Final report for trans-Atlantic research passages between the UK and USA via the Azores and Iceland, conducted from R/V *Song of the Whale* 26 March to 28 September 2012

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EXECUTIVE SUMMARY

During the summer and autumn of 2012, the IFAW research vessel *Song of the Whale* (SOTW) conducted research projects in the Azores, Gulf of Maine, USA and Iceland with a focus on blue whales, right whales, beaked whales, humpback whales and minke whales respectively. The following report summarises the four passages between these study areas during which acoustic and visual surveys were carried out: these include a passage from the UK to the Azores (26 March - 8 April), a passage from the Azores to USA via Bermuda (6 May – 1 June), USA to Iceland via Laurentian Channel and Cape Farewell Ground (7 – 28 July) and Iceland to UK (20 – 28 September). The *Song of the Whale* team conducted a total 66 days of survey effort during these passages during which 16 species of cetaceans were observed: blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), sei whale (*B. borealis*), humpback whale (*Megaptera novaeangliae*), minke whale (*B. acutorostrata*), sperm whale (*Physeter macrocephalus*), Sowerby's beaked whale (*Mesoplodon bidens*), northern bottlenose whale (*Hyperoodon ampullatus*), pilot whale (*Globicephala* sp.), white-sided dolphin (*Lagenorhynchus acutus*), white-beaked dolphin (*L. albirostris*), short-beaked common dolphin (*Delphinus delphis*), Atlantic spotted dolphin (*Stenella frontalis*), bottlenose dolphin *(Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*) and harbour porpoise (*Phocoena phocoena*). Harbour porpoises were detected acoustically in waters up to 2000 m deep over the Mid-Atlantic and Iceland-Faroe Ridges. The most commonly encountered species overall during the offshore passages was the common dolphin. Humpback whales were frequently encountered off the Gulf of Maine and Newfoundland, and sei and fin whales were encountered over the Mid-Atlantic Ridge. An aggregation of blue whales was observed in the Laurentian Channel (which extends from the St. Lawrence and Saguenay Rivers to the Newfoundland shelf edge) and at least two species of beaked whales encountered in the Gully MPA, a submarine canyon off Nova Scotia. There were no acoustic or visual detections of right whales made; this species was of particular interest while transiting through the former whaling grounds off SE Greenland, where right whale vocalisations have been detected with remote static recorders in the past decade.

1. INTRODUCTION

R/V *Song of the Whale* (SOTW) is a research vessel owned by the International Fund for Animal Welfare's (IFAW) and managed by Marine Conservation Research (MCR). The SOTW team has conducted research previously in both the Azores in the late 1980s to the 1990s and in 2008 and North America in the late 1990s, 2000, 2001 and 2005. The team has also carried out research projects in Iceland previously in 2004 and 2006. Research passages between these areas provided the rare opportunity to collect additional data on cetaceans inhabiting the offshore waters of the mid-Atlantic and between Iceland and the UK which are scarcely surveyed.

The research passages described herein aimed to build upon existing research effort on the distribution, habitat and vocalisations of baleen and beaked whales by conducting visual and acoustic research in the waters off the Azores and across the Atlantic Ocean while en route from the Azores to the US and on to Iceland and finally the UK. Several key regions were surveyed including the New England seamounts chain, the Laurentian Channel, the Gully and Cape Farewell Grounds. The New England Seamounts and the Gully were surveyed in order to detect beaked whales, while The Laurentian Channel and Cape Farewell Grounds were surveyed primarily for blue and right

whales. The waters off Cape Farewell, east of southern Greenland were once a key whaling area for the now critically endangered North Atlantic right whales, however there have only been a couple of sightings in the past 50 years and few data exist on their recent abundance and distribution (Mellinger *et al.,* 2011).

2. METHODOLOGY

Four research passages were carried out amounting to a total 66 days of effort between: Ipswich, UK – Horta, Azores (26 March - 8 April); Horta – Boston, USA via Bermuda (6 May – 1 June); Boston – Reykjavik, Iceland via the Laurentian Channel and Cape Farewell grounds (7 – 28 July); Reykjavik – Ipswich (20 – 28 September). The voyage was conducted from the 21 m auxiliary-powered cutter-rigged sailing research vessel *Song of the Whale* under sail, motor or motor/sail. The speed was maintained between five and eight knots, the speed required to stream hydrophone arrays at depth while reducing cable strum.

2.1 Data collection

Visual data were collected by an observer positioned on a dedicated platform with an eye height of 5.5 m above sea level during daylight hours when Beaufort sea state was below four. In higher sea states, visual monitoring continued from deck. Observations were carried out by experienced observers on rotation in order to prevent fatigue. Sightings information including species, initial cue, number of animals and behaviour were entered directly into a database using IFAW's Logger 2010 software (www.marineconservationresearch.co.uk/downloads). Environmental and GPS data were logged automatically to the same database, including date, time, vessel position (latitude and longitude), sea surface temperature (°C) and wind speed (knots). Manual records of other environmental variables (such as Beaufort sea state, wave and swell height (m)) and survey effort (numbers and positions of observers) were made hourly.

Acoustic data was collected using two 400 m towed-hydrophone arrays. One array consisted of two low frequency elements for detecting baleen whale vocalizations while the other array had two broadband elements for detecting a wider spectrum of frequency vocalizations produced by dolphins, beaked whales and porpoises. Stereo recordings were made continuously using Pamguard (Passive Acoustic Monitoring Guardianship, www.pamguard.org) and written to disk as two-channel 16 bit wav files. Signals from the hydrophones passed through bespoke buffer boxes to an NI-6251 card, RME Fireface or NI-6356 data acquisition card to be sampled at 8 kHz, 192 or 500 kHz respectively. The 8 kHz recording system also incorporated a Behringer Ultracurve DEQ2496 to introduce a 4 kHz low-pass filter prior to signal digitisation in order to prevent aliasing. The buffer boxes provided variable frequency responses; however, the entire system was capable of detecting signals from 10 Hz to 200 kHz. For the bandwidths of interest for baleen whale vocalisations (10 to 800 Hz), beaked whale (25 to 50 kHz) and harbour porpoise (115 to 180 kHz) clicks, the response of the system was approximately flat.

Pamguard software was run, utilising Click Detector and Whistle and Moan Detector modules to detect odontocete click trains and frequency modulated whistles.

2.2 Baleen whales

Whenever possible, if a baleen whale was sighted, the vessel approached the animal in order to gather more detailed information such as species identification, number of animals and behaviour and to obtain high quality photo-identification pictures. If blue, fin and sei whales were encountered, photographs of the dorsal fin and / or flank (side mottling for blue whales and / or right jaw and chevron behind the head in the case of fin whales), were taken for photo-identification and subsequent matching. Blue whale images were compared to an Atlantic-wide photo-ID database in order to infer population identity where possible (Richard Sears and the Mingan Island Cetacean Study, Canada maintain the blue whale photo-id catalogue for the western North Atlantic).

Baleen whales, especially blue whales, produce very low frequency modulated (FM) calls and many automated software algorithms produce false detections due to low-frequency signals such as shipping noise. Continuous recordings were made for baleen whale calls which were re-analysed later to determine and classify detections. Right whales generally produce frequency modulated upsweeps in the 50-200 Hz range (Matthews *et al.*, 2001; Parks & Tyack, 2005; Mellinger *et al*., 2007, 2011) and the software package Call Seeker (see Gillespie, 2004) was utilised to detect right whale calls.

2.3 Beaked whales

Beaked whales are very difficult to detect by visual means due to their deep diving habits and inconspicuous nature; therefore priority was given to acoustic techniques for detecting their presence. As typical beaked whale clicks have the distinctive form of a relatively long duration (~200 µs) FM upsweep with dominant energy between 25 and 50 kHz (Johnson *et al*., 2004; Johnson *et al*., 2006; Gillespie *et al*., 2009), it is possible to detect and extract potential beaked whale clicks from background noise using click detection algorithms. Thus, acoustic signals were scanned continuously during the passage using a click detector module in Pamguard whereby sounds with significant energy (>8 dB above background noise) in the 25 to 50 kHz band were classified as potential beaked whale clicks (see Gillespie *et al*., 2009 for details). Any beaked whales encountered were photographed for species identification purposes where possible.

2.4 Harbour porpoise

Continuous stereo 500 kHz recordings were made during the passages from the USA to Iceland and Iceland to the UK via a SEICHE buffer box passing signals to a National Instruments USB-6251 sound card. Recordings were made using Pamguard and written to hard drive as two channel 16 bit wav files. As typical harbour porpoise clicks are distinctive high frequency, narrowband signals with a long duration (100 µs), a peak frequency of around 130 kHz, an inter-click interval of around 60 ms and a maximum source level of 172 dB re 1µPa pp @1m (see, for example, Møhl & Andersen, 1973; Akamatsu *et al*., 1994; Teilmann *et al*., 2002), it is possible to detect and extract potential harbour porpoise clicks from background noise using click detection algorithms. Thus, acoustic signals were monitored in real-time using a Pamguard click detector whereby sounds with significant energy (>8 dB above background noise) in the 100 to 150 kHz band were classified as potential harbour porpoise clicks.

3. RESULTS

A total of 1400 hours of effort was undertaken over almost 15,000 nautical miles of passage (see Table 1 for details).

Table 1. Summary of research effort during each passage.

Effort status	Nautical miles	Kilometres	Hours
UK to Azores 26 March - 8 April			
Passage	5	10	44
Passage + acoustic	743	1375	111
Passage + visual	32.1	59.5	05
Passage + acoustic + visual	455	843	65
With Animals	3.1	5.8	56
Total	1906	3529	284
Azores to USA 6 May – 1 June			
Passage	1403	2599	240
Passage + acoustic	75	139	12
Passage + visual	19	35	03
Passage + acoustic + visual	1	1	06
With Animals	0	0	00
Total	1498	2774	255
USA to Iceland 7 – 28 July			
Passage	105	195	20
Passage + acoustic	1702	3151	272
Passage + visual	62	114	9
Passage + acoustic + visual	1110	2057	171
With Animals	15	27	2
Total	2994	5544	474
Iceland to UK 20 – 28 September			
Passage	161	298	23
Passage + acoustic	1139	2209	177
Passage + visual	0	0	0
Passage + acoustic + visual	3	6	1
Total	1303	2513	201
Overall Total	**14,733**	**27,483**	**1,396**

The passages incorporated a range of habitats including coast, shelf, continental slope, abyssal plain and regions of heterogeneous bathymetry including the Mid-Atlantic Ridge and numerous seamounts (Figure 1).

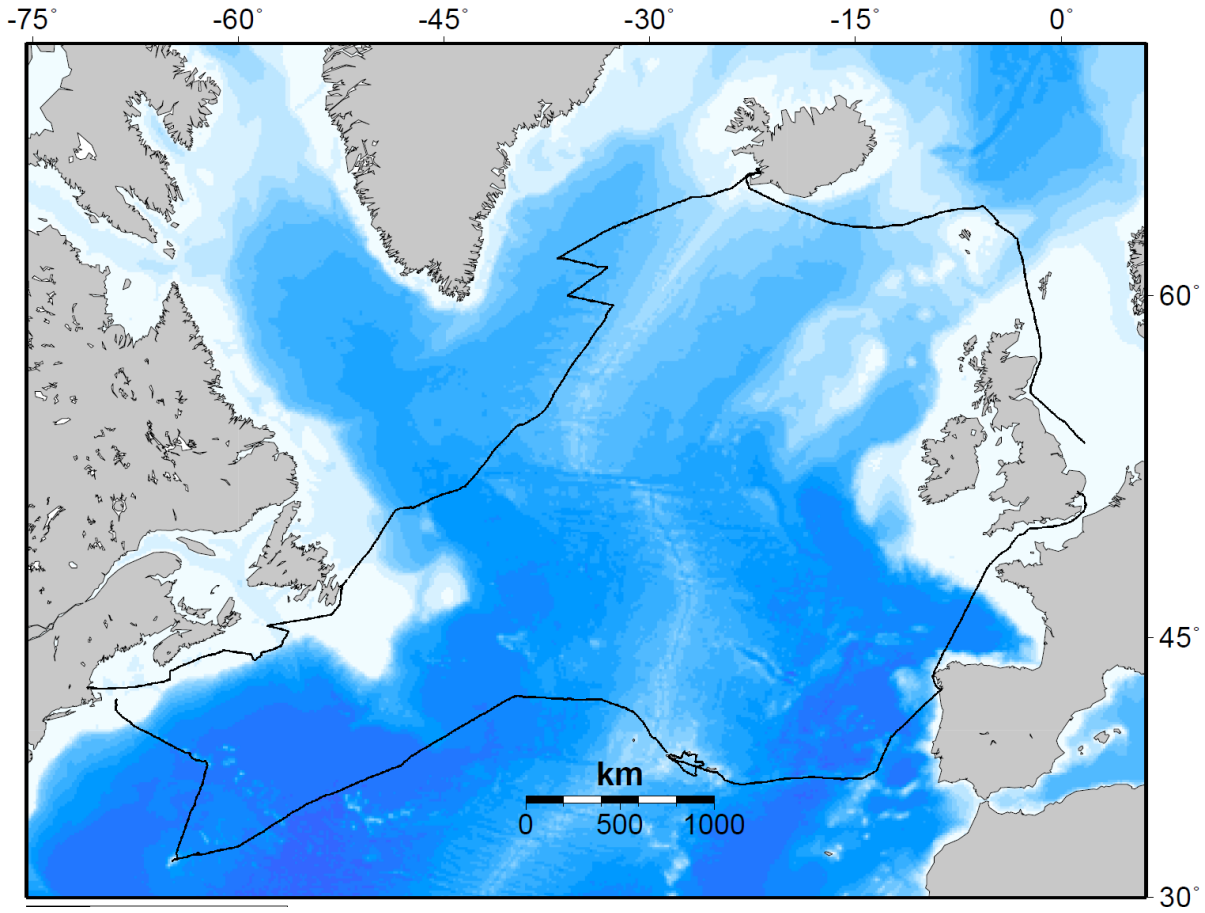


Figure 1. Track of R/V *Song of the Whale* during trans-Atlantic research passages.

3.1 Acoustic detections

A total of 629 hours of acoustic survey effort was carried out during 66 days in the field, over a distance of 5,228 nautical miles (Table 2). Acoustic data were collected with corresponding visual survey data for 28% of the time.

3.1.1 Harbour porpoise

Acoustic sampling at a rate suitable for detecting harbour porpoises (i.e. 500 kHz) was carried out for the northern legs only, excluding the Spain to Azores and Azores to USA legs. Harbour porpoise detections were made mostly on the continental shelves of the UK, Canada and Iceland (Figure 2). Rather significantly, they were detected in deep waters over the Mid-Atlantic Ridge and the Iceland-Faroe Ridge, and also in deep waters of the Canadian and Icelandic shelf edges.

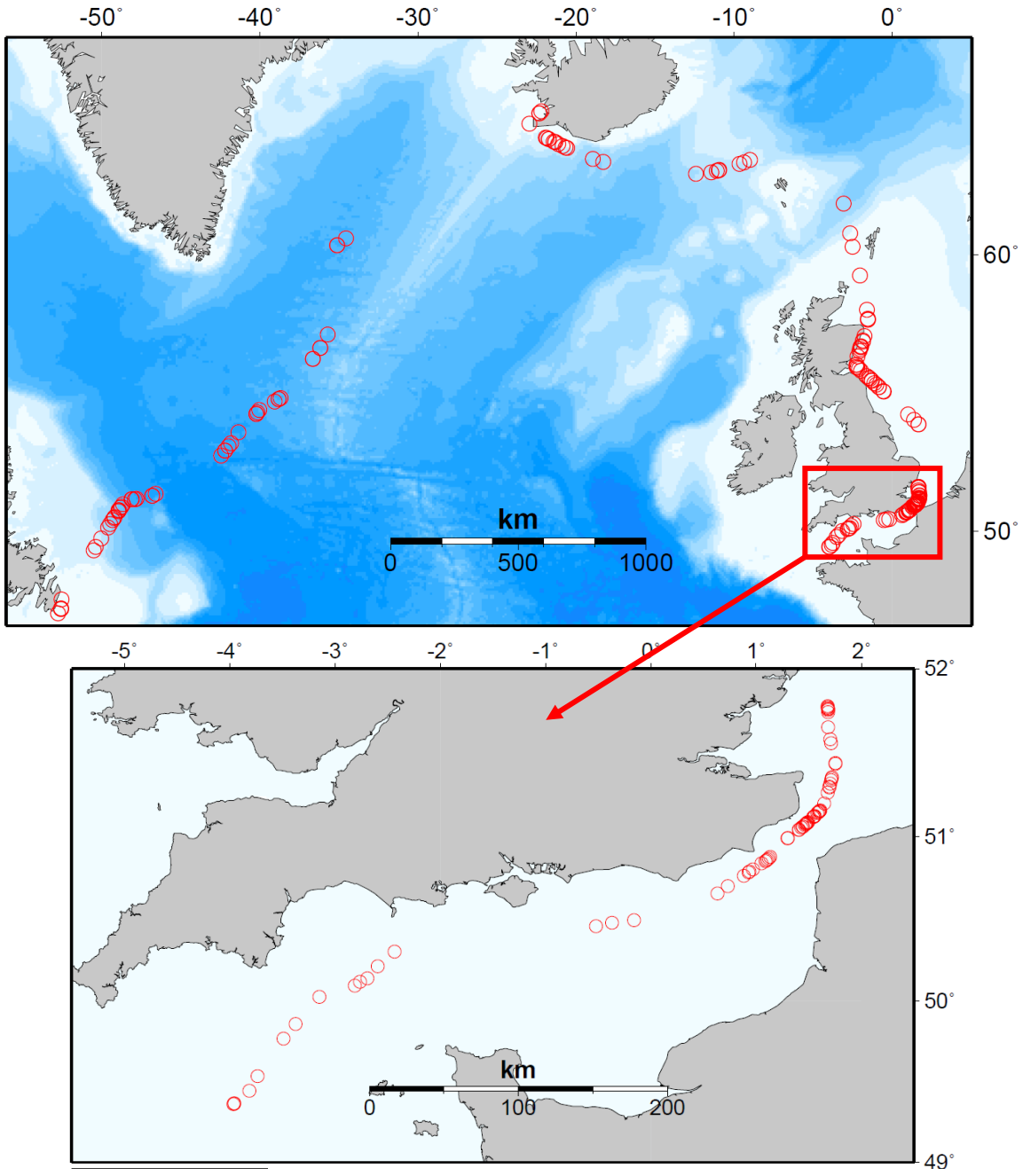


Figure 2. Acoustic detections of harbour porpoise – classified as 'certain' (○). The area with highest detection rate is expanded (English Channel).

3.1.2 Beaked whales

During the four research passages, seven 'certain' or 'likely' acoustic detections of beaked whales were recorded (Figure 3). These coincided with two canyon systems to the south and west of Nova Scotia (Northeast Channel and The Gully respectively). Some detections were also made in mid-ocean regions (Figure 3).

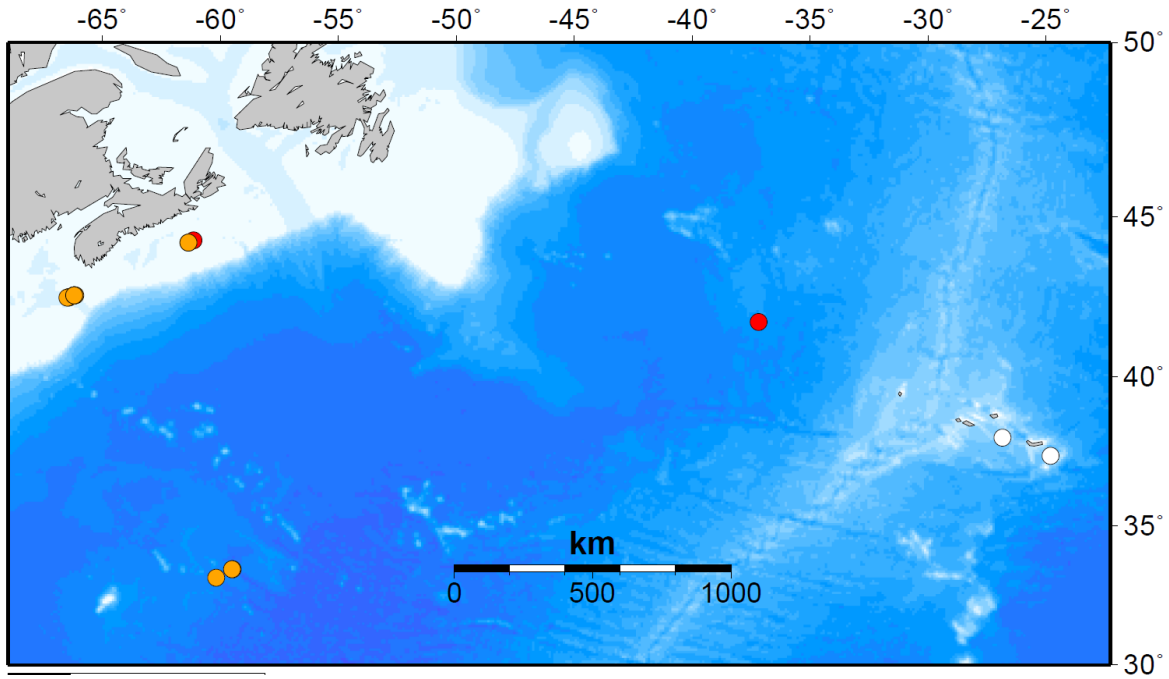


Figure 3. Acoustic detections of beaked whales (not identified to species level) for all passages during 2012: ● = certain detection, ● = likely detection, ○ = possible detection. Detections during the survey period in the Azores and Iceland have been included in separate reports (see http://www.marineconservationresearch.co.uk/downloads).

3.1.3 Baleen whales

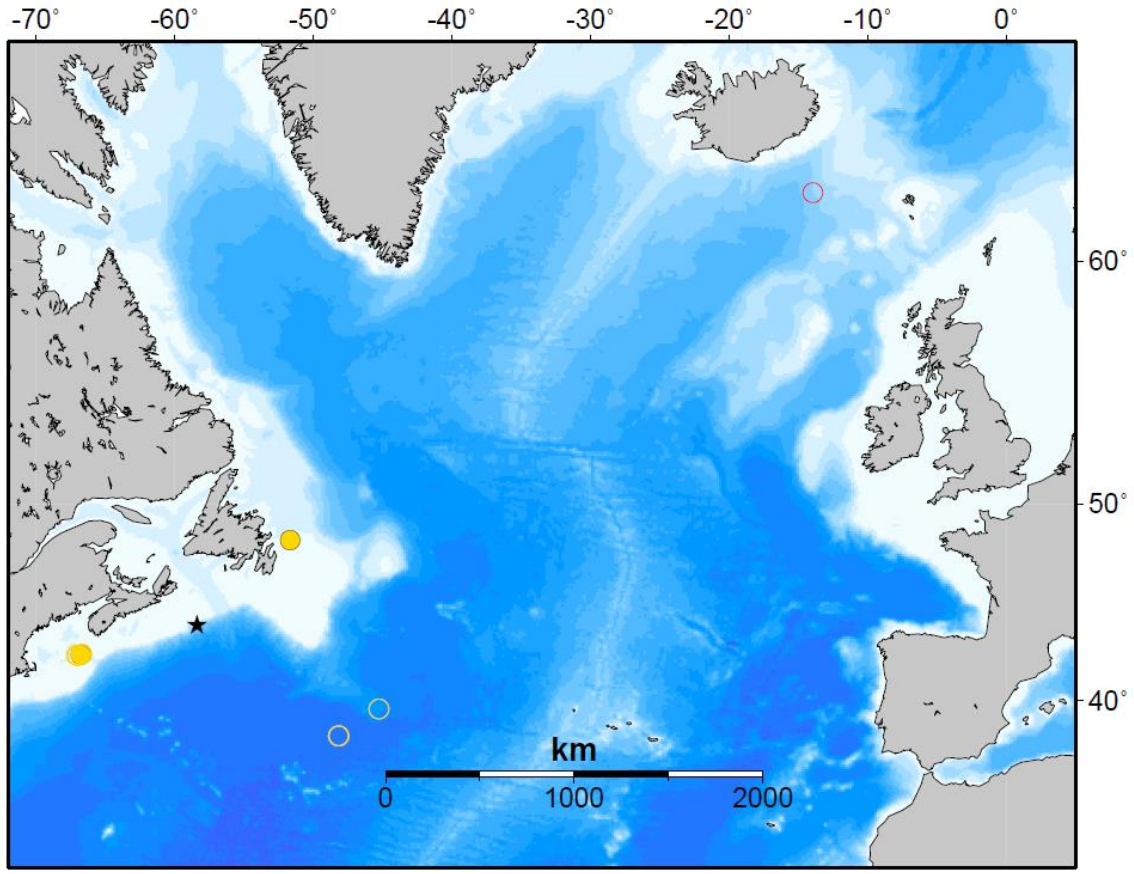


Figure 4. Acoustic detections of baleen whales for all passages where ○ = Unidentified baleen whale; ○ = probable humpback whale; ● = certain humpback whale; ★ = certain blue whale.

3.2 Sightings

In total, 3,483 nautical miles of visual effort was carried out, amounting to 462 hours of survey time from either the A-frame or from the deck (Table 1). This effort resulted in 599 sightings of 16 species during the passages (Table 2). The highest species diversity was found on the USA to Iceland leg, where four baleen whale, two beaked whale and six dolphin species and sperm whales were observed. The Iceland to UK leg resulted in fewest sightings; however sea (and therefore sighting) conditions were poor throughout this passage. Notable sightings of rarely encountered species included Sowerby's beaked whale (species confirmed from photographs). There were only three harbour porpoise sightings, confined to the continental shelf of Iceland (Figure 7).

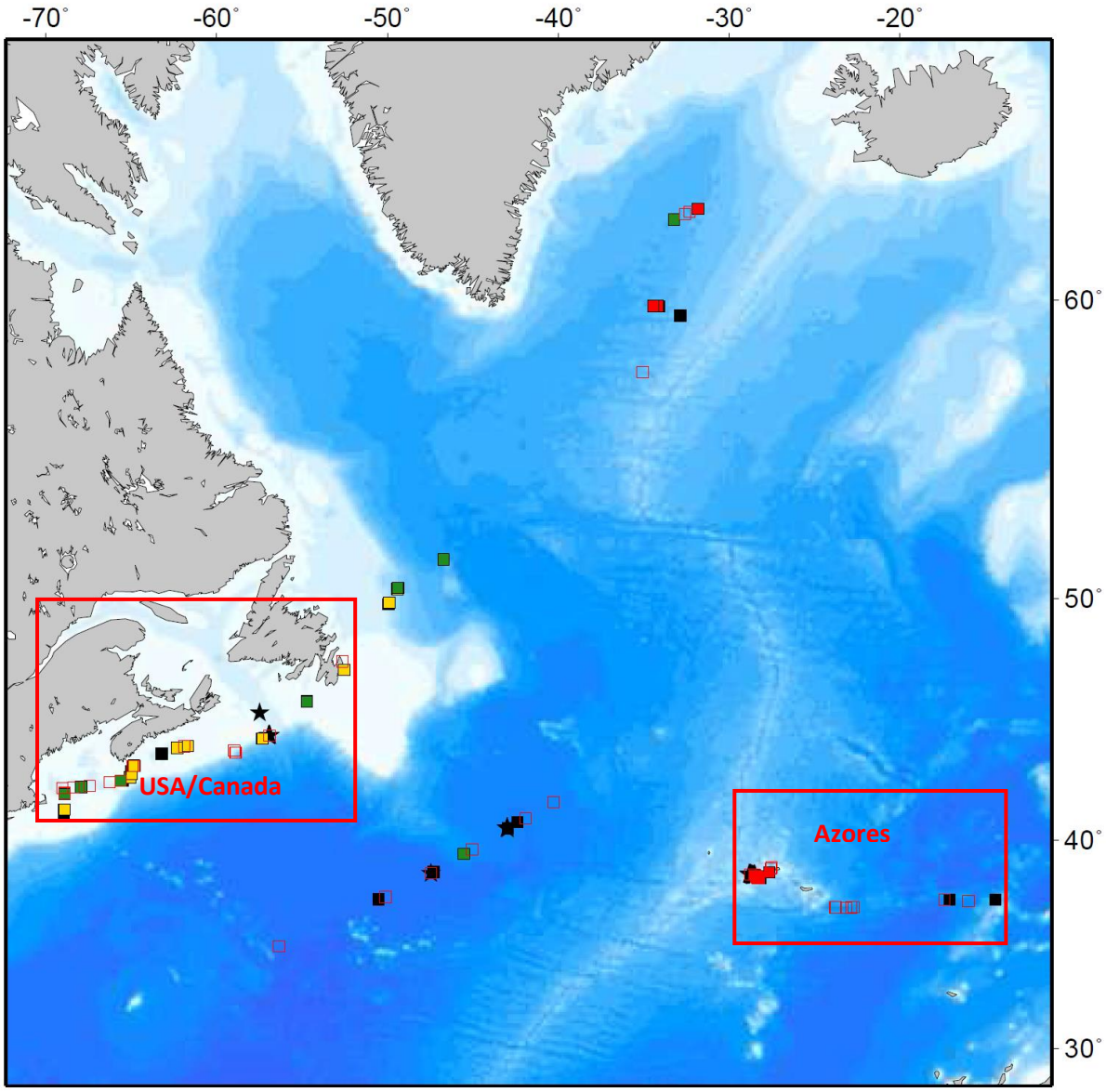
Table 2. Summary of marine mammals observed during all passages.

Passage	No of Encounters	Mean Group Size	Group Size Range
UK to Azores 26 March - 8 April			
Common dolphin (*Delphinus delphis*)	58	6.8	1-50
Fin whale (*Balaenoptera physalus*)	2	1.7	1-2
Risso's dolphin (*Grampus griseus*)	1	17.0	15-20
Sei whale (*Balaenoptera borealis*)	4	1.1	1-2
Sperm whale (*Physeter macrocephalus*)	8	1.5	1-2
Striped dolphin (*Stenella coeruleoalba*)	8	9.8	3-20
White-beaked dolphin (*Lagenorhynchus acutus*)	1	2.0	2
Unidentified dolphin	68	2.1	1-7
Unidentified whale	12	1.1	1-2
Azores to USA 6 May – 1 June			
Atlantic spotted dolphin (*Stenella frontalis*)	4	19.8	4-35
Blue whale (*Balaenoptera musculus*)	3	1.0	1
Bottlenose dolphin (*Tursiops truncatus*)	2	2.0	1-3
Common dolphin (*Delphinus delphis*)	40	8.0	1-55
Fin whale (*Balaenoptera physalus*)	1	1.0	1
Humpback whale (*Megaptera novaeangliae*)	1	1.0	1
Long-finned pilot whale (*Globicephala melas*)	3	4.6	1-10
Sperm whale (*Physeter macrocephalus*)	3	1.1	1-2
Striped dolphin (*Stenella coeruleoalba*)	2	12.2	2-30
White-sided dolphin (*Lagenorhynchus acutus*)	2	8.0	5-12
Unidentified dolphin	15	13.2	1-15
Unidentified whale	1	1.0	1
Unidentified beaked whale	2	2.0	2
USA to Iceland 7 – 28 July			
Blue whale (*Balaenoptera musculus*)	10	1.2	1-2
Bottlenose dolphin (*Tursiops truncatus*)	1	17.0	15-20
Common dolphin (*Delphinus delphis*)	29	10.7	1-50
Fin whale (*Balaenoptera physalus*)	12	1.4	1-3
Humpback whale (*Megaptera novaeangliae*)	22	1.6	1-8
Harbour porpoise (*Phocoena phocoena*)	3	1.3	1-2
Long-finned pilot whale (*Globicephala melas*)	13	8.5	2-20
Minke whale (*Balaenoptera acutorostrata*)	10	1.0	1
Northern bottlenose whale (*Hyperoodon ampullatus*)	5	2.3	1-4
Sei whale (*Balaenoptera borealis*)	6	1.5	1-3
Sowerby's Beaked whale (*Mesoplodon bidens*)	1	2.5	1-3
Sperm whale (*Physeter macrocephalus*)	6	1.0	1
White-beaked dolphin (*Lagenorhynchus albirostris*)	6	5.3	2-10
White-sided dolphin (*Lagenorhynchus acutus*)	14	6.9	2-16
Unidentified beaked whale (Ziphiidae)	4	2.8	1-4

Unidentified dolphin	19	3.4	1-12
Unidentified whale	16	1.3	1-3
Iceland to UK 20 – 28 September			
Common dolphin (*Delphinus delphis*)	1	4.0	3-5
Harbour porpoise (*Phocoena phocoena*)	3	1.3	1-2
White-beaked dolphin (*Lagenorhynchus albirostris*)	12	3.2	1-7
Unidentified dolphin	2	5.0	1-10

3.2.1 Baleen whales

Baleen whales were sighted most frequently over the continental shelf or near the shelf-break. However some encounters, particularly of fin and sei whales, occurred in association with the Mid-Atlantic Ridge and over deep waters between Spain and the Azores.



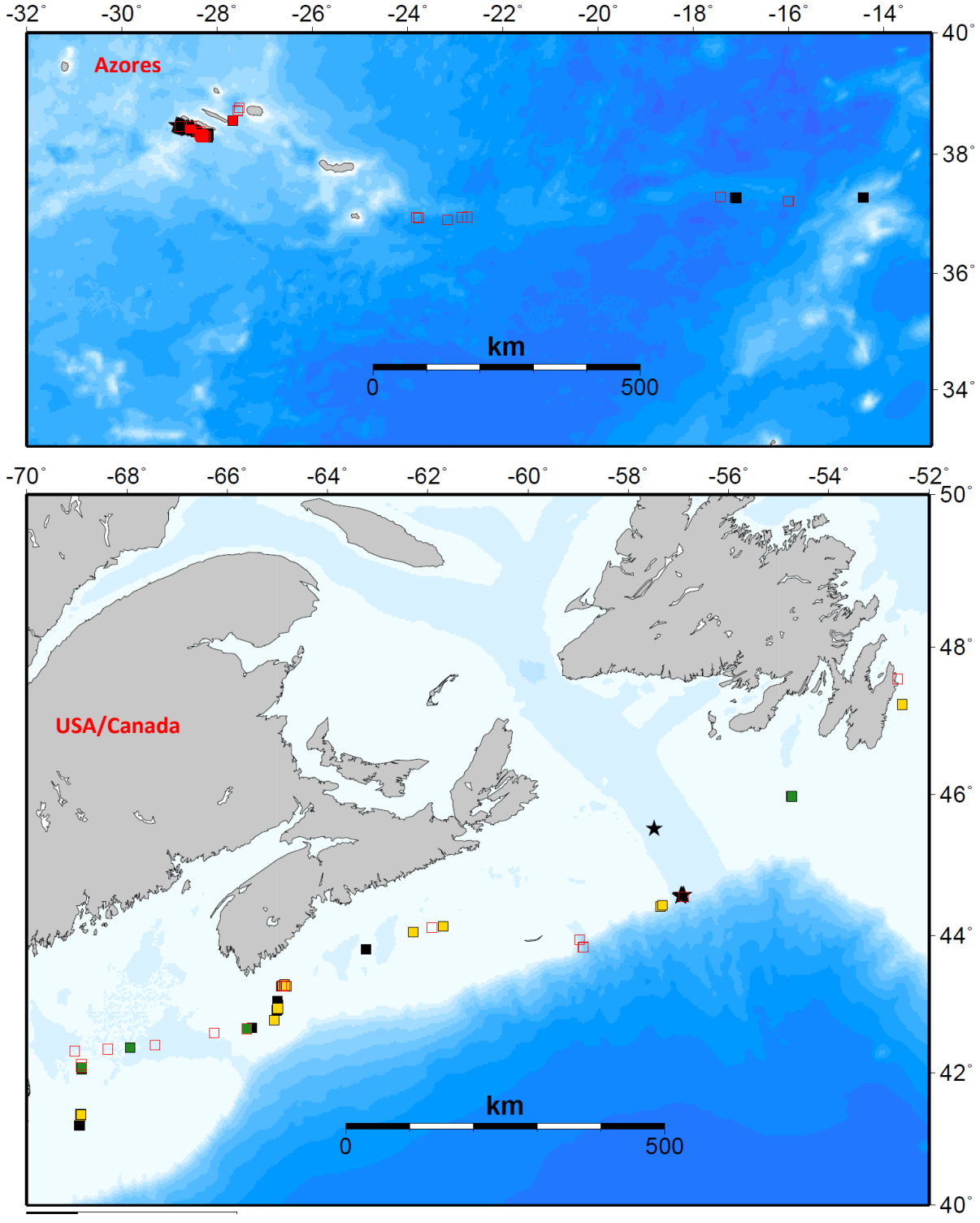


Figure 5. Baleen whale sightings: ★Blue; ■ Fin; ■ Humpback; ■ Minke; ■ Sei; □ Unidentified whales, showing areas with higher relative abundances on passage from the Azores, the Gulf of Maine and the Gulf of St. Lawrence (USA/Canada).

3.2.2 Beaked whales and sperm whales

Beaked whale were only seen in waters over 1000 m deep, often over continental shelf breaks and seamounts, but occasionally in abyssal waters (Figure 6). Sperm whales were found to have a similar distribution and were the most widespread species recorded during the research passages, observed between 36° and 63° north and in the eastern, western and central Atlantic.

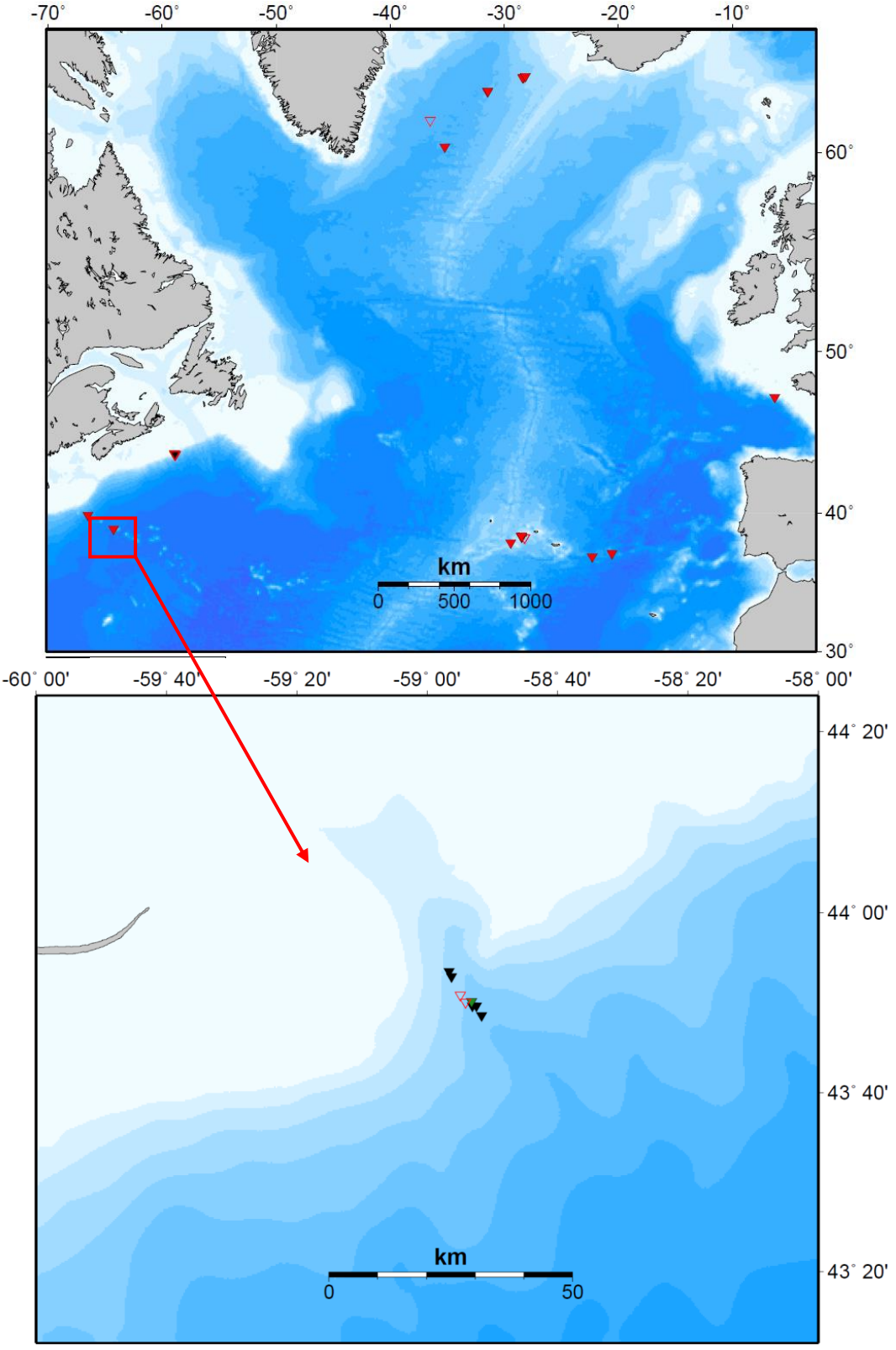


Figure 6. Above: Large odontocete sightings: ▼Sperm; ▼Northern Bottlenose; ▼ Sowerby's beaked whale; ▽Unidentified Beaked whale, including (map below) details of sightings at the Gully MPA, Nova Scotia.

3.2.3 Small odontocete sightings

Below 50 degrees north, common dolphins were the most frequently sighted small cetacean, however above this latitude, long-finned pilot whales and white-beaked dolphins were predominant in offshore and shelf waters respectively (Figure 7). Dolphins were seldom sighted over abyssal plain waters, but were recorded frequently over continental shelf and Mid-Atlantic Ridge waters.

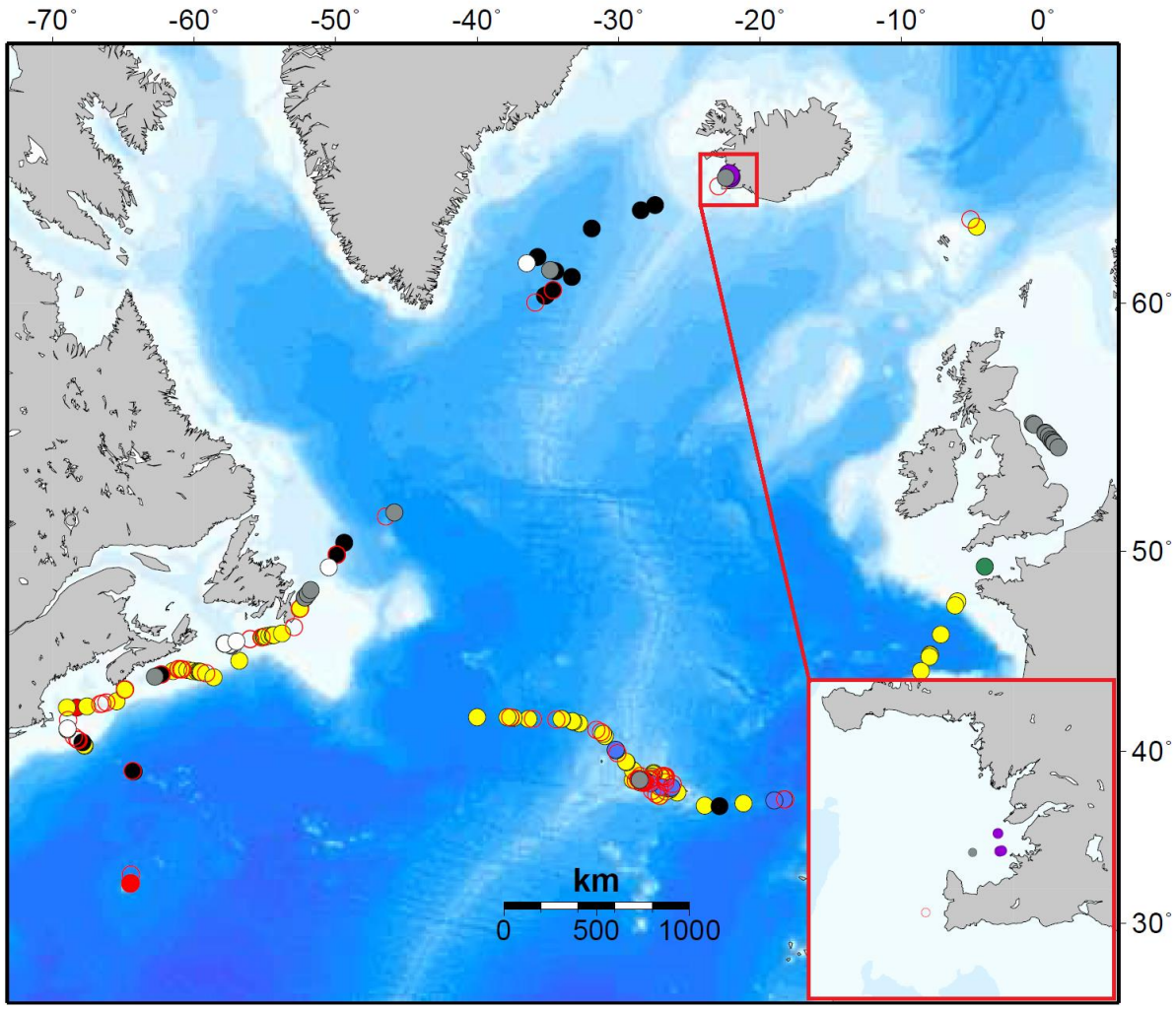


Figure 7. Small odontocete sightings for all four passages: ● Bottlenose dolphin; ●Common dolphin; ●Long-finned pilot whale; ●Risso's dolphin; ●Striped dolphin; ●Atlantic spotted dolphin; ●White-beaked dolphin; ○Atlantic white-sided dolphin; ○Unidentified dolphin; ●Harbour porpoise.

4. DISCUSSION

This report summarises both visual and acoustic encounters with marine mammals in the mid-Atlantic, a region that has traditionally received little dedicated research effort.

4.1 Harbour porpoise

Despite frequent acoustic detections of harbour porpoises, there were just three sightings of this species, all in near-shore waters off Iceland. This is consistent with previous harbour porpoise surveys (see for example Barlow, 1988; Palka, 1996), whereby individuals are hard to detect visually unless sea states are close to zero because of their inconspicuous nature. This reaffirms the importance of using acoustic methods to investigate presence and distribution for this species. A key finding from the research passages is the presence of harbour porpoises in deep waters (2000 m and deeper) over the Mid-Atlantic Ridge and Iceland-Faroe Ridge, although they were not recorded from abyssal plain waters. Generally considered to be a coastal species, the presence of harbour porpoises so far offshore is of interest in terms of understanding of their ecology. Whether harbour porpoises utilise these regions on a seasonal basis or were transiting through (e.g. en route to Greenland) is unclear. Two porpoises satellite tagged in Greenland in 2012 travelled offshore to deep waters, see http://www.natur.gl/en/birds-and-mammals/marine-mammals/harbour-porpoise/satellite-tracking-harbour-porpoises/. To our knowledge, these are some of the few data available which show that harbour porpoises may also be present in some deep offshore waters, as opposed to being confined to a coastal distribution.

Harbour porpoises were detected frequently in the Dover Straits, English Channel and also east of the Moray Firth, Scotland. The latter area is known to be important for this species from previous surveys (e.g. Hammond *et al*., 2002); however the high detection rates from the English Channel support growing evidence that this area is an important habitat for this species. The English Channel remains poorly surveyed for cetaceans, in part due to logistical challenges in conducting surveys in an area with such busy shipping lanes. The SOTW team is building a dataset of harbour porpoise detections from regular transits through the area by the vessel. It is hoped that this dataset will facilitate a more thorough analysis of the presence and distribution of harbour porpoises in the English Channel from passive acoustic data.

Although narrowband ultrasonic clicks with significant energy above 100 kHz are rare amongst the cetaceans, three phylogenetically different groups of toothed whales have evolved to utilise similar signals; the family Phocoenidae (Møhl & Andersen, 1973), the subfamily Lissodelphinae including the *Cephalorhynchus* and *Lagenorhynchus* genera (Dawson & Thorpe, 1990; Kyhn *et al*., 2010) and the genus *Kogia* (Marten, 2000; Madsen *et al*., 2005). Only the pygmy sperm whale (*Kogia breviceps*) has a distribution that potentially overlaps that of the harbour porpoise in parts of the North Atlantic (Taylor *et al*., 2009). Although it is hard to estimate population sizes for *Kogia* due to their extremely inconspicuous nature, current estimates are only 741 for pygmy sperm whales in the western North Atlantic (CV = 0.4; Palka *et al*., 2012). Conversely, the same study derived an abundance estimate for harbour porpoises of 79,883 (CV = 0.3) and as such it is more than likely the acoustic detections reported in this study are of porpoises rather than pygmy sperm whales (which are also generally reported in tropical and warm temperate waters).

4.2 Beaked whales

There were more acoustic detections of beaked whales than sightings. Species identification of mesoplodont whales at sea by visual means is challenging, however with increased access to high powered telephoto lenses, photographic species identification is possible. For example, during the research passage from the US to Iceland, a Sowerby's beaked whale was positively identified from

photographs taken during the encounter (Wojtek Bachara, *pers. comm*.). Additionally, from a sighting of distant breaching beaked whales, identification of True's or Gervais beaked whale was made (Wojtek Bachara, *pers. comm*.). This demonstrates the importance of having a dedicated photographer during beaked whale encounters. Most beaked whale detections during these research passages were made over sharp discontinuities in the seabed (canyons and steep shelf-breaks), which is consistent with knowledge on their preferred habitat. Northern bottlenose whales were encountered on five occasions within or adjacent to the marine protected area known as the Gully; a canyon which cuts deep into the Scotian Shelf and is known for its importance for this species (for example Gowans *et al*., 2000).

Figure 8. Sowerby's beaked whale (*Mesoplodon bidens*) photographed within the Gully MPA on 12 July 2012 (see figure 6 for exact location). The long narrow beak is visible (above), which is diagnostic for this species in the North Atlantic Ocean.

4.3 Baleen whales

Blue whales were observed in the Laurentian Channel and near the Azores. Three sightings of individual blue whales were made in abyssal plain waters of the Mid-Atlantic. There were no other sightings of this species elsewhere during the research passages; the Azores and Laurentian Channel areas appear to represent important habitat for this critically endangered species. Sightings of sei whales and minke whales on the Cape Farewell Ground (between Iceland and Greenland) are consistent with current knowledge of their summer northward migration to these highly productive waters. However, no right whales were detected acoustically or visually observed in the region,

which was one of three principal 19th century North Atlantic right whaling grounds (Reeves and Mitchell 1986). In 2007-2008 the presence of right whales was confirmed close to the Cape Farewell Ground between July and November using remote static acoustic recorders (Mellinger *et al.,* 2011). Evidence for the presence of even a few North Atlantic right whales summering close to this former whaling ground is significant; thus this specific area was included as part of the passage to Iceland. Humpback whale encounters and acoustic detections occurred exclusively on the shelf or occasionally the shelf-break of the Gulf of Maine and Newfoundland, which are some of the most important feeding grounds in the North Atlantic for this species. While no mid-ocean sightings were recorded of humpback whales, probable acoustic detections were made between Bermuda and Newfoundland during May, possibly animals migrating between feeding and breeding grounds, further south.

4.4 Small odontocetes

Below 50°N, common dolphins were the most frequently sighted small cetacean, however above this latitude, long-finned pilot whales and white-beaked dolphins were predominant in offshore and shelf waters respectively. A group of common dolphins comprising five individuals was observed at 62.5°N, north of the Faroe Islands. This record is unusually far north for this species for which sightings above 60°N are very rare (Reid *et al.* 2003). This observation adds to the mounting evidence of a northward movement of temperate species with warming sea temperatures, and a change in the cetacean community in northwest Europe (see for example, MacLeod *et al.,* 2005, Robinson *et al.,* 2011).

5. ACKNOWLEDGEMENTS

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