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Pilot cetacean survey of the sub-Arctic North Atlantic utilizing a cruise-ship platform

Ross Compton*ʃ, Aaron Banks†, Lissa Goodwin† and Sascha K. Hooker‡

*Research & Innovation, 17a Portland Villas, University of Plymouth, Drake Circus, Plymouth, Devon, PL4 8AA, UK. †School of Biological Sciences, University of Plymouth, Drake Circus, Plymouth, Devon, PL4 8AA, UK. ‡Sea Mammal Research Unit, University of St Andrews, St Andrews, Fife, KY16 8LB, UK. ʃCorresponding author, e-mail: ross.compton@plymouth.ac.uk

Using a large passenger cruise-ship (MV 'Discovery') as a platform, a cetacean survey was conducted between 1 August and 3 September 2005 across the northern North Atlantic Ocean and back, covering waters between the UK, Iceland, Greenland and Canada. The objective was to collect sightings data for all cetacean species encountered to begin to collate information for a large-scale sightings database. Two observers employed standard-distance sampling techniques and visual observations (naked eye) to scan for cetaceans during daylight hours and favourable weather conditions. Approximately 112 h were spent surveying over 23 d. A total of 13 cetacean species were encountered, with 173 separate sightings recorded, totalling over 2000 animals. The most commonly sighted species were minke whales (*Balaenoptera acutorostrata*: N=44), Atlantic white-sided dolphins (*Lagenorhynchus acutus*: N=34, with group sizes of up to 600), and humpback whales (*Megaptera novaeangliae*: N=31). The distribution of minke whales, Atlantic white-sided dolphins and fin whales was linked to underlying oceanographic variables. Overall patterns of distribution were consistent with our understanding of the summer distributions for the species encountered. The survey highlighted the cetacean diversity of the northern North Atlantic region. Repeat work using this methodology will allow an examination of species' distributions and estimation of their relative abundance.

INTRODUCTION

Reliable information relating to the distribution and abundance of cetaceans is difficult and costly to obtain, requiring logistically challenging and often prohibitively expensive surveys (Williams et al., 2006). Platforms of opportunity such as ferries, fishing vessels, and oceanographic research vessels are increasingly being exploited for conducting cetacean research, as they minimize the costs of such work and enable large areas to be covered (Evans & Hammond, 2004). Groups such as Organization Cetacea and the Biscay Dolphin Research Programme have successfully utilized ferries as observation platforms for a number of years, yielding important distribution and abundance data for cetaceans and other marine life in the Bay of Biscay (Walker & Macleod, 2004).

The North Atlantic Ocean, particularly in sub-Arctic and Arctic areas, has not been subject to regular, wide-reaching cetacean surveys with the exception of the North Atlantic Sightings Surveys (NASS) of 1987 and 1989 (Sigurjónsson et al., 1991). It is an area of increasing importance as global environmental change and anthropogenic activities such as whaling and oil and gas exploration have the potential to impact upon populations across this region, many of which are poorly understood. In light of this importance, coordination and planning is under way for the broad scale Trans-North Atlantic Sightings Survey (TNASS), due to commence during the summer of 2007.

Described here is a pilot trans-North Atlantic survey conducted aboard a 170 m long passenger cruise vessel, the MV 'Discovery'. Our goals were to examine whether this platform could provide a useful means for the collection of cetacean sightings data in this region, and to collect sightings data for all cetacean species encountered during the passage of the cruise vessel.

MATERIALS AND METHODS

Data were collected during a return cruise from Harwich, UK to St John's, Newfoundland, between 1 and 17 August 2005 (outward leg) and 18 August to 3 September 2005 (return leg). Port calls included the Færoe Isles (Torshavn), Iceland (Reykjavik), Greenland (Narsarsuaq, Nuuk and Ilulissat) and Canada (Red Bay, L'anse aux Meadows (outward), St John's and Trinity (return)).

A team of two observers employed standard-distance sampling techniques and visual observations (naked eye) to scan for cetaceans during daylight hours and favourable weather conditions (Beaufort sea state ≤4, swell height ≤2m). The average cruising speed of the vessel was 16 knots. The deck immediately above the ship's bridge was used for observations (19 m above sea level). Observers scanned 90° sectors to port and starboard of the vessel's track-line; 7×50 reticule binoculars were used to aid species identification. The time, vessel location (latitude/longitude), distance (reticules) and angle (using an angle board) from the vessel track were recorded for each sighting, together with species information (species, number, behaviour, direction of travel).

For species sighted more than five times, multiple regression analysis was performed within the Geographical

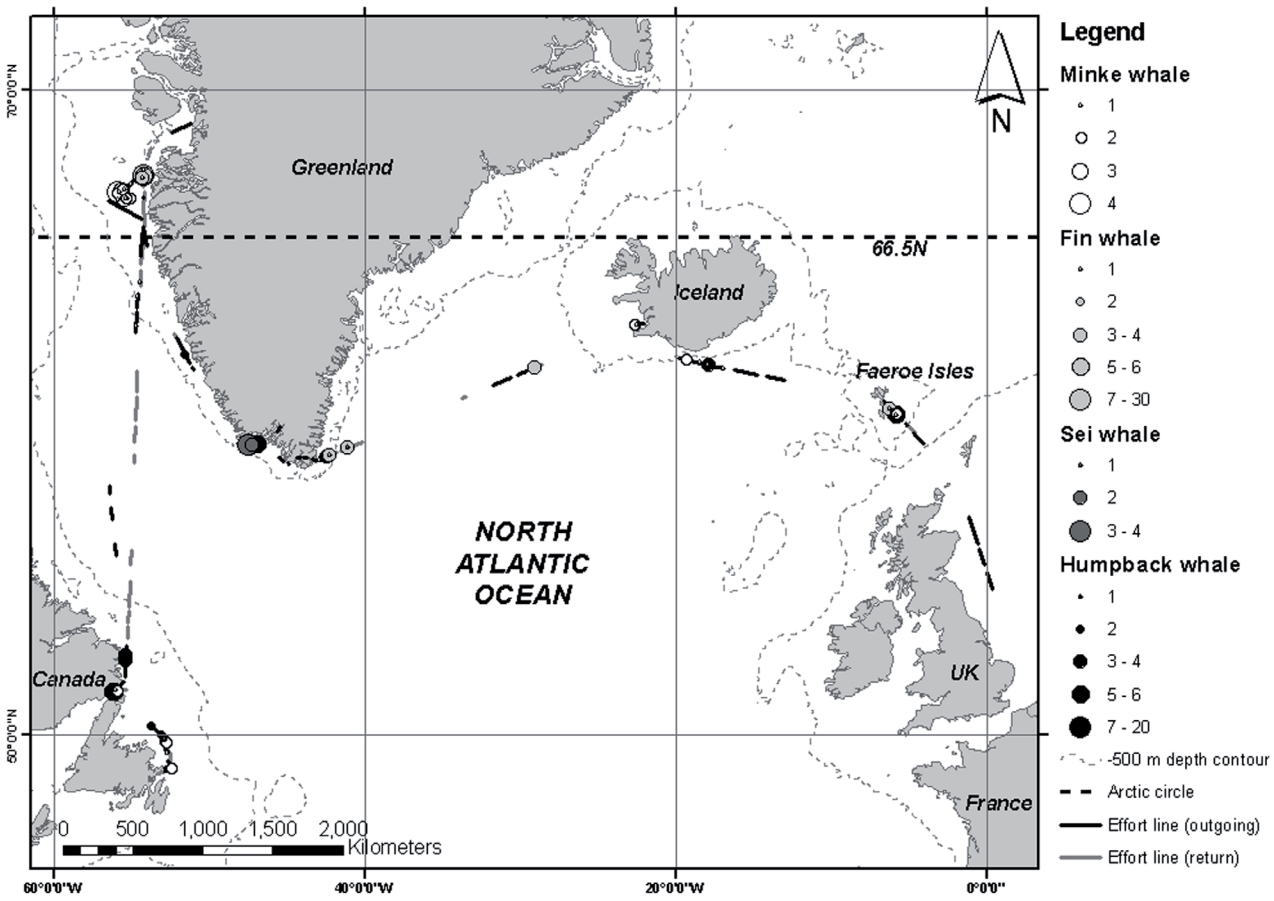

Figure 1. Locations and group sizes of mysticete sightings.

Information System (GIS) Idrisi Kilimanjaro. Distributions were compared with two topographic variables; depth and slope, and sea surface temperature (SST). Depth and slope were derived from the ETOP02 4-min bathymetric grid (Smith & Sandwell, 1997). From these data, a raster grid of 4-min bathymetry was constructed. Each 4-min grid cell is 27.3 km^2, or ≈5.2 km×5.2 km. Slope for this study area was calculated from the bathymetric base map using surface analysis tools within Idrisi, and was constructed as an additional independent raster grid. SST data for August 2005 derived from the Pathfinder 5 advanced very high resolution radiometer (AVHRR) satellite were obtained from the NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC 2004). Multiple regression analysis was carried out using the 'MULTIREG' statistics function within Idrisi.

RESULTS

Approximately 112 h (70 outgoing leg, 42 return leg) were spent surveying 3473 km over 23 separate days. Over the

Table 1. *Summary of sighting information for species observed.*

Species	Number of sightings	Average group size	Group size-range
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	34	55	2–600
Common dolphin (*Delphinus delphis)*	1	4	–
White-beaked dolphin (*Lagenorhynchus albirostris*)	5	4	3–6
Long-finned pilot whale (*Globicephala melas*)	5	33	10–100
Minke whale (*Balaenoptera acutorostrata*)	44	1	1–4
Fin whale (*Balaenoptera physalus*)	13	5	1–30
Sei whale (*Balaenoptera borealis*)	5	3	1–4
Humpback whale (*Megaptera novaeangliae*)	31	2	1–6
Killer whale (*Orcinus orca*)	1	2	–
Sperm whale (*Physeter macrocephalus*)	8	1	1–2
Unidentified beaked whale	1	3	–
Unidentified dolphin	6	5	1–10
Unidentified whale	19	1	1–5

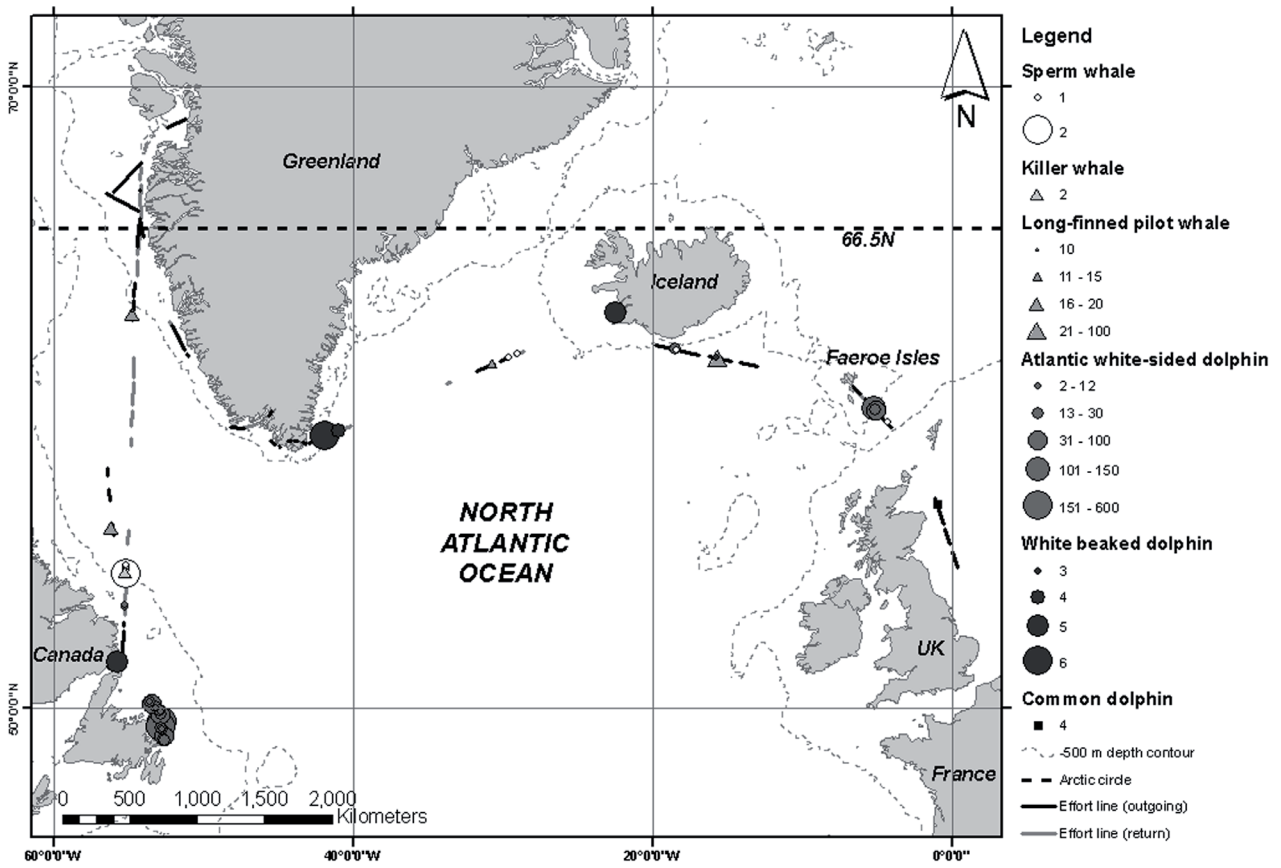

Figure 2. Locations and group sizes of odontocete sightings.

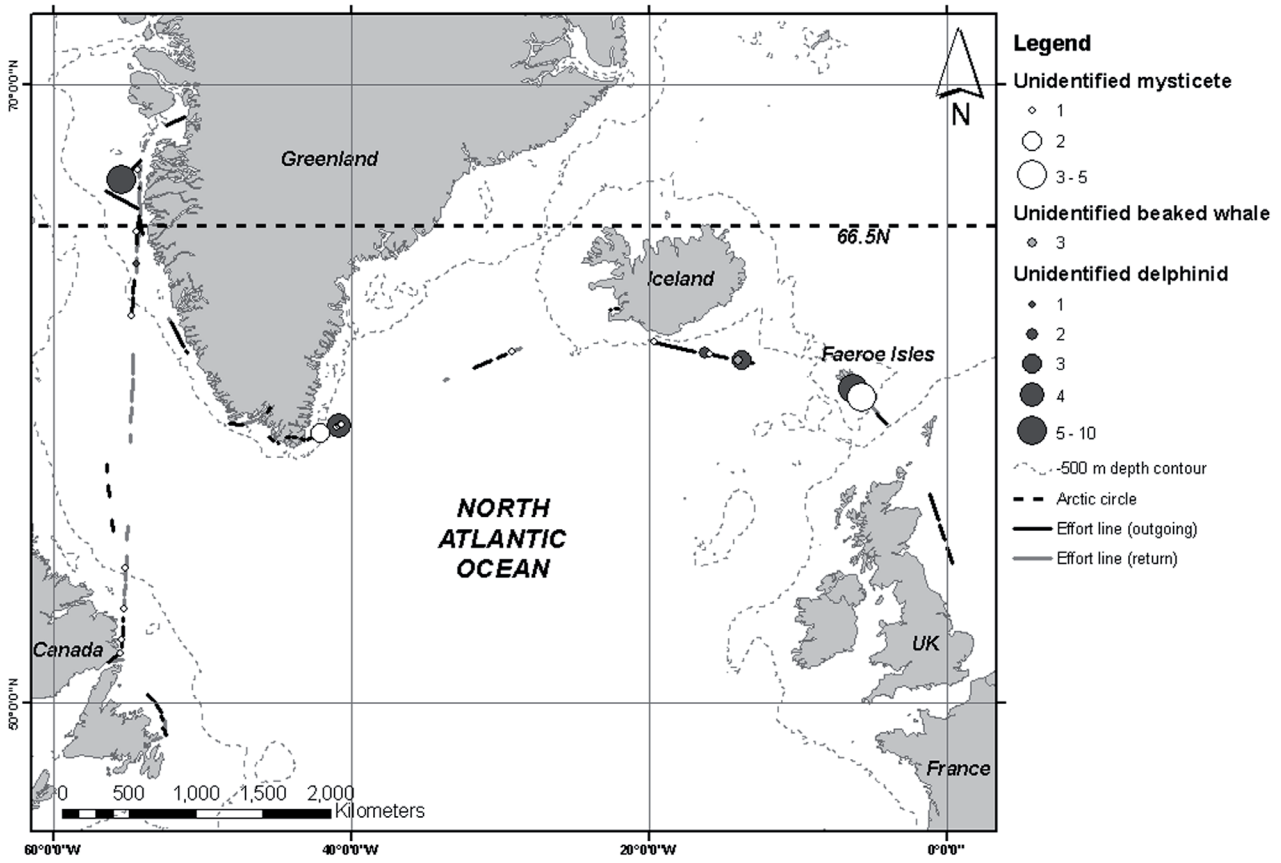

Figure 3. Locations and group sizes of unidentified cetacean species.

survey period a total of 13 cetacean species were encountered, with 173 sightings recorded, totalling over 2000 animals (Table 1). The most commonly sighted species were minke whales (*Balaenoptera acutorostrata*: N=44), Atlantic white-sided dolphins (*Lagenorhynchus acutus*: N=34) and humpback whales (*Megaptera novaeangliae*: N=31). Large aggregations of Atlantic white-sided dolphins were observed off the north coast of Newfoundland during both legs of the survey. The overall cetacean sighting rate (per 100 km) was similar during the return leg of the survey (10.8), to the outgoing (9.3).

Figures 1, 2 and 3 show the distribution of sightings for mysticetes, odontocetes and unidentified species respectively. From the general pattern of sightings, it can be seen that the waters of eastern Canada, southern Greenland and west Greenland to the south of Disko Bay were areas of high sighting density. However, as shown by the track-lines (Figures 1, 2 and 3), the north-west Atlantic was subject to more continuous survey effort from the combined outward and return legs of the cruise than the rest of the survey area. The area of the Great Hellefiske Bank to the south of Disko Bay is an area of high sighting density for minke (*Balaenoptera acutorostrata*) and fin whales (*Balaenoptera physalus*) (see Figure 1). Another area of high sighting density was off the north-east coast of Newfoundland, where large numbers of Atlantic white-sided dolphins were encountered (see Figure 2). While the majority of species encountered were found across the study area, only a single sighting of a small group of common dolphins was recorded in the North Sea, and this species was not recorded anywhere else. Similarly, sei whales (*Balaenoptera borealis*) were only recorded off the southwest coast of Greenland.

Multiple regression analysis showed that the distribution of minke whales was correlated with sea surface temperature (t =–2.9, P<0.01), showing a preference for cool waters. The distribution of Atlantic white-sided dolphins (t =–2.6, P<0.01) and fin whales (t =–2.8, P<0.01) were correlated with depth, with a preference for shallow continental shelf waters. Analyses were also conducted for sperm (*Physeter macrocephalus*), long-finned pilot (*Globicephala melas*) and humpback whales, for which no correlations were found.

DISCUSSION

The distributions observed are largely consistent with our understanding of the summer distributions of the species encountered (Reid et al., 2003). High numbers of minke and fin whales have previously been observed in the region of the Great Hellefiske Bank (≈68°N 55°W), with local variation similar to that seen in Figure 1 (Kapel & Larsen, 1983). The preference for shallow continental shelf waters during the summer months illustrated for fin whales concurs with previous observations by Sigurjónsson et al. (1991).

Atlantic white-sided dolphins have been reported to favour shelf-edge waters, with a marked increase in sightings in water shallower than 1000 m during July and August (Northridge et al., 1997; Reid et al., 2003; Weir et al., 2001). Large aggregations of Atlantic white-sided dolphins, as seen off the north coast of Newfoundland during this survey, have previously been reported for this species in the north-east Atlantic, particularly during August (Weir et al., 2001). They are present on both sides of the North Atlantic, but as shown here, they are known to be more numerous in the north-west Atlantic (Northridge et al., 1997).

Minke whales were encountered across the range of the survey, though the large number of sightings occurring in a cold water area close to Disko Bay and within the Labrador Current of eastern Canada no doubt influenced the correlation with cooler waters shown by the regression analysis. They are known to occur widely within the North Atlantic particularly in continental shelf waters, and have been frequently sighted in previous regional surveys such as those reported by Weir et al. (2001).

The distribution of humpback whales was not found to be correlated with the variables used in the analysis, though humpback whales are known to frequent the banks of west Greenland and Newfoundland in summer and autumn as they represent important feeding areas for this species (Larsen & Hammond, 2000; Dietz et al., 2002). Most humpback whale sightings occurred in shallow continental shelf waters, though they were present in a variety of waters across the whole range of the survey and, as has previously been observed, this species was also seen in a deep water area off Iceland (Sigurjónsson & Gunlaugsson, 1989). The sighting distribution of long-finned pilot whales and sperm whales was also not found to be correlated with the variables used, though this is likely due in part to the small sample size. Those observed were in deep water areas, as would be expected for these deep-diving species.

Given further data, finer scale analysis would be useful to understand the potential local variation in distribution such as that seen for fin and minke whales off west Greenland. Sigurjónsson et al. (1991) previously noted similar variation between fin and sei whales, with fin whales occurring closer to the ice edge, indicating that distance to the ice edge may be a useful variable to factor into future analyses. Using a more local scale it would be possible also to use higher resolution bathymetry data and develop an index of topographical complexity, previously shown to be a driver of Atlantic white-sided dolphin distribution (Northridge et al., 1997).

This pilot survey confirmed the utility of this cruise-ship platform for the collection of cetacean sighting data. However, the speed at which the vessel cruises may be a source of bias in terms of not spotting beaked whales (one unidentified beaked whale encounter presented here) and presents a difficulty in terms of spotting and identifying cetacean species in general. Our results have highlighted the cetacean diversity of the northern North Atlantic region. It is intended that the survey be repeated annually in order to build a larger dataset with which to calculate relative abundance estimates for these populations, to further elucidate species' distributions and to examine whether and how species' distributions are changing over time with varying environmental influences.

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