessing and mitigating potential anthropogenic impacts on beaked whales and serves to highlight gaps in our knowledge that need to be filled if assessment and mitigation are to be successfully conducted.

KEY WORDS: DISTRIBUTION; NORTHERN HEMISPHERE; SOUTHERN HEMISPHERE; CONSERVATION

INTRODUCTION

To understand the extent to which beaked whales may be affected by anthropogenic activities, it is essential to know where they occur. The spatial distribution of a species has two closely-related aspects: the global range and the way individuals are distributed throughout that range. Individuals may be clumped in space and time, occurring in higher numbers or more regularly in some areas and at some times than others. The global range of a species is defined by the limits outside which individuals of a species cannot survive, for example where it is too warm or too cold, while the distribution within that range is defined by the preference for particular conditions, for example, certain habitats and the presence of food. This paper reviews what is known about the range of each beaked whale species and, where possible, the total range is inferred. This inferred range defines where the species may occur, but it does not necessarily identify where the highest densities or abundance occurs.

The family Ziphiidae is one of the most wide-ranging families of cetaceans, occurring from the ice edges at both poles, to the equator in all the world's oceans. However, knowledge of individual species ranges varies greatly. For some species the range is fairly well known (e.g. Sowerby's beaked whale (*Mesoplodon bidens*) – MacLeod, 2000), while for others it is almost completely unknown (e.g. the spade-toothed beaked whale (*M. traversii*) – van Helden *et al.*, 2002). This variation in knowledge exists for a number of reasons. Firstly, while for some species there are many distribution records, for others our entire understanding comes from a very small number of widely scattered records. In addition, while some species are regularly sighted at sea (e.g. Cuvier's beaked whale, *Ziphius cavirostris* – see below), giving us a picture of where living animals actually occur, others are mostly, or only, known from strandings (e.g. Andrews' beaked whale, *M. bowdoini*).

Stranded animals may have drifted, either incapacitated or as dead carcasses, for long distances before making landfall, meaning that such evidence may not reflect the actual distribution of the species. Finally, while a great deal of cetological research has been conducted in some parts of the world, in terms of sightings surveys (Fig. 1) and recording of strandings (e.g. in US and European waters), there has been little or no such effort in other parts of the world (e.g. the tropical eastern Atlantic). Therefore, apparent discontinuities in species distribution may reflect patchy data collection rather than true gaps in occurrence.

Defining beaked whale ranges is further confounded by uncertain taxonomy. On occasion, morphologically similar species have initially been considered as a single species and only later identified as separate species, causing major shifts in the perceived distribution of the species. For example, Hubbs' beaked whale (*M. carlhubbsi*) was initially identified as Andrews' beaked whale and the recently described Perrin's beaked whale (*M. perrini*) from California, USA, was originally identified as Hector's beaked whale, *M. hectori* (Hubbs, 1946; Moore, 1968; Mead, 1981; Dalebout *et al.*, 2002). In both cases, the lumping of separate species under a single name resulted in falsely perceived anti-tropical distributions. Species identification of beaked whales, particularly of living animals at sea, has been difficult, either because the external morphology of a species has been unknown, as in the case of the spade-toothed whale, or because of a poor understanding of species-specific field marks and/or a lack of obvious morphological differences between species.

This paper describes the known range of each currently recognised species of beaked whale based on a review of published information and from unpublished sighting and stranding records collected by the authors or obtained from other sources. As many specific locations as possible (i.e. those with available latitude and longitude or details of a species location) were plotted to show their geographic

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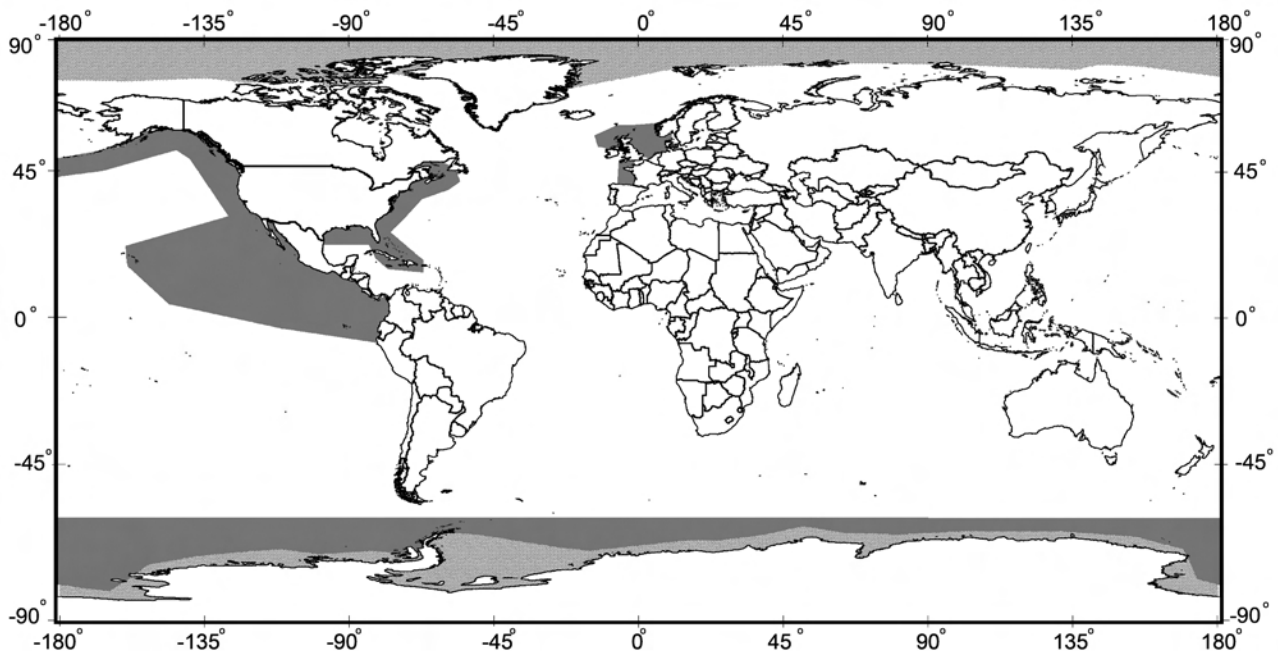


Fig. 1. Areas where dedicated surveys for cetaceans have been conducted and where sightings data may be more representative of actual at-sea distribution. However, these surveys have been conducted from different research platforms and using different methodologies, and so levels and types of effort are not directly comparable between surveyed areas. Therefore, this figure should not be used to make comparisons between different survey areas in terms of densities and/or abundance of beaked whales or different beaked whale species.

spread and these are the records plotted as individual locations on species distribution maps (Fig. 2). However, to provide a full understanding of species distribution, these records were then augmented by a detailed investigation of the available literature to identify additional general areas where a species has been recorded, but where available information is insufficient to allow a specific location to be plotted (e.g. published catch records from the whaling industry and species occurrence lists for countries or areas). As a result, a lack of specific point locations on a distribution map should not be interpreted as a lack of occurrence of a species in a specific area. Both specific locations and more general distribution information were then used, where possible, to infer a global range for each species. For some species the data are relatively sparse, meaning that there is significant risk that the inferred distributions do not accurately reflect the actual distributions. For species or areas where the range has been inferred from stranding records, it should be remembered that the transportation of dead or incapacitated animals by ocean currents and winds may lead to inaccuracies in the inferred distributions. Finally, this review has used beaked whale records going back as far as the early 1800s to infer current species ranges to increase the amount of available data. Species ranges are not static and can change over time. Therefore, the historical presence of a species at a specific location does not necessarily mean that it still occurs there, nor does the current range necessarily reflect the future range of a species. These limitations should be borne in mind when interpreting the figures and using them to assess and mitigate human impacts on beaked whales.

GENUS *BERARDIUS*

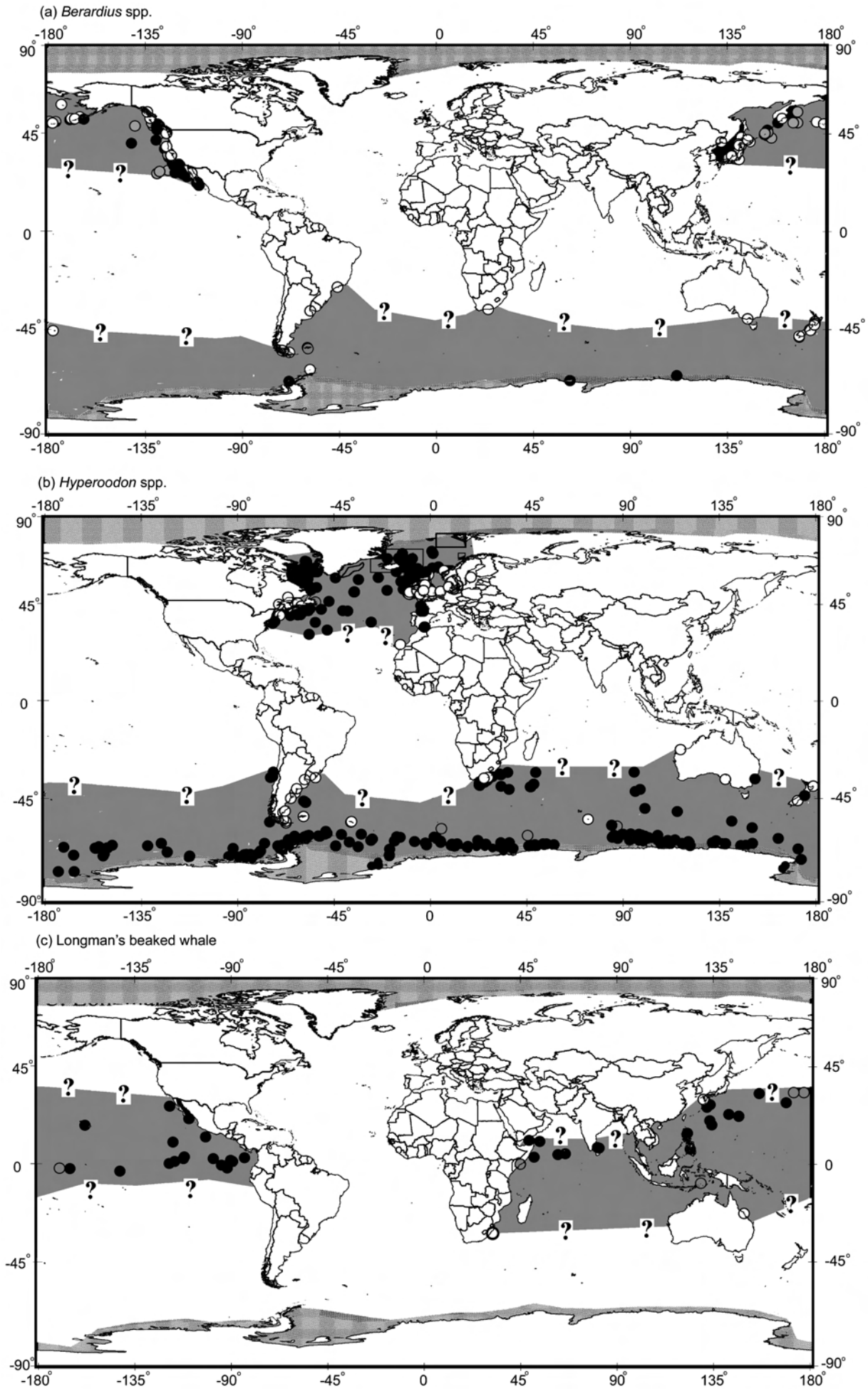
Arnoux's beaked whale (*Berardius arnuxii*)

This species has been recorded throughout the colder waters of the Southern Hemisphere, with strandings as far north as southern Brazil (Martuscelli *et al.*, 1995), South Africa

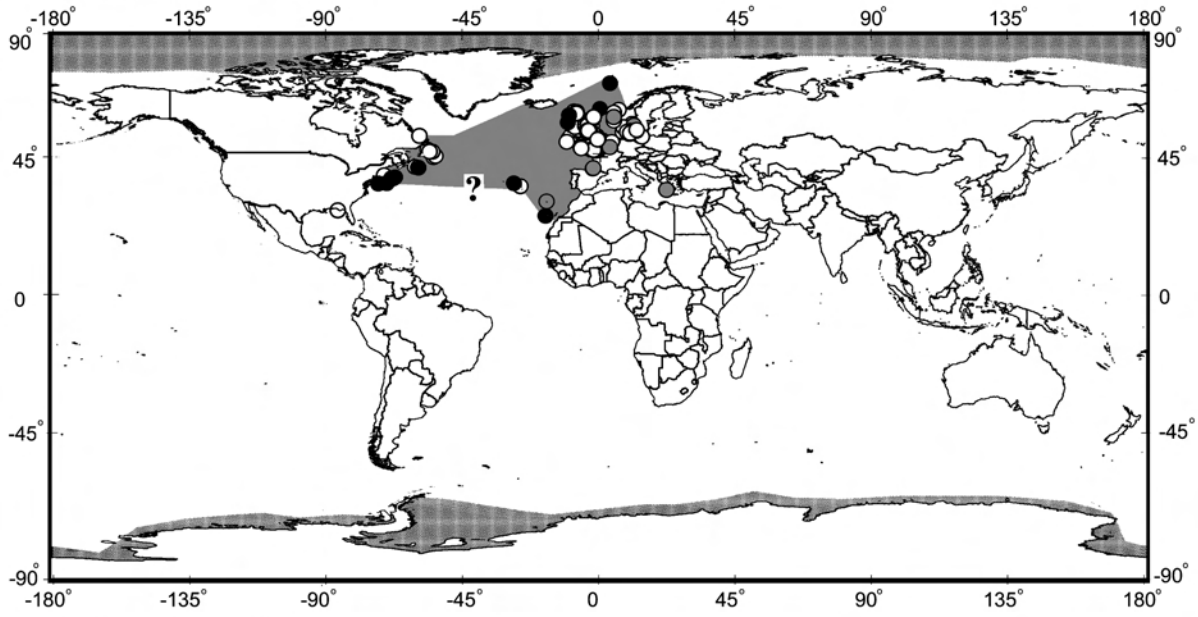
(Ross, 1984), southern Australia, New Zealand and the Chatham Islands (McCann, 1975). In addition, strandings have been recorded in northern Argentina (McCann, 1975), Tierra del Fuego (Goodall, 1978), the Falkland Islands (Lichter, 1986) and Antarctica (e.g. McCann, 1975; Ponganis *et al.*, 1995; Hobson and Martin, 1996; Rogers and Brown, 1999) (Fig. 2a). Based on sightings, the southern limit for this species is the ice edge and the continental shore of Antarctica. It has also been recorded in polynyas inside the ice edge (e.g. Kasamatsu *et al.*, 1988; Ponganis *et al.*, 1995; Hobson and Martin, 1996). The distribution along the western coast of South America is unclear, with no definite records known from this region. The northern limit of Arnoux's beaked whale is unclear throughout much of its range, but most records are from latitudes south of approximately 40°S (Fig. 2a).

Baird's beaked whale (*B. bairdii*)

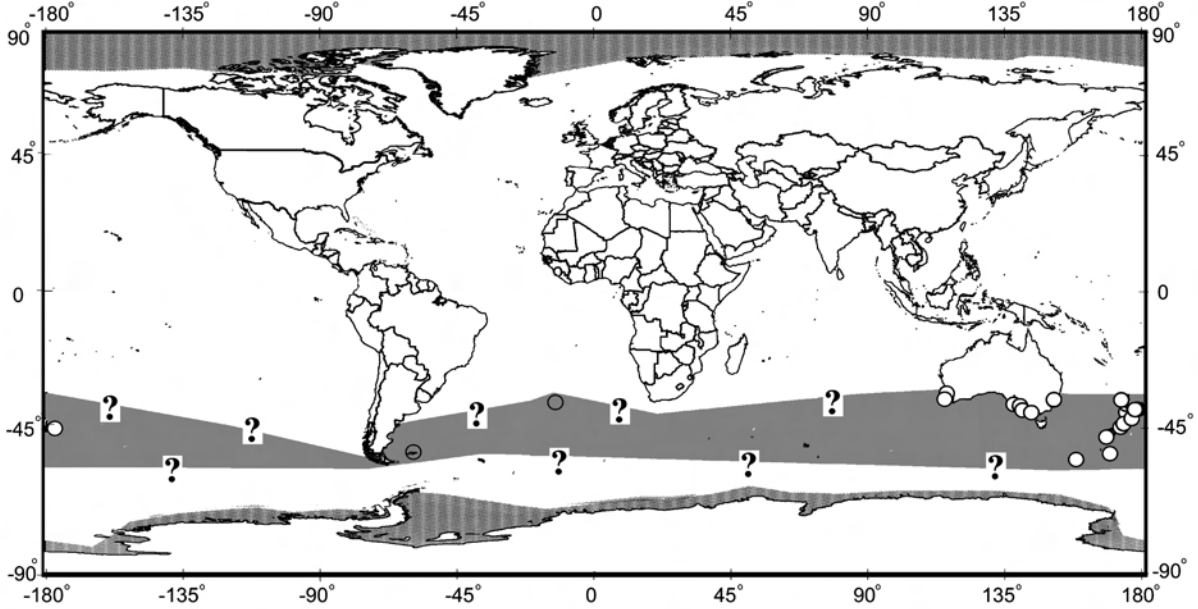
This species is endemic to the colder waters of the North Pacific Ocean (Fig. 2a). In the eastern North Pacific it is known from strandings as far south as La Paz at the southern tip of Baja California, Mexico (Aurioles-Gamboa, 1992) and as far north as mainland Alaska and the Aleutian Islands (Scheffer, 1949; Reeves and Mitchell, 1993). In the western Pacific it is known from whaling data to occur along both the eastern and western coasts of Japan (Omura *et al.*, 1955; Nishiwaki and Oguro, 1971; Nishiwaki and Oguro, 1972; Kasuya and Miyashita, 1997; Marine Mammal Database, National Museum of Science, Tokyo) and from strandings to occur as far north as the Kamchatka Peninsula in Russia (Reeves and Mitchell, 1993). Around Japan, the southern limit appears to be 34°N. The distribution in the central North Pacific is unclear. These whales appear to be relatively common around Japan, with evidence of seasonal movements into and out of the shelf-edge regions (Kasuya and Miyashita, 1997). Reports of Baird's beaked whales from farther south in the Pacific Ocean (e.g. Miyashita *et al.*, 1996) may represent sightings of Longman's beaked whales



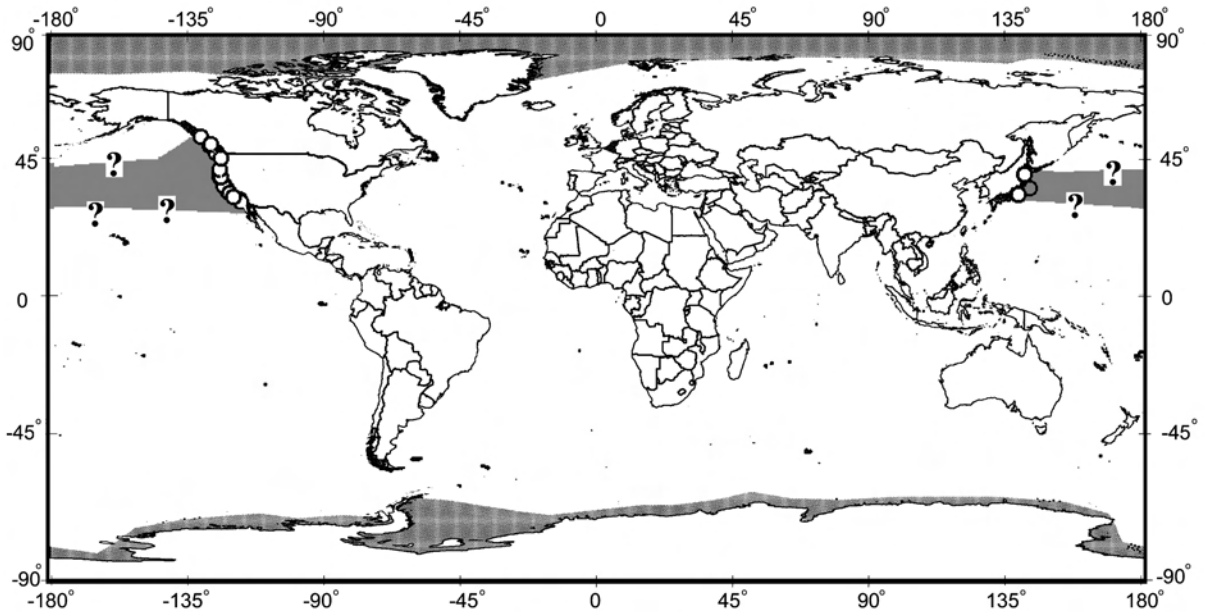
(d) Sowerby's beaked whale



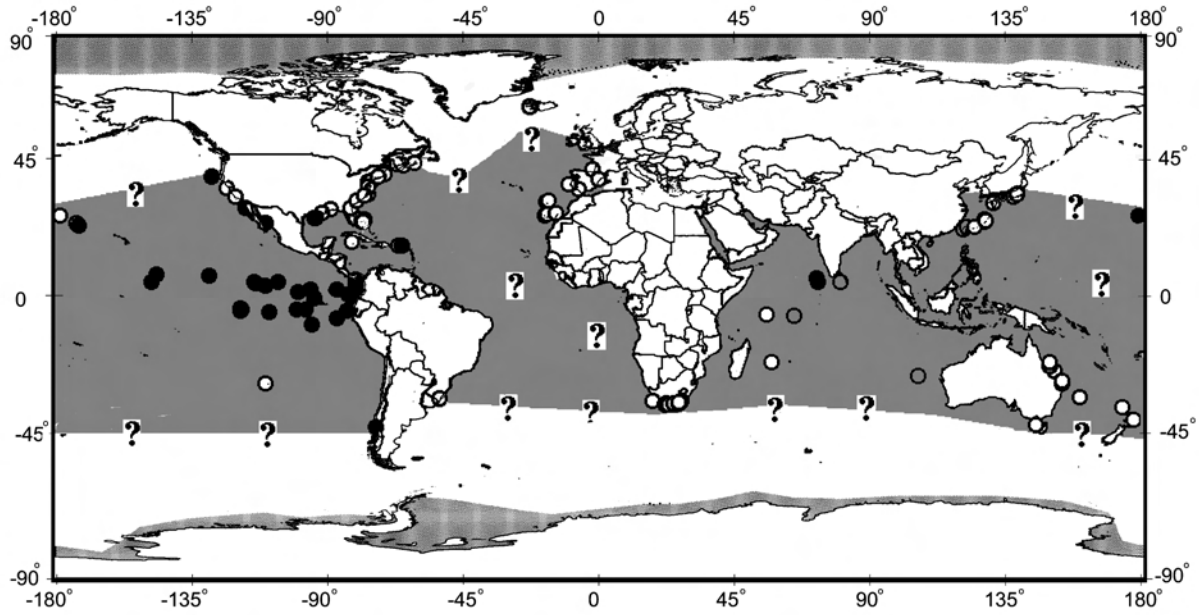
(e) Andrews' beaked whale



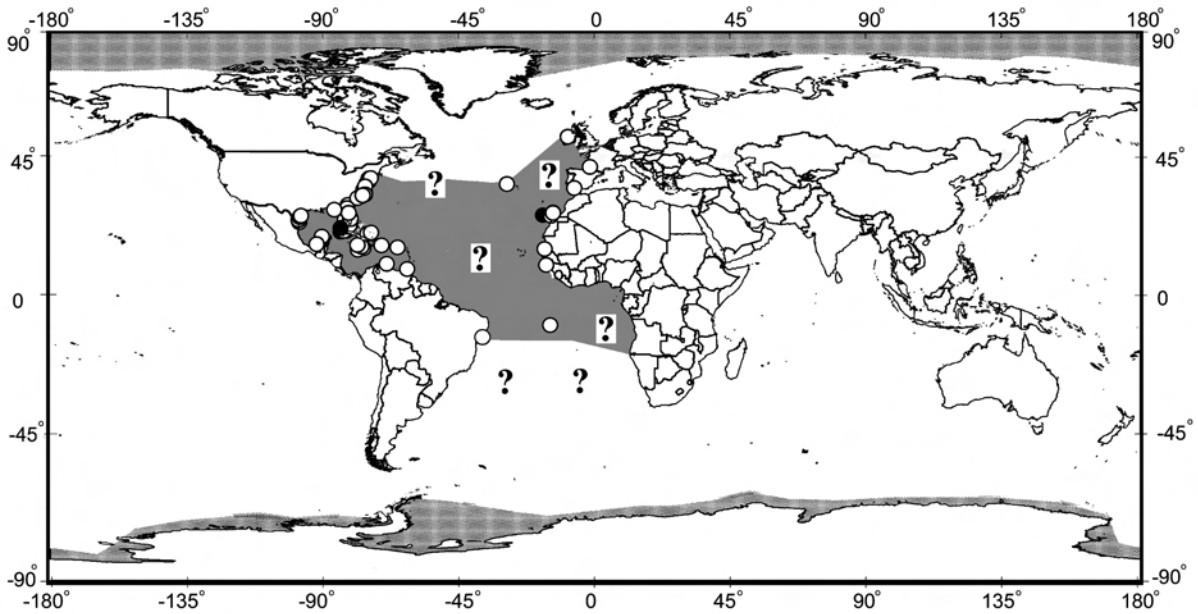
(f) Hubbs' beaked whale



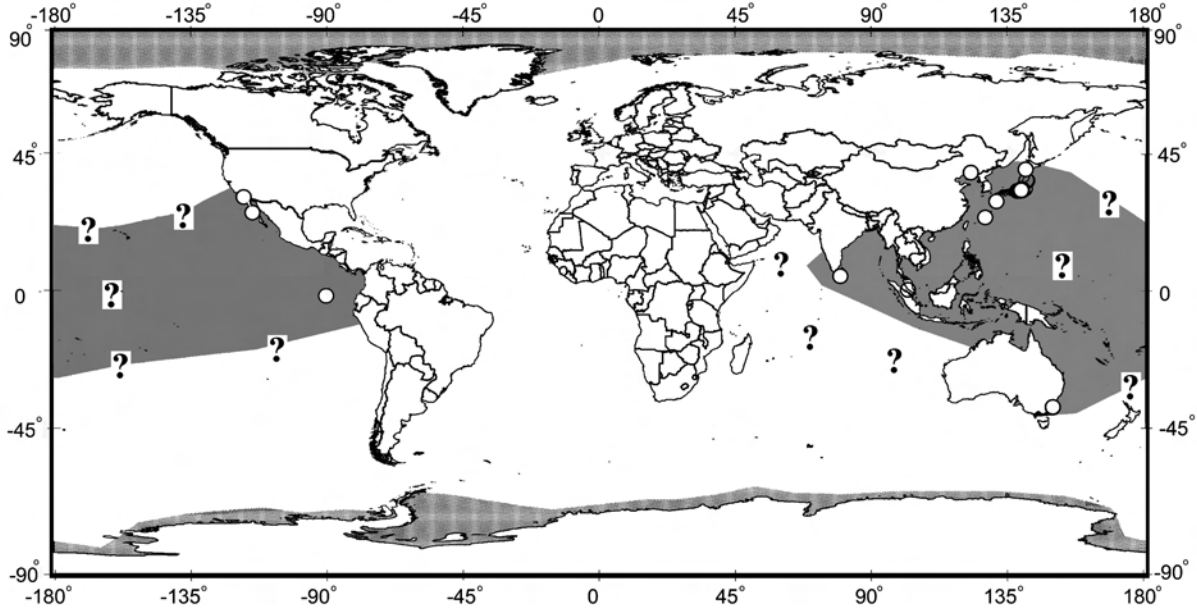
(g) Blainville's beaked whale



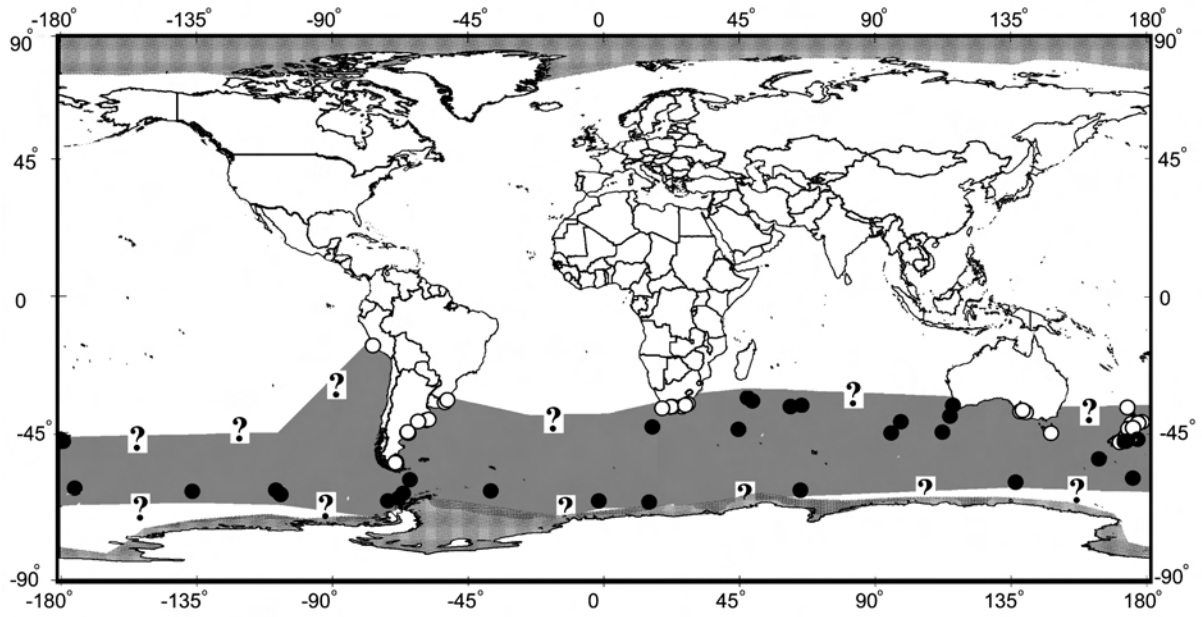
(h) Gervais' beaked whale



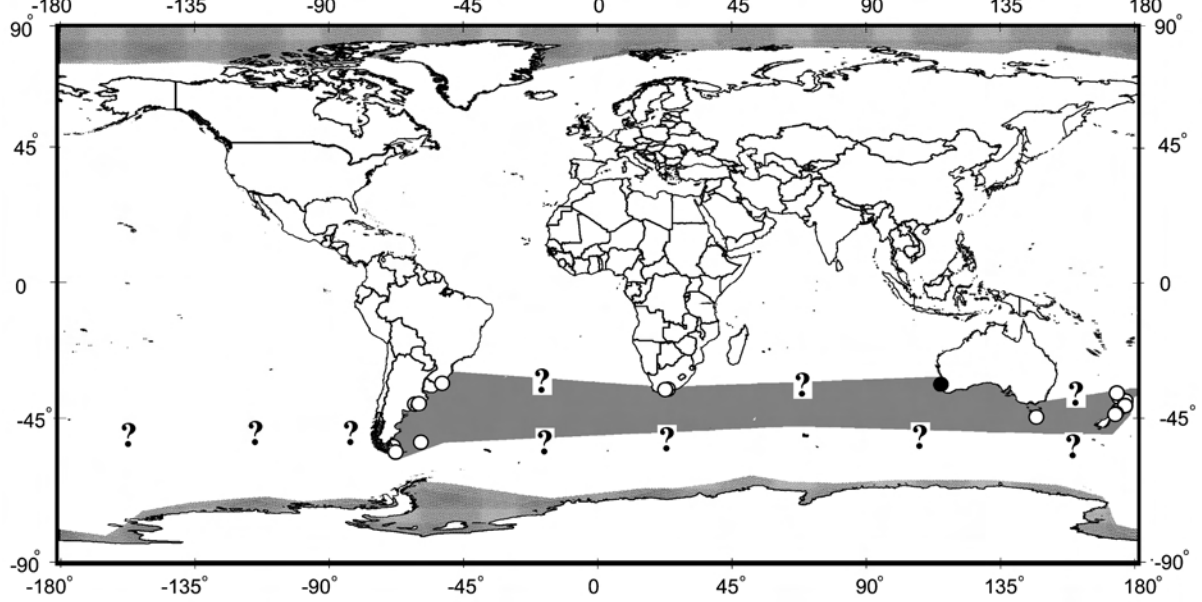
(i) Ginkgo-toothed beaked whale



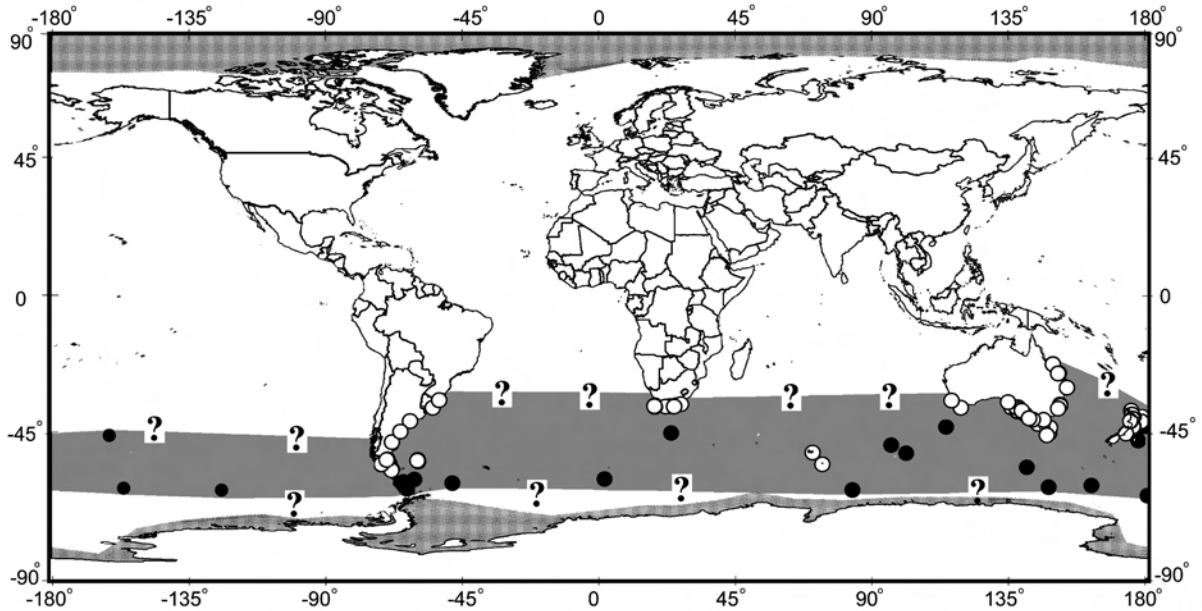
(j) Gray's beaked whale



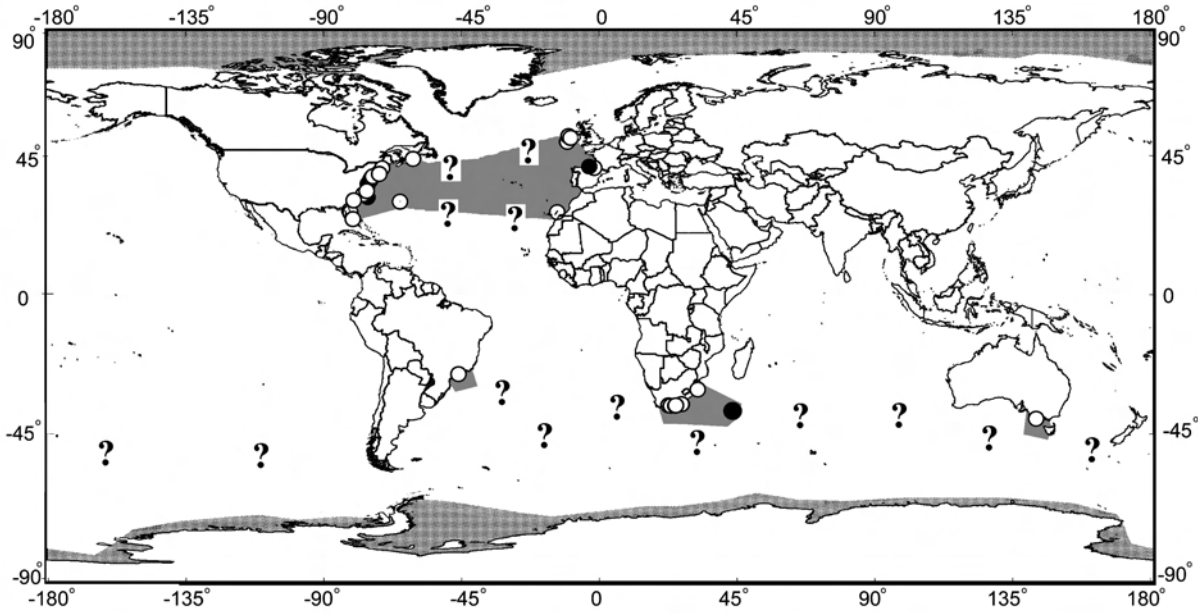
(k) Hector's beaked whale



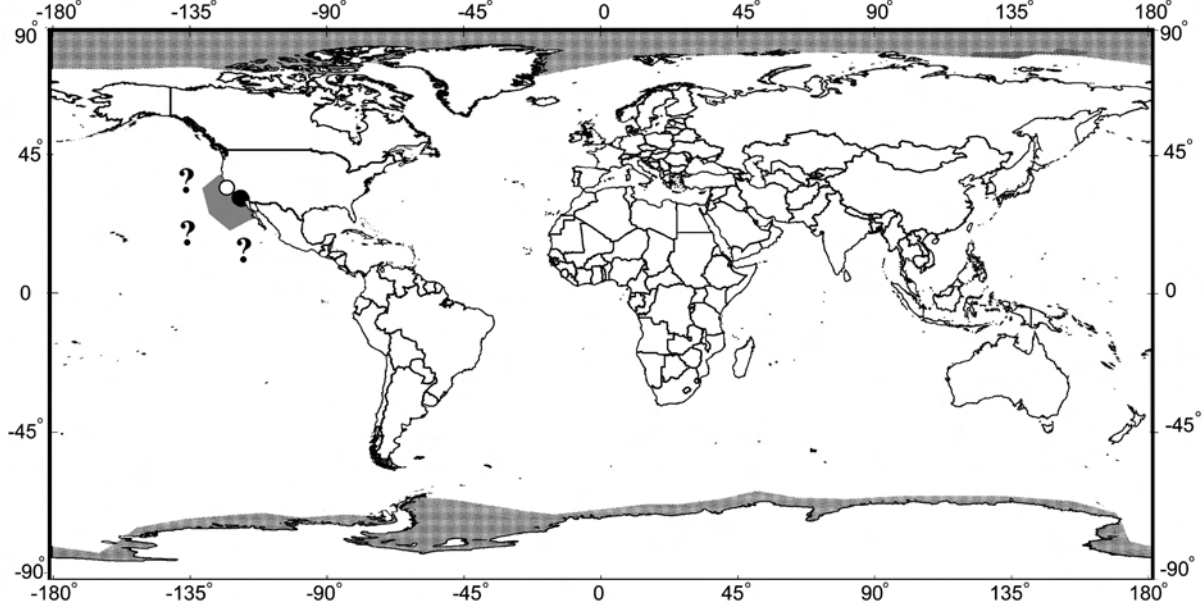
(l) Strap-toothed whale



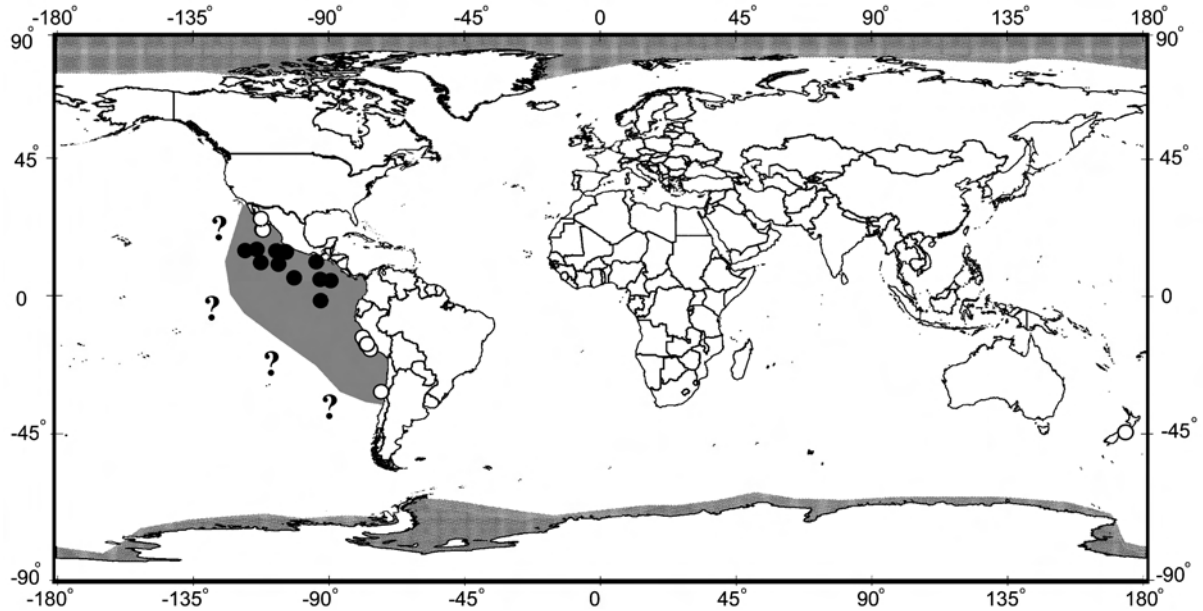
(m) True's beaked whale

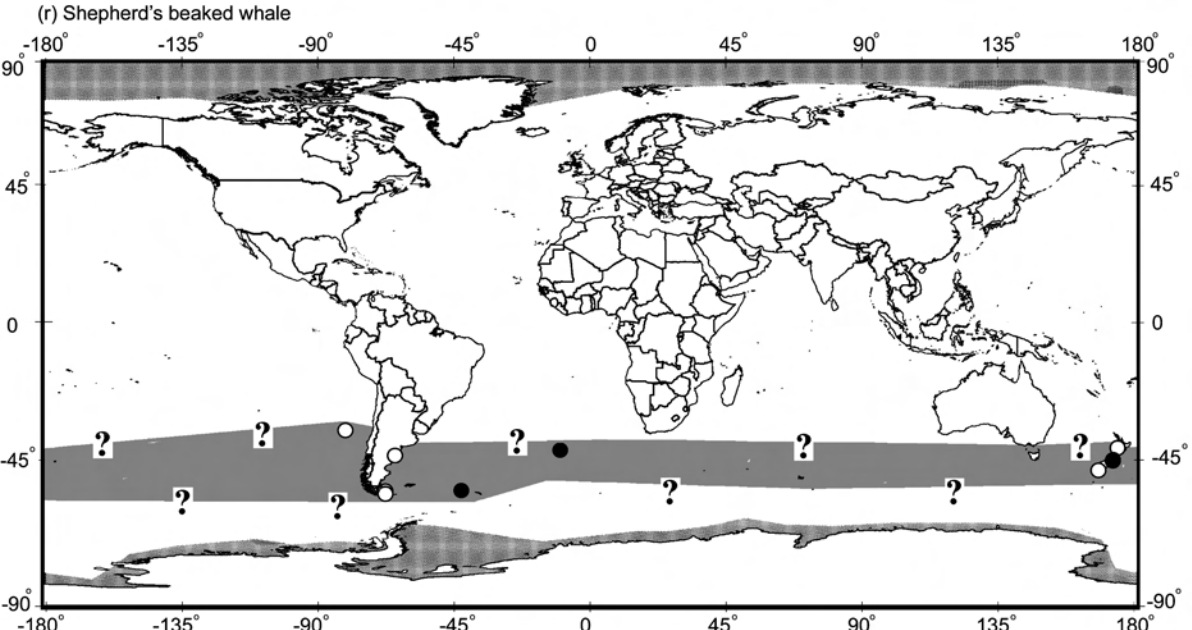
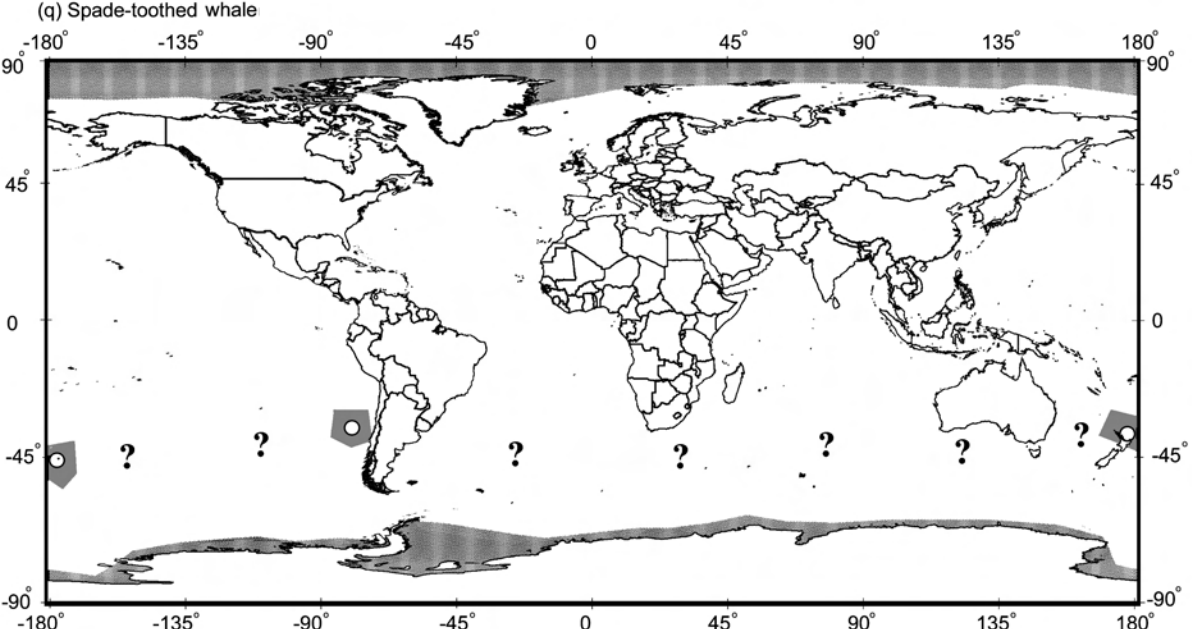
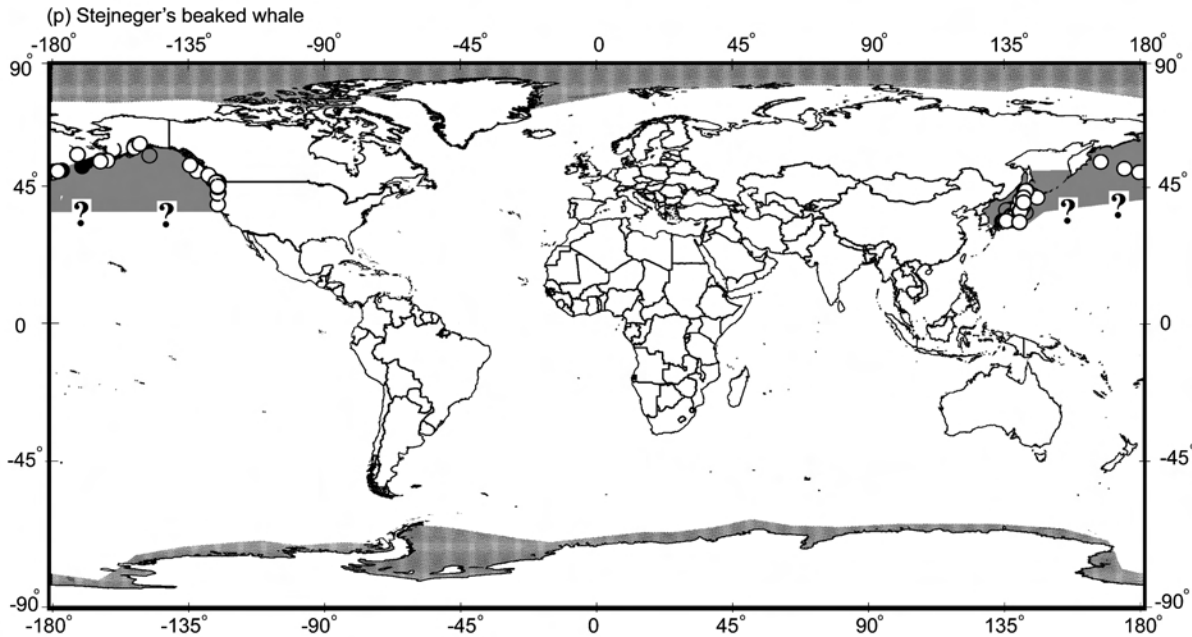


(n) Perrin's beaked whale



(o) Pygmy beaked whale





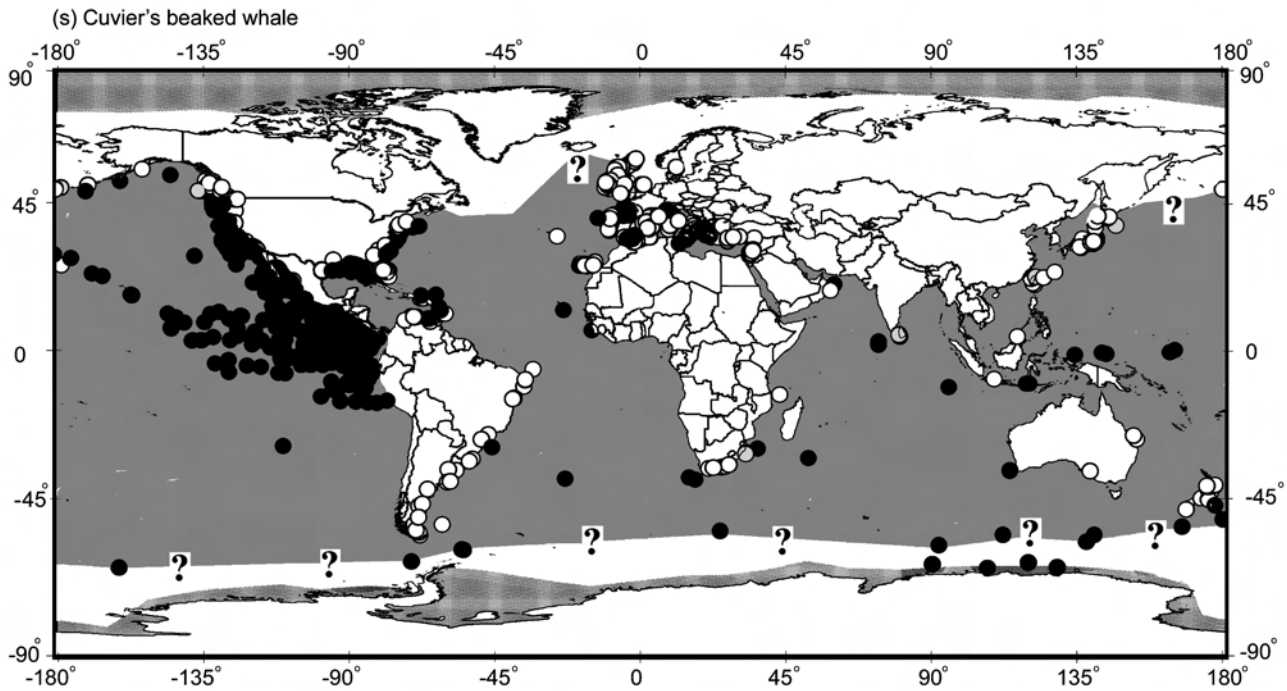


Fig. 2. Known and inferred distributions of beaked whales by species. Shaded areas indicate inferred distribution, ? indicates probable but unconfirmed areas/limits of occurrence. Stippled area indicates average minimum ice cover. Circles represent known records for which positions were available. Black circles – sightings; white circles – strandings; grey circles – other/unknown record types. PLEASE NOTE: Plotted records originate from a number of sources and are NOT corrected to take into account differences in levels of effort between different areas. Therefore, the densities of plotted at-sea sightings ARE NOT representative of the actual densities of these species NOR is absence of records indicative of a lack of occurrence at a specific location. (a) Arnoux's beaked whale (Southern Hemisphere) and Baird's beaked whale (North Pacific); (b) The northern bottlenose whale (North Atlantic) and the southern bottlenose whale (Southern Hemisphere). For northern bottlenose whales, main areas where this species was killed by whalers are marked with a black box (extent taken from Benjaminsen 1972); (c) Longman's beaked whale; (d) Sowerby's beaked whale; (e) Andrew's beaked whale; (f) Hubbs' beaked whale; (g) Blainville's beaked whale; (h) Gervais' beaked whale; (i) The ginkgo-toothed beaked whale; (j) Gray's beaked whale; (k) Hector's beaked whale; (l) strap-toothed whale; (m) True's beaked whale; (n) Perrin's beaked whale; (o) pygmy beaked whale; (p) Stejneger's beaked whale; (q) The spade-toothed whale; (r) Shepherd's beaked whale; (s) Cuvier's beaked whale.

(*Indopacetus pacificus*), a species for which the external morphology has only recently become known (Dalebout *et al.*, 2003).

GENUS HYPEROODON

Northern bottlenose whale (*Hyperoodon ampullatus*)

This species is endemic to the North Atlantic Ocean. It has been recorded from sightings and whaling data as far north as the Davis Strait, Iceland and the Norwegian Sea, south to the northeastern USA, the Azores and the western Mediterranean and from a stranding in the Canaries (Mitchell and Kozicki, 1975; Christensen *et al.*, 1977; 1992; Benjaminsen and Christensen, 1979; Clarke, 1981; Vonk and Martel, 1989; Reeves *et al.*, 1993; Dalebout *et al.*, 2001; Leal *et al.*, 2004; Cañadas, pers. comm.) (Fig. 2b). Although strandings have been recorded in the North and Baltic Seas (e.g. Fraser, 1953; Aguayo L, 1978; Kinze, 1995), these waters are generally too shallow for northern bottlenose whales. In fact, the North Sea may act as a trap for oceanic cetaceans, such as northern bottlenose whales and other beaked whales, as they migrate southward from higher-latitude areas such as the Norwegian Sea (Smeenk, 1997; MacLeod, 2000).

Southern bottlenose whale (*H. planifrons*)

Southern bottlenose whales have a circumpolar distribution throughout the Southern Hemisphere, with strandings as far north as southern Brazil (at 33.7°S – Gianuca and Castello, 1976), South Africa (Sekiguchi *et al.*, 1993) north-western Australia (at 20.6°S – Flower, 1882), south-eastern Australia (34.3°S – Hale, 1931), and northern New Zealand (37.7°S –

Gianuca and Castello, 1976) and sightings off central Chile (sighting at 31.2°S – Clarke *et al.*, 1978) and off the west coast of South Africa (31.2°S – IWC, unpublished data). Observations, either sightings or whaling records, have been made at sea off South Africa, Chile, around the Falkland Islands and throughout Antarctic waters as far south as the ice edge (Clarke *et al.*, 1978; Kasamatsu *et al.*, 1988; White *et al.*, 2002; IWC, unpublished data) (Fig. 2b). Most at-sea records are from 57-70°S, however this may be due to higher levels of research effort at these latitudes. The southern bottlenose whale appears to be one of the most abundant beaked whales and indeed one of the most abundant cetacean species in Antarctic waters (Kasamatsu and Joyce, 1995). It is worth noting that two specimens at the northern end of this species range in South Africa originally identified as southern bottlenose whales have since been re-identified as Longman's beaked whales (Dalebout *et al.*, 2003).

GENUS INDOPACETUS

Longman's beaked whale (*I. pacificus*)

Very poorly known, this is the only species in the genus *Indopacetus*. Until recently it was known from only two skulls, one from Queensland, Australia (Longman, 1926), and another from Somalia (Azzaroli, 1968). However, additional specimens have been identified from South Africa, the Maldives and Japan, providing the first description of the species' external morphology (Press Release, National Museum of Science, Tokyo, 25th December 2002; Dalebout *et al.*, 2003). This has given weight to the suggestion by Pitman *et al.* (1999) that a

number of sightings of unidentified beaked whales in the tropical Indo-Pacific may have been of this species. Those sightings occurred off the coast of Mexico, from the eastern tropical Pacific to the western Pacific and into the Indian Ocean all the way to eastern Africa (Fig. 2c). These sightings were made in surface water temperatures of 21–31°C, with most of them in waters warmer than 26°C (Pitman *et al.*, 1999). Pitman *et al.* (1999) suggested that Longman's beaked whale is more common in the western than the eastern Pacific. To date, this species has not been recorded in the Atlantic Ocean.

GENUS *MESOPLODON*

Sowerby's beaked whale (*M. bidens*)

This species is endemic to the North Atlantic and has a well described distribution due to its occurrence in the waters off North America and Europe. It has been sighted at 71.5°N in the Norwegian Sea (Carlström *et al.*, 1997) and strandings have been documented in Iceland and in Double Mer, Labrador, Canada (Lien and Barry, 1990). The southernmost records are strandings in Madeira in the east (Maul and Sergeant, 1977), the Azores in the mid-Atlantic (Reiner, 1986) and Port Saint Jose, on the Gulf of Mexico coast of Florida, USA (Bonde and O'Shea, 1989) in the west (Fig. 2d). The majority of stranding records are from northern Europe, particularly around the British coasts and in other countries bordering the North Sea (Mead, 1989a), with some also in the Baltic Sea (e.g. Aguayo L, 1978). However, the North and Baltic Seas are not thought to be areas of regular occurrence (MacLeod, 2000). There are fewer records from the western than the eastern Atlantic. All but one stranding (from the Gulf of Mexico coast of Florida, USA) have occurred between Labrador and New England (Bonde and O'Shea, 1989). Sowerby's beaked whale was the principal *Mesoplodon* species killed in the former large-pelagic driftnet fishery along the southern edge of Georges Bank (NOAA Fisheries, NEFSC, unpublished data). The Florida specimen is generally considered to have been a stray and the species is not thought to inhabit the Gulf of Mexico (Bonde and O'Shea, 1989; Jefferson and Schiro, 1997). There is some debate as to whether Sowerby's beaked whale occurs in the Mediterranean Sea (Mead, 1989a) but Van Bree (1975) found no evidence to support their presence in this area. However, Frantzis *et al.* (2003) reported a dead adult male *Mesoplodon* floating two miles off Cape Tainaro (36.4°N, 22.6°E) off the southern coast of Greece. The description, including the position of a large pair of teeth approximately in the middle of the lower jaw, is consistent with the characteristics of an adult male Sowerby's beaked whale (Frantzis *et al.*, 2003). However, as with the Florida specimen, this animal is most likely to represent a stray individual and not a regular occurrence in this area.

Andrews' beaked whale (*M. bowdoini*)

Andrews' beaked whale is known from 35 records, all of which are from strandings (Baker, 2001). Of these, 21 come from New Zealand and its surrounding islands. Of the remaining 14 records, most come from the southern coasts of Australia, with two from Tristan da Cunha and two from the Falkland Islands (Fig. 2e). There is also an additional record from Tierra del Fuego (N. Goodall, pers. comm.). These records range in latitude from 35.2°S (western Australia) south to 54.5°S (Macquarie Island). Baker (2001) surmised from these records that the species has a

circumpolar distribution north of the Antarctic Convergence to 32°S. However, as Baker (2001) emphasised, there is a gap in the distribution from Chatham Island (176.57°W) east to the South American Coast (approximately 66°W in Tierra del Fuego) that may either represent a real break in distribution, or only reflect a general shortage of cetacean records for this part of the world.

Hubbs' beaked whale (*M. carlhubbsi*)

This species is endemic to the North Pacific, with most records consisting of strandings from the western seaboard of North America. The strandings ranged from 54.3–32.7°N (Mead *et al.*, 1988; Willis and Baird, 1998). A small number of stranded animals have been recorded on the Pacific coast of Japan, 41.7°N–35.0°N (Marine Mammal Database, National Museum of Science, Tokyo) (Fig. 2f). These records suggest a pan-North Pacific distribution, at least at these latitudes, although no records are available from the central North Pacific and it is possible that separate western and eastern populations exist. Mead *et al.* (1982) suggested that the distribution of Hubbs' beaked whale is related to the deep sub-Arctic current system.

Blainville's beaked whale (*M. densirostris*)

Blainville's beaked whale is the most widely distributed *Mesoplodon* species. Although it has not been recorded in some areas, it is thought to have a continuous distribution throughout the tropical, sub-tropical and warm-temperate waters of the world's oceans, with occasional occurrences in cold-temperate areas (Fig. 2g). The only apparent exception is the eastern Mediterranean, where it has yet to be recorded. In the North Atlantic, strandings have been recorded in Iceland, south to the Canaries in the east and Puerto Rico and into the Gulf of Mexico in the west (Mead, 1989a; Ritter and Brederlau, 1999; Rosario-Delestre *et al.*, 1999; A. Petersen, unpublished report). In the South Atlantic, strandings have been recorded in Brazil (Lichter, 1986) and South Africa (Ross, 1984). It is presumed that the distribution is continuous across the equator in the North Atlantic, particularly in the light of cross-equatorial distributions in other oceans, but this is as yet unconfirmed. In the Indian Ocean, there have been strandings off South Africa (Ross, 1984), the Seychelles (Besharse, 1971), and Mauritius (Michel and van Bree, 1976) and the species has been taken accidentally by fisheries off Sri Lanka (Ilangakoon, 2002) and sighted in the Maldives (Ballance *et al.*, 2001) and west of Australia (McCann, 1964). In the western Pacific, strandings have been recorded from Japan (Kasuya and Nishiwaki, 1971) to Tasmania, Australia (Guiler, 1966). In the central Pacific there have been strandings in Hawaii (Galbreath, 1963) and at Easter Island (Aguayo *et al.*, 1998), with sightings from the Society Islands (Gannier, 2000) and the Cook Islands (N. Hauser, pers. comm.). In the eastern Pacific strandings and sighting records range 37.3°N–41.5°S (Mead *et al.*, 1988; Pastene *et al.*, 1990; Pitman and Lynn, 2001).

Gervais' beaked whale (*M. europaeus*)

This species is endemic from the warm-temperate to tropical Atlantic (Fig. 2h). Strandings records range from Ireland (Berrow and Rogan, 1997) in the north, to southeast Brazil in the south (de Oliveira Santos *et al.*, 2004), with records from the Gulf of Mexico (e.g. Reynoso and Pimienta, 1989), the Caribbean (e.g. Debrot and Barros, 1994), the Canaries (e.g. Martin *et al.*, 1990), Mauritania (Robineau and Vely, 1993) and Guinea-Bissau (Reiner, 1980). The distribution in the South Atlantic remains unclear, but Gervais' beaked

whales have stranded at Ascension Island (Mead, 1989a; White, pers. comm.) and in Brazil (23.97°S – de Oliveira Santos *et al.*, 2004). Based on its distribution in the North Atlantic, it would be expected that it occurs as far south as Uruguay in the west and Angola in the east. However, further data are needed to confirm or deny this possible distribution.

Ginkgo-toothed beaked whale (*M. ginkgodens*)

There are approximately 23 known records of the ginkgo-toothed beaked whale, all of which are from strandings and are restricted to the Pacific and Indian Oceans (Fig. 2i). Most records (15) are from Japan (Nishiwaki and Kamiya, 1958; Nishiwaki *et al.*, 1972; Marine Mammal Database, National Museum of Science, Tokyo). Strandings have also been recorded in China (Mead *et al.*, 1988), Taiwan (Nishiwaki *et al.*, 1972), Malaysia (Mead, 1989a), Guam (K. Robertson, pers. comm.), Sri Lanka (Deraniyagala, 1963), south-eastern Australia (Tidemann, 1980; Mead, 1989a), California (Moore and Gilmore, 1965), Mexico (Mead, 1989a) and the Galapagos Islands (Palacios, 1996). These locations range from 42.0°N–36.4°S in the western Pacific and 32.9°N–00.3°N in the eastern Pacific. The extent to which this reflects the actual distribution of this species is unknown and its range could include other areas of the Pacific and Indian Oceans. For example, Ballance and Pitman (1998) reported possible sightings in the Arabian Sea. However, this species is almost impossible to identify with certainty at sea and there have been as yet no confirmed sightings.

Gray's beaked whale (*M. grayi*)

Gray's beaked whale has been recorded in the temperate South Atlantic and Indian Oceans, with additional records eastward into the Pacific as far as New Zealand and south to Antarctic waters where the distribution is circumpolar (Fig. 2j). Along the eastern coast of South America, Gray's beaked whale has stranded from the southern tip of Brazil (31.8°S – Pinedo *et al.*, 2002a), south to Tierra del Fuego (53.3°S – Goodall, 1978). Strandings have occurred as far north as 31.1°S in South African waters (Ross, 1984), 33.6°S in Australia (Gales *et al.*, 2002), 34.4°S in New Zealand (Mead, 1989a) and 13.8°S in Peru (Reyes, 1990). The record from Peru is significantly farther north than all other Southern Hemisphere records, which are south of 30°S, and may represent an extension of this species into lower latitudes along the western South American coast in the cooler waters of the Humboldt current. Gray's beaked whale has been seen close to the Antarctic Peninsula and other Antarctic coastlines in summer months (IWC, unpublished data). A single stranding was reported from the Dutch coast in the North Sea (Boschma, 1951). Geographically, this is so far from all other records of this species that it is presumed to be extralimital rather than representing the normal presence of this species in the North Atlantic.

Hector's beaked whale (*M. hectori*)

Hector's beaked whale is known of from 25 published strandings, mostly from the southeast coast of South America or New Zealand (Fig. 2k). In South America, the species has been recorded from southern Brazil (32.0°S – Zerbini and Secchi, 2001), to Tierra del Fuego (55.1°S – Siefeld, 1979), while in New Zealand records range from 35.2°S–42.4°S (Mead, 1981; 1989a). Additional records come from Tasmania (Guiler, 1967), Western Australia

(Gales *et al.*, 2002) and South Africa (Ross, 1984), giving a range of 68.5°W–176.9°E. There are no records from the southern Pacific between New Zealand and South America. Whether this represents a break in distribution or a lack of cetological effort in this area is unknown. Stranded animals previously identified as Hector's beaked whale from the eastern North Pacific (e.g. Mead, 1981; 1989a) have now been reclassified as Perrin's beaked whale (*M. perrini*) and Hector's beaked whale is no longer thought to occur in the Northern Hemisphere (Dalebout *et al.*, 2002).

Strap-toothed whale (*M. layardii*)

This species is endemic to the Southern Hemisphere and has a circumpolar distribution (Fig. 2l). It has stranded in southern Brazil (32.1°S – Pinedo *et al.*, 2002b), Uruguay (Lichter, 1986), Argentina (Goodall, 1978), the Falkland Islands (Lichter, 1986), South Africa (33.48°S – Ross, 1984), Kerguelen Island (Robineau, 1989), Heard Island (Guiler *et al.*, 1987), the southern coast of Australia and as far north as 20.3°S (Dixon, 1980; Paterson and van Dyck, 1990) and New Zealand (Mead, 1989a). With the exception of records in Western Australia, all known records are south of 32°S. The southernmost record is a sighting at 63.3°S (IWC, unpublished data). While it is assumed here that all reported records are accurately identified, it is possible that some older osteological records previously identified as strap-toothed whales are actually referable to the spade-toothed whale (*M. traversii*), a species which is morphologically similar and which has recently been classified as distinct (van Helden *et al.*, 2002).

True's beaked whale (*M. mirus*)

True's beaked whale is apparently the only species of *Mesoplodon* with isolated populations in separate hemispheres (Fig. 2m). This species has been recorded only in the temperate North Atlantic and South America, southern Africa and southern Australia. In the North Atlantic, it apparently occurs only in temperate waters and possibly only in warm temperate waters. In the western Atlantic, stranded animals have been recorded from Nova Scotia (46.3°N) to Florida (26.7°N – Mead *et al.*, 1988), with additional records along the length of the eastern seaboard (e.g. True, 1913) and in Bermuda (MacLeod, 2000). There have also been sightings off the northeast US coast (e.g. Tove, 1995). In the eastern Atlantic, the species has stranded from Ireland (53.7°N – Berrow and Rogan, 1997) south to the Canaries (28.9°N – Vonk and Martel, 1988), with sightings in the Bay of Biscay (Weir *et al.*, 2004). As yet, True's beaked whale has not been recorded in the Gulf of Mexico, the Caribbean, the Mediterranean or farther south in the North Atlantic. In the Southern Hemisphere, this species has stranded in southern Brazil (de Souza *et al.*, 2004), on the Indian Ocean coasts of South Africa at around 34°S, 22.6–25.3°E (Ross, 1984) and in southern Australia at around 38.4°S (Dixon and Frigo, 1994). Sightings have been recorded at approximately 33°S, 44°E in the Indian Ocean off Madagascar. The full extent of the range of True's beaked whale in the Southern Hemisphere is currently unclear and it is worth noting that for other *Mesoplodon* species which were previously thought to have anti-tropical distributions (Andrews' beaked whale and Hector's beaked whale), it has since been discovered that the putative populations in separate hemispheres represent distinct species. Therefore, the possibility that the anti-tropical populations of True's beaked whales may represent distinct species needs to be investigated.

Perrin's beaked whale (*M. perrini*)

Perrin's beaked whale was first described in 2002 through genetic analysis of skeletal material originally identified as Hector's beaked whale, a species now known to be restricted to the Southern Hemisphere (Dalebout *et al.*, 2002). Currently, there are five confirmed records of this species, all of stranded animals (Fig. 2n). All of these records are from the waters of the state of California, USA (Dalebout *et al.*, 2002). Whether this species is restricted to these waters or actually has a more widespread distribution is unknown.

Pygmy beaked whale (*M. peruvianus*)

The pygmy beaked whale was first described in 1991 from bycaught and stranded specimens from Peru (Reyes *et al.*, 1991). Since then there have been identified strandings along the coasts of North and South America 29.2°S-27.9°N (Reyes *et al.*, 1991; Pitman and Lynn, 2001) (Fig. 2o). Sightings at sea have been difficult to interpret due to possible mis-identifications of living animals based on descriptions of stranded ones, particularly in relation to pigmentation patterns. However, prior to the description of the pygmy beaked whale, Pitman *et al.* (1987) had reported sightings of an unidentified beaked whale in the eastern tropical Pacific and suggested it may represent an undescribed species referred to as '*Mesoplodon sp. A*' (Pitman *et al.*, 1987). Pitman and Lynn (2001) provided evidence that the pygmy beaked whale and *Mesoplodon sp. A* are in fact the same species. Based on the sightings of *Mesoplodon sp. A*, Pitman and Lynn (2001) concluded that the pygmy beaked whale is probably endemic to the eastern tropical Pacific. A recent stranding record from New Zealand (Baker and van Helden, 1999) may represent either an extralimital stray or be indicative of a wider distribution.

Stejneger's beaked whale (*M. stejnegeri*)

Stejneger's beaked whale is endemic to the northern North Pacific where it is found in cold-temperate and sub-polar waters (Fig. 2p). It has stranded as far north as the Gulf of Alaska (55.0°N – Willis and Baird, 1998), the Aleutian Islands (around 52°N – Mead, 1989a; Walker and Hanson, 1999) and northern Russia (57.4°N – Moore, 1963) and been sighted around the Aleutian Islands (51.8°N – Loughlin *et al.*, 1982). The southernmost records are strandings from central California (36.6°N – Henshaw *et al.*, 1997) and the southern coast of Japan (35.1°N – Marine Mammal Database, National Museum of Science, Tokyo). The southern limit in the central Pacific is unknown.

Spade-toothed beaked whale (*M. traversii*)

The spade-toothed beaked whale is currently known of from three stranding records in the south-western Pacific; in New Zealand, the Chatham Islands and the Juan Fernandez Archipelago (van Helden *et al.*, 2002) (Fig. 2q). These three records suggest a Southern Hemisphere distribution in temperate waters approximately 33-44°S in the South Pacific. Morphological similarities between the spade-toothed and strap-toothed whales may mean that some osteological records assigned to the latter species actually represent the former and an investigation of this possibility may alter the perceived distributions of these two species.

GENUS *TASMACETUS***Shepherd's beaked whale (*T. shepherdii*)**

This species is known only from a small number of strandings in New Zealand (Oliver, 1937; Sorensen, 1940; Smith, 1965; Mead, 1989b), the Juan Fernandez

Archipelago (Brownell *et al.*, 1976), Tierra del Fuego (Goodall, 1978) and Peninsula Valdez in central Argentina (Mead and Payne, 1975) and Tristan da Cunha, and a few probable or possible sightings at sea. A probable sighting was reported by Laughlin (1996) at approximately 53°45'S, 42°30'W in the western South Atlantic. Possible sightings have been reported near Christchurch, New Zealand (Watkins, 1976) and at 40.32°S, 9.88°W (Pym, pers. comm.). From these records it has been presumed that this species has a circumpolar distribution in the colder waters of the Southern Hemisphere, but the records are sufficiently sparse that this should be treated as unconfirmed (Fig. 2r).

GENUS *ZIPHIUS***Cuvier's beaked whale (*Ziphius cavirostris*)**

This species is the most widely distributed beaked whale, with a cosmopolitan distribution throughout almost all temperate, sub-tropical and tropical waters of the world as well as sub-polar and even polar waters in some areas (Fig. 2s). It is the only beaked whale regularly recorded in the eastern Mediterranean Sea (e.g. Politi *et al.*, 1994). In the Atlantic Ocean, Cuvier's beaked whales have stranded as far north as northeast USA (Backus and Schevill, 1961), Iceland (Petersen, pers. comm.) and northern UK (Fraser, 1953; MacLeod *et al.*, 2004), south to Tierra del Fuego (Goodall, 1978), the Falkland Islands (Lichter, 1986) and South Africa (Ross, 1984). A sighting was reported 37.5°S in the central South Atlantic (Findlay *et al.*, 1992). In the Indian Ocean, animals have stranded in South Africa (Ross, 1984), Oman (Alling, 1986), the Comoros (Robineau, 1975), Sri Lanka (Deraniyagala, 1965) and Indonesia (Dammerman, 1926) and been sighted in the Arabian Sea (Ballance and Pitman, 1998), the Maldives (Ballance *et al.*, 2001), and eastern Australia (IWC, unpublished data). In the western Pacific, records range from Japan in the north to southern New Zealand in the south (Fordyce *et al.*, 1979; Marine Mammal Database, National Museum of Science, Tokyo). In the eastern Pacific, this species has stranded as far north as the Aleutians (Kenyon, 1961) and Alaska (Foster and Hare, 1990) and been sighted as far south as 27.3°S (Aguayo *et al.*, 1998). It has also been sighted in the Southern Ocean as far south as 64.9°S (Kasamatsu *et al.*, 1988; IWC, unpublished data).

CONCLUDING REMARKS

For almost every beaked whale species, there are areas where it is suspected or presumed to occur, but where it has not as yet been recorded. In particular, data are generally scarce for offshore areas away from the continental shelf. Except in the eastern tropical Pacific, little systematic research has been conducted in such areas and even opportunistic records are rare. In other regions, data are not available even for nearer-shore areas, including the continental slope, due to a generally low level of cetological research or monitoring. This is true, for example, in the eastern tropical Atlantic, where little information is available on the occurrence of any cetacean species. Therefore, it can be difficult to produce, with any certainty, a complete beaked whale species list for specific locations. Such lists can be an important first step in the assessment

and mitigation of potential anthropogenic impacts on beaked whales, particularly if different species are affected by anthropogenic activities to different degrees or in different ways. The inferred ranges outlined here provide a starting point for understanding which species are likely to occur at a given location, but further work is required to clarify and evaluate these inferred ranges. In addition, we need to understand whether and how these distributions may change in the future, e.g. with respect to global climate change (Harwood, 2001).

The best way to clarify the distribution of beaked whale species, and to monitor changes in distribution over time, is to conduct dedicated sightings surveys on a regular and continuous basis. However, to do this effectively at a global level would be expensive, and it would take many years to achieve a reasonable level of baseline coverage. Therefore, in the short term, and with less cost, it is important that full advantage is taken of currently available data and specimens, as well as existing opportunities to collect new information. At least three approaches should be considered. Firstly, improvements are needed in methods for accurately identifying beaked whales, whether dead (e.g. stranded, in fish markets, bycaught etc.) or alive. It is now possible to identify beaked whales from their DNA, including DNA extracted from biopsies, stranded animals and osteological specimens in museums (e.g. Dalebout *et al.*, 2002; 2003). Genetic identification should be applied when there is a possibility of confusion between morphologically similar but poorly known species to help clarify species ranges. In addition, more effort should be made to ensure that tissue samples are procured from as many future strandings, bycaught or killed animals as possible, as well as sightings (where feasible), to help to ensure that animals are identified correctly. In terms of sightings data, a definitive guide to field marks of species would prove useful, particularly for species that are more difficult to identify in the field or about which less is known. Such a guide would prove invaluable for the training purpose and for observers on general cetacean sightings cruises to allow beaked whales to be identified to species level rather than simply noted as an unidentified beaked whale species.

Secondly, survey effort should be directed at areas where little research has previously been conducted. In particular, where available, ‘platforms of opportunity’ can be used to achieve survey coverage of such areas at relatively low costs. If possible, networks of opportunistic surveys should be arranged, using a standardised methodology, to enable the most to be achieved from such surveys.

Finally, the underlying factors that determine species ranges need to be investigated. Once our knowledge of these has improved, it may be possible to predict the occurrence of species in locations where little direct information exists and to predict how ranges may change in response to environmental flux. Once species ranges have been defined, it may be possible to predict the finer-scaled distribution of individuals using models of habitat preferences and of factors related to local variations in species density and/or abundance.

In summary, there are still many gaps in our knowledge of beaked whale distribution that need to be resolved to allow potential impacts on beaked whales around the world to be adequately assessed and mitigated. While these gaps may not be filled in the near future, by making the most of available data and future data collection opportunities it may be possible to expand our knowledge of the distribution of beaked whale species in the near future at relatively little cost.

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