EMFF Operational Programme 2014-2020

Marine Biodiversity Scheme

Marine Institute Cetacean Monitoring

During the Mackerel Egg Survey

June 2019

Lead Agency: Marine Institute
Lead Partners: National Parks and Wildlife Service,
Authors: Emerald Marine
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An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
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Foras na Mara
Marine Institute

Operational Programme	European Maritime and Fisheries Fund (EMFF) Operational Programme 2014-2020
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Thematic Objective	TO 6 - Preserving and protecting the environment and promoting resource efficiency
Specific Objective	UP1 SO1 - Reduction of the impact of fisheries and aquaculture on the marine environment, including the avoidance and reduction, as far as possible, of unwanted catch. UP1 SO2 - Protection and restoration of aquatic biodiversity and ecosystems. UP6 SO1 - Development and implementation of the Integrated Maritime Policy
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Executive Summary

Irish waters represent one of the most important marine habitats for cetaceans in Europe and are utilized by a wide range of cetacean species. However, the abundance, distribution and conservation status of many of the cetacean species occurring in Irish waters remains poorly understood. Under the EU Habitats Directive, there is a requirement on member states to conduct surveillance of cetaceans occurring within their waters. The Department of Arts, Heritage and the Gaeltacht (DAHG), through the Marine Institute, commissioned a cetacean survey from the MRV Corystes during the Mackerel Egg Survey (MEGS), running from 9th to 29th of June 2019.

A standard, single platform line transect survey methodology was employed by the cetacean observer with additional visual point sampling at oceanographic sampling stations. Survey transects were undertaken at speeds of 5-10 knots, with fishing activity being conducted at speeds of 3-4 knots. The cetacean observer's survey effort was maximized and optimized during periods of sea state less than or equal to sea state 6 and with visibility of greater than 1km. A total of 127 hours and 57 minutes of survey effort was conducted over the course of the MEGS 2019 survey. In total, 126 hours and 18 minutes of survey effort were conducted using a line transect methodology, while 1 hours and 38 minutes of effort were conducted using the point sampling methodology.

A total of 65 sightings, were recorded throughout the survey. This includes 6 sightings recorded as auxiliary sightings and 25 sightings recorded as incidental sightings. From the total 65 sightings, marine mammals accounted for 64 sightings. The remaining sighting consisted of an incidental sighting of a probable basking shark. The marine mammal sightings included; 2 whale species, 6 dolphin species, 1 porpoise species, 1 seal species, and a number of sightings which could not be identified to species level.

Introduction

Irish waters represent one of the most important marine habitats for cetaceans in Europe (Berrow, 2001) and are utilized by a wide range of cetacean species. The waters of the Irish EEZ consist of an area high in biological productivity within the North-East Atlantic and include widespread areas over shallower continental shelf, deep oceanic waters and waters overlying the continental slope (DEHLG, 2009), providing diverse habitats for a range of cetaceans. At present, there are twenty-five species of cetaceans known to occur in Ireland (Whooley, 2016), along with two species of seals (NPWS, 2013).

In 1937, legal protection for marine mammals in Ireland began with the enactment of the Whale Fisheries Act. The 1976 Wildlife Act provides a legal framework for the conservation of Irish wildlife and their habitats, conferring specific protection on seals, whales, dolphins and porpoises up to 12nmi from the coast (NPWS, 2014). In 1991, the Irish government acknowledged the importance of Irish waters for cetaceans and declared all Irish waters a whale and dolphin sanctuary. The sanctuary covers all waters within the Irish Economic Exclusive Zone (EEZ) which extends 200nmi from the coast (Rogan & Berrow, 1995).

Marine mammals in Ireland are also protected under EC Council Directive (92/43/EEC) on the conservation of natural habitats, and of wild flora and fauna commonly referred to as the EU Habitats Directive. All cetaceans are listed under Annex IV of the Habitats Directive as species requiring strict protection in their natural range (Article 12, EC Council Directive 92/43/EEC). The harbour porpoise (*Phocoena phocoena*) and the bottlenose dolphin (*Delphinus delphis*), together with both seal species occurring in Irish waters, the grey seal (*Halichoerus grypus*) and the common seal (*Phoca vitulina*), are listed in Annex II and further protected under Article 3 of the Directive, as species whose conservation requires the designation of Special Areas of Conservation (SAC).

Despite accounting for 48% of all native mammal species (DEHLG, 2009), the abundance, distribution and conservation status of many of the cetacean species occurring in Irish waters remains poorly understood (NPWS, 2013; *Table 1*). Under the EU Habitats Directive, there is a requirement on member states to conduct surveillance of cetaceans occurring within their waters.

Table 1: Marine mammal species occurring in Irish waters and their conservation status (Sources: Wall et al., 2013; Whooley, 2016; Temple, et al., 2007)

Common name	Scientific name	Occurrence	Conservation Status (IUCN Europe)
Baleen whales			
Humpback whale	*Megaptera novaeangliae*	May-Aug	Least concern
Blue whale	*Balaenoptera musculus*	July-March	Endangered
Fin whale	*Balaenoptera physalus*	All year	Near threatened
Sei whale	*Balaenoptera borealis*	All year	Endangered
Northern minke whale	*Balaenoptera acutorostrata*	All year	Least concern
Northern right whale	*Eubalaena glacialis*	Vagrant	Critical
Bowhead whale	*Balaena mysticetus*	Data deficient	Not assessed
Toothed whales and dolphins			
Sperm whale	*Physeter macrocephalus*	All year	Vulnerable
Pygmy sperm whale	*Kogia breviceps*	Vagrant	Not assessed
Killer whale	*Orcinus orca*	All year	Data deficient
False killer whale	*Pseudorca crassidens*	June-Nov	Not assessed
Long-finned pilot whale	*Globicephala melas*	All year	Data deficient
Cuvier's beaked whale	*Ziphius cavirostris*	May-Aug	Least concern
Northern bottlenose whale	*Hyperoodon ampullatus*	May-Aug	Data deficient
Gervais' beaked whale	*Mesoplodon europaeus*	Vagrant	Data deficient
Sowerby's beaked whale	*Mesoplodon bidens*	All year	Data deficient
True's beaked whale	*Mesoplodon mirus*	All year	Data deficient
Beluga	*Delphinapterus leucas*	Vagrant	Not assessed
Risso's dolphin	*Grampus griseus*	March-July	Data deficient
Common bottlenose dolphin	*Tursiops truncatus*	All year	Data deficient
Short-beaked common dolphin	*Delphinus delphis*	All year	Data deficient
Striped dolphin	*Stenella coeruleoalba*	May-Sept	Data deficient
White-beaked dolphin	*Lagenorhynchus albirostris*	All year	Least concern
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	All year	Least concern
Porpoises			
Harbour porpoise	*Phocoena phocoena*	All year	Vulnerable
Seals			
Grey seal	*Halichoerus grypus*	All year	Least concern
Common (harbour) seal	*Phoca vitulina*	All year	Least concern

Since 1994, several dedicated studies on cetaceans have been conducted in Ireland, providing data on the presence, distribution and abundance of the numerous cetacean species in coastal and offshore waters (e.g. Pollock et al. 1997; Ó Cadhla et al. 2004; Wall *et al*., 2013; O'Brien, *et al., 2016*). In recent years, the Marine Institute has facilitated the surveillance of cetaceans in Irish waters by providing berths for cetacean observers on-board the national research vessels, MRV Celtic Explorer and MRV Celtic Voyager, as well as the Northern Irish research vessel, MRV Corystes, during oceanographic and fisheries surveys (Oudejans, 2014). Fisheries acoustic surveys are particularly

suited to the conduction of cetacean surveys as the vessel spends the majority of the survey travelling at a steady speed along pre-determined survey tracks.

The Mackerel egg survey is undertaken every 3 years by the Fisheries Ecosystems Advisory Services (FEAS) department of the Marine Institute of Ireland as part of a series of international egg surveys co-ordinated by the International Council for the Exploration of the Seas (ICES). The aim of the survey programme is to estimate the spawning stock biomass of Atlantic mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*) stocks (O'Hea, 2010). The survey is generally undertaken in two legs with leg 1 taking place in February and covering the Celtic sea, and leg 2 taking place in June and covering the waters west of Ireland and Scotland. The present survey covered waters west of Ireland and west of Scotland from 52°45'N to 58°45'N and from 4°55'W to 18°12'W. While theoretical easterly and westerly limits to the survey were set, in practice the survey was adaptive, with the absence of eggs dictating when the vessel would move to the next transect. Survey sites were at 0.5 degrees spacing, both latitudinally and longitudinally. Vessel speed while on transect or inter-transect was 5-10 knots with plankton tows conducted as speeds of 3-4 knots.

The MEGS provides a unique opportunity for surveillance of the summer distribution of cetaceans in both shelf water and deep water habitats along Ireland's Atlantic margins which can be difficult to reach by other means. The waters of Ireland's Atlantic margin are highly productive owing to the upwelling of nutrient rich oceanic waters, and support large and diverse species' assemblages (Mackey et al., 2004). The availability and distribution of prey is a key factor affecting the distribution of cetaceans, and the complex bathymetry and hydrology of the Atlantic margin maintain a heterogeneous marine environment (MCR, 2011), making it an ideal habitat for cetaceans (Wall *et al*., 2006).

In order to contribute to its current monitoring regime, the Department of Arts, Heritage and the Gaeltacht (DAHG), through the Marine Institute, commissioned the conduction of a cetacean survey from the MRV Corystes during leg 2 of the Mackerel Egg Survey (MEGS), running from 9th to 29th of June 2019.

Methodology

Given the presented survey transects (*Figure 1)*, a standard, single platform line transect survey methodology in passing mode was determined to be most suitable and was employed by the cetacean observer. Survey transect were undertaken at speeds of 5-10 knots, with horizontal plankton tows conducted at speeds of 3-4 knots. The cetacean observer's survey effort was maximized and optimized during periods of sea state less than or equal to sea state 6 and with visibility of greater than 1km. Additional visual point sampling at oceanographic sampling stations and incidental recording was also employed; however line transect survey effort was prioritised by the observers.

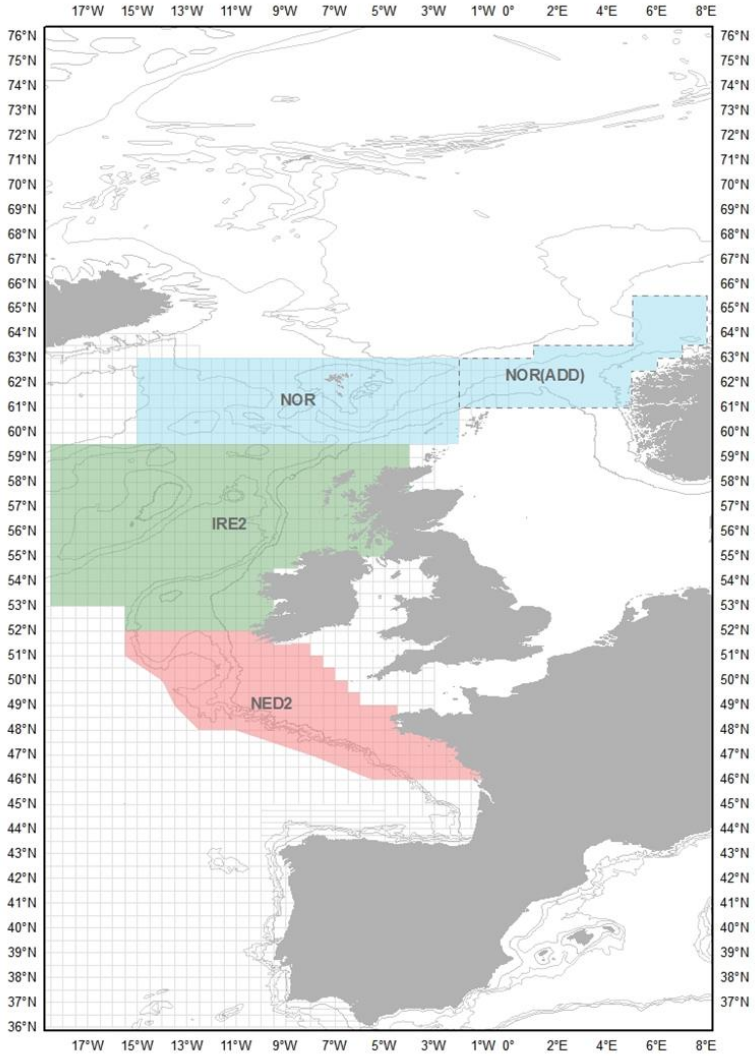

Figure 1: The planned MEGS 2019 survey area (Green) (Source: Marine Institute, 2019).

Line transect survey methodology

The data collection methodology employed was based on that originally proposed by Tasker *et al.* (1984). Although originally developed as a method for counting seabirds at sea, the method has been adapted to the surveying of cetaceans (Ó Cadhla *et al.* 2004) and has been used extensively in cetacean surveys (Berrow, S. *et al*., 2011, Hammond, 2013, Ó Cadhla *et al.* 2004, O'Donnell, C., *et al*., 2015; 2016; 2017; Pollock, *et al*., 1997, Ryan *et al.* 2010). The method used a standard single platform line transect survey design where a single experienced cetacean observer conducted visual watches from an elevated platform during daylight hours.

The observer's survey effort was maximized and optimized during the prevailing hours of daylight. Regular breaks were taken by the observer to avoid observer fatigue and its associated negative consequences. Survey effort was concentrated in periods of sea state 6 or less and in moderate or good visibility. Survey effort conducted outside of these parameters was recorded as auxiliary effort. Observations for cetaceans was conducted from the bridge wings (deck height 8.3m above sea level) or the bridge (deck height 8.3m above sea level) depending on weather conditions. Observations were preferably conducted from the bridge wings as they provided a better viewing platform. Survey effort for cetaceans was concentrated within an arc of 60^{o} either side (i.e., to port and to starboard) of the vessel's track-line but all sightings to 90^{o} both side of the track-line and further aft were also recorded. Searching for cetaceans was, predominantly, done with the naked eye, however, Nikon Prostaff 7s 8x42 binoculars and a Canon EOS 100D DSLR camera with a Canon EF 70-300mm F5-6.3 telephoto lens were used to confirm parameters such as species identification, group size and behaviour, following Ó Cadhla *et al.* 2004.

Data collection and recording

The Cybertracker (https://cybertracker.org) data collection software was configured for optimum use on the survey. Cybertracker was used to record all positional, environmental and sightings data. Using a portable GPS receiver with USB connection, the Cybertracker software automatically recorded the ships position directly into a Microsoft Access database every 5 seconds. Environmental data was recorded in Cybertracker every 15-30 minutes, and included data such as; wind speed, wind direction, sea state, swell, visibility, cloud cover and precipitation. The data was time stamped by Cybertracker and saved in the Access database. If environmental conditions changed at any point, the cetacean observer recorded an environmental update of the above listed data. Survey effort start- and end- points, together with any waypoints or other ancillary information (such as line changes, changes in survey activity, other vessel activity, etc.) were also recorded on Cybertracker.

The GPS position of each cetacean sighting was time stamped and digitally marked using Cybertracker. The distance of each sighting from the ship was estimated using a fixed interval range finder (Heinemann, 1981), while the bearing from the ship (where the ship's heading = 0°) was estimated with the aid of an appropriately positioned angle board. This data, along with data such as species identification, group size, composition, heading, sighting cues, surfacing interval, behaviour and any associations with birds or other cetaceans (Ó Cadhla *et al.* 2004), was also recorded on the time stamped Cybertracker sighting record page. Where species identification could not be confirmed, sightings were recorded at an appropriate taxonomic/ confidence level (i.e. probable, possible, unidentified whale, unidentified dolphin etc.).

Sightings were classified in one of the three following categories; 1) Primary Sighting: Any sighting which is initially detected by the observer while 'on effort', 2) Auxiliary Sighting: Any sighting occurring while the cetacean observer is 'on effort' which is initially detected by someone other than the cetacean observer and reported to the cetacean observer at the time of sighting. For all auxiliary sightings, the distance, angle and species identification was confirmed by the cetacean observer, or 3) Incidental sighting: Any sighting recorded while the cetacean observer is 'off effort' or any sighting occurring while the cetacean observer is 'on effort' which has not been independently detected by the cetacean observer and which was not reported to the cetacean observer at the time of the sighting.

Additional visual point sampling was conducted at a number of fishing stations. Observation and data recording methodology remained similar for both point sampling and line transect methods, however, as the vessel was stationary, point sampling was conducted irrespective of the ships heading. Survey effort for cetaceans was concentrated within an arc of 180^{o} but all sightings outside this arc were also recorded. The positioning of the 180^{0} arc was selected by the observer to minimize environmental factors affecting detection probability (e.g. sun glare) (Palka, 1996; Cominelli, et al., 2016).

Results

Effort

A total of 133 hours and 28 minutes of survey effort was conducted over the course of the MEGS 2019 survey. In total, 126 hours and 18 minutes of survey effort were conducted using a line transect methodology, while 1 hours and 38 minutes of effort were conducted using the point sampling methodology.

The observer's survey effort was maximized and optimized during the prevailing hours of daylight. As there was only a single observer deployed per survey leg, the maximum recorded daily survey effort was 7 hours and 51 minutes while the average daily survey effort was 6 hours and 44 minutes. Cetacean survey effort was greatly reduced on the 20th and 21st due to a port call, and on the 25th of June due to weather conditions exceeding the specified weather limits for observations. Poor weather conditions also resulted in reduced visual survey effort on a number of other occasions over the course of the survey. During these periods of unsuitable environmental conditions, casual 'off effort' watches were conducted by the observers. Cetacean survey effort was not undertaken on the 9th and 29th as the vessel was at port during daylight hours. A graph of daily effort is provided in *Figure 2 b*elow.

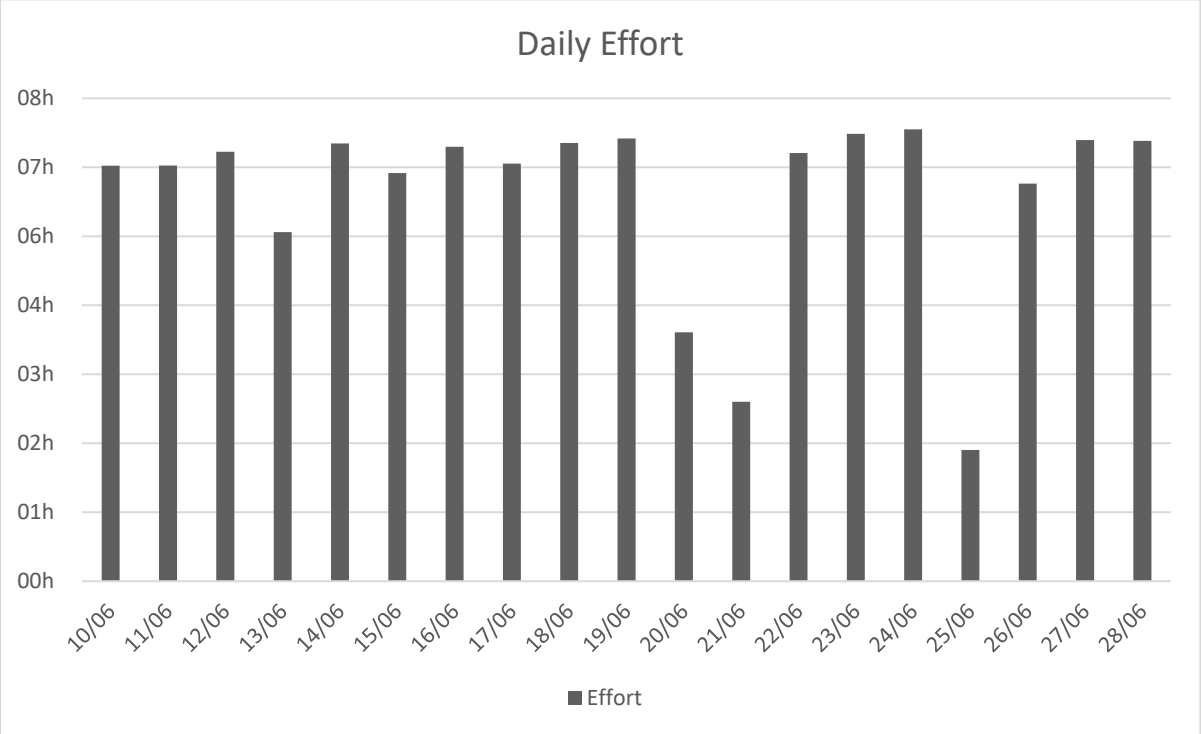

Figure 2: Daily visual effort undertaken during the survey.

Environmental Conditions

Environmental conditions were generally moderate to poor throughout the survey, however, on a number of occasions cetacean survey effort was restricted due to environmental conditions. A breakdown of key environmental factors recorded during the survey is provided hereunder.

Sea State

Sea state was recorded using both the World Meteorological Organisation (WMO) sea state scale and the Beaufort scale. The WMO scale takes account of the effect of wind, swell and currents (WMO, 2011) on the sea conditions and is judged in terms of height in meters. Beaufort sea state was recorded in terms of Beaufort wind force and was judged based on the effect of the wind and currents on the sea surface.

The most frequently recorded WMO sea state was 4, accounting for over 73 hours (57%) of observation effort. A WMO sea state of 3 accounted for over 40 hours (31%) of observation effort (*Fig. 3a*).

The most frequently recorded Beaufort sea state was also a sea state 5, accounting for almost 40 hours (31%) of survey effort, while sea state 4 and 6 each accounted for 29 hours (23%) of survey effort. Sea state 3 accounted for almost 13 hours (10%) of survey effort, while sea state 2 accounted for almost 12 hours (9%) of recorded conditions (*Fig. 3b*).

Swell

A swell height of greater than 1.1-2 meters was most frequently recorded throughout the survey, being recorded on over 72 hours (56%) of survey effort. A swell height of >2 meters accounted for 33 hours (26%) of survey effort, the remaining survey hours (23 hours / 18%) recorded a swell of 0.1-1 meters (*Fig. 3c*).

Visibility

Visibility was generally very good during cetacean survey effort. The most frequently recorded visibility was 16-20km, being recorded over 84 hours (66%) of survey effort, while visibility of 11-15km was recorded over 34 hours (27%) of survey effort (*Fig. 3d*).

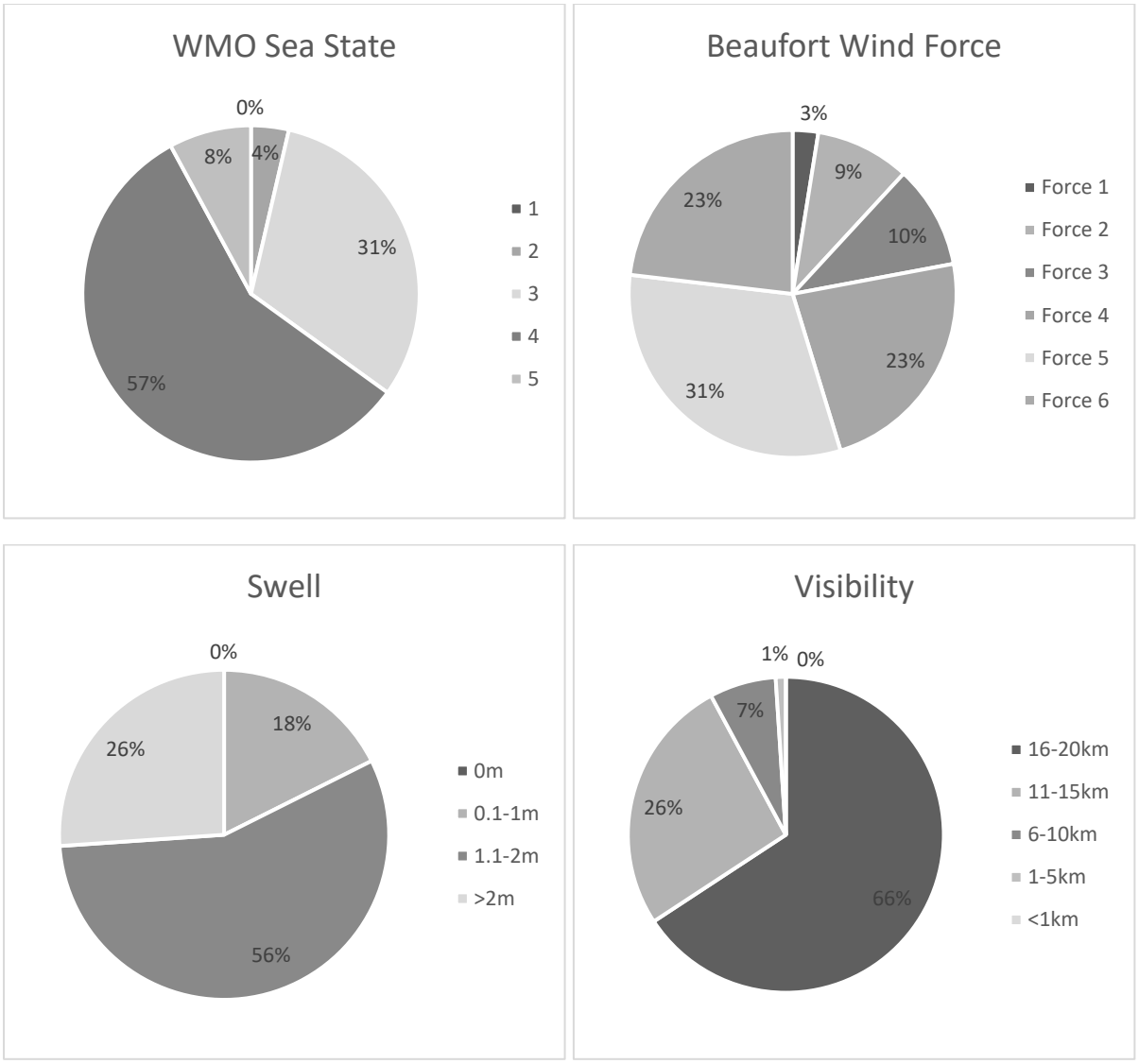

Figure 3: Summary of environmental conditions recorded on the MEGS 2019; a) WMO sea state, b) Beaufort sea state/ wind force, c) Swell height (meters), d) Visibility (kilometres).

Sightings

A total of 65 sightings were recorded on the survey, reaching a total of 205 individuals across all sighting types and taxa. A summary of all sightings recorded on the survey is presented in *Table 2* and includes primary, auxiliary and incidental sightings of all megafauna groups recorded during line transect and point sampling effort watches as well as those recorded while 'off effort'.

53 cetacean sightings were recorded during the survey. The cetacean sightings included; 2 whale species, 6 dolphin species, 1 porpoise species and a number of sightings which could not be identified to species level.

11 pinniped sightings were recorded on the survey, 6 sightings were identified as grey seals (*Halichoerus grypus*), while a further 5 sightings could not be identified to species level.

The remaining sighting consisted of an incidental sighting of a single probable basking shark (*Cetorhinus maximus*).

Table 2: Summary of all sightings recorded on the survey, including primary, auxiliary and incidental sightings of all megafauna groups

Common Name	*Species name*	*No. of Sightings*	*No. of individuals*	*Group Size*
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	1	5	5
Bottlenose dolphin	*Tursiops truncatus*	1	1	1
Common dolphin	*Delphinus delphis*	8	56	1-30
Fin or Sei whale	*Balaenoptera physalus/borealis*	1	1	1
Harbour Porpoise	*Phocoena phocoena*	1	1	1
Killer whale	*Orcinus orca*	1	1	1
Long finned pilot whale	*Globicephala melas*	9	64	1-20
Minke whale	*Balaenoptera acutorostrata*	11	14	1-2
White beaked dolphin	*Lagenorhynchus albirostris*	1	4	4
Unidentified cetacean	*Cetacea sp.*	3	4	1-2
Unidentified dolphin	*Delphinid sp.*	10	32	1-10
Unidentified large whale		6	6	1
	Total	**53**	**189**	
Grey Seal	*Halichoerus grypus*	6	6	1
Unidentified Seal	*Phocid sp.*	5	9	1-5
	Total	**11**	**15**	
Basking shark	*Cetorhinus maximus*	1	1	1
	Total	**1**	**1**	

Sightings were classified in one of the three following categories; 1) Primary Sighting: Any sighting which is initially detected by the observer while 'on effort', 2) Auxiliary Sighting: Any sighting occurring while the cetacean observer is 'on effort' which is initially detected by someone other than the cetacean observer, or 3) Incidental sighting: Any sighting recorded while the cetacean observer is 'off effort' or any sighting occurring while the cetacean observer is 'on effort' which has not been independently detected by the cetacean observer.

From the total of 65 sightings, 34 (52.3%) were recorded as primary sightings, 6 (9.2%) were recorded as auxiliary sightings, while 25 (38.5%) were recorded as incidental sightings. Incidental sightings could be recorded while the cetacean observer was either 'on' or 'off' effort. All of the 25 incidental sightings recorded during the survey were recorded while 'off effort'.

Of the total 65 sightings, 40 (61.5%) were recorded while conducting line transect watches, while 25 sightings (38.5%) were recorded 'off effort'. No sightings were recorded while conducting a point sampling watch. From the 40 sightings recorded during line transect effort, 34 (85%) were recorded as primary sightings and 6 (15%) were recorded as auxiliary. A breakdown of all species encountered during line transect effort watches is presented in *Table 3* and includes all marine mammal sightings.

Table 3: Summary of all sightings recorded during line transect effort on the survey, including primary, auxiliary and incidental sightings.

Common Name	*Species name*	*Primary sightings*	*Auxiliary sightings*	*Incidental Sightings*
Common dolphin	*Delphinus delphis*	5	1	0
Fin or Sei whale	*Balaenoptera physalus/borealis*	1	0	0
Killer whale	*Orcinus orca*	0	0	0
Long finned pilot whale	*Globicephala melas*	4	1	0
Minke whale	*Balaenoptera acutorostrata*	6	2	0
White beaked dolphin	*Lagenorhynchus albirostris*	1	0	0
Unidentified dolphin	*Delphinid sp.*	8	0	0
Unidentified large whale		1	2	0
	Total	**26**	**6**	**0**
Grey Seal	*Halichoerus grypus*	5	0	0
Unidentified Seal	*Phocid sp.*	3	0	0
	Total	**8**	**0**	**0**

Point sampling was conducted at 4 fishing stations. No sightings were recorded during these point sampling watches.

A total of 25 sightings were recorded while 'off effort' during the survey (*Table 4*). As no effort was being recorded when these animals were detected, each sighting was recorded as an incidental sighting.

Table 4: Summary of all sightings recorded while 'off effort' during the survey.

Common Name	*Species name*	*Incidental Sightings*
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	1
Bottlenose dolphin	*Tursiops truncatus*	1
Common dolphin	*Delphinus delphis*	2
Harbour Porpoise	*Phocoena phocoena*	1
Killer whale	*Orcinus orca*	1
Long finned pilot whale	*Globicephala melas*	4
Minke whale	*Balaenoptera acutorostrata*	3
Unidentified cetacean	*Cetacea sp.*	3
Unidentified dolphin	*Delphinid sp.*	2
Unidentified large whale		3
	Total	**21**
Grey Seal	*Halichoerus grypus*	1
Unidentified Seal	*Phocid sp.*	2
	Total	**3**
Basking shark	*Cetorhinus maximus*	1
	Total	**1**

The distribution of all sightings of marine mammals and other marine megafauna recorded during the survey effort can be seen in *Figures 4 -7.*

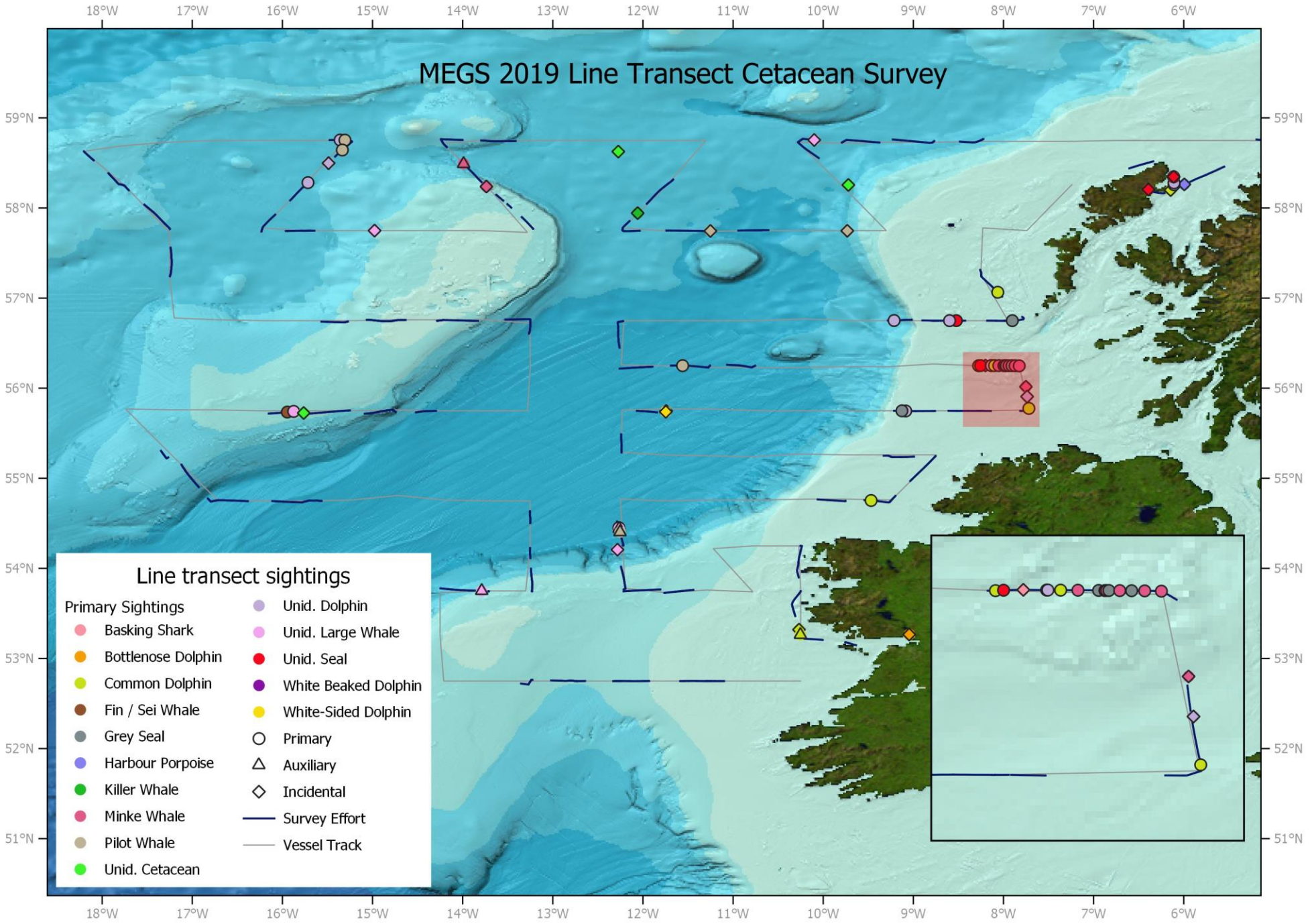

Figure 4: Distribution of all marine mammal and megafauna sightings recorded during the survey. Cetacean survey effort transects are overlaid on the vessels track line.

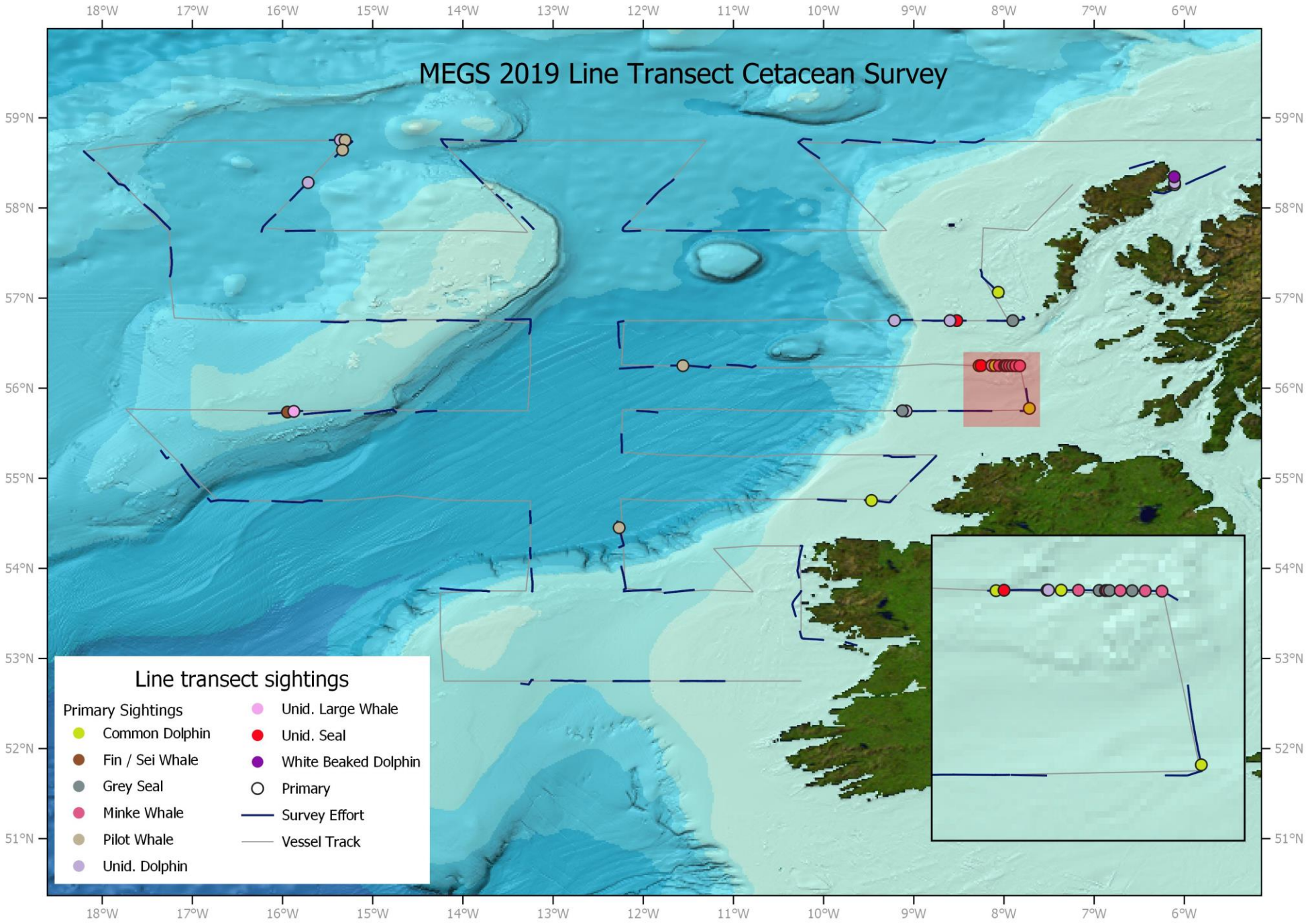

Figure 5: Distribution of all primary sightings recorded during line transect watches on the survey. Cetacean survey effort transects are overlaid on the vessels track line.

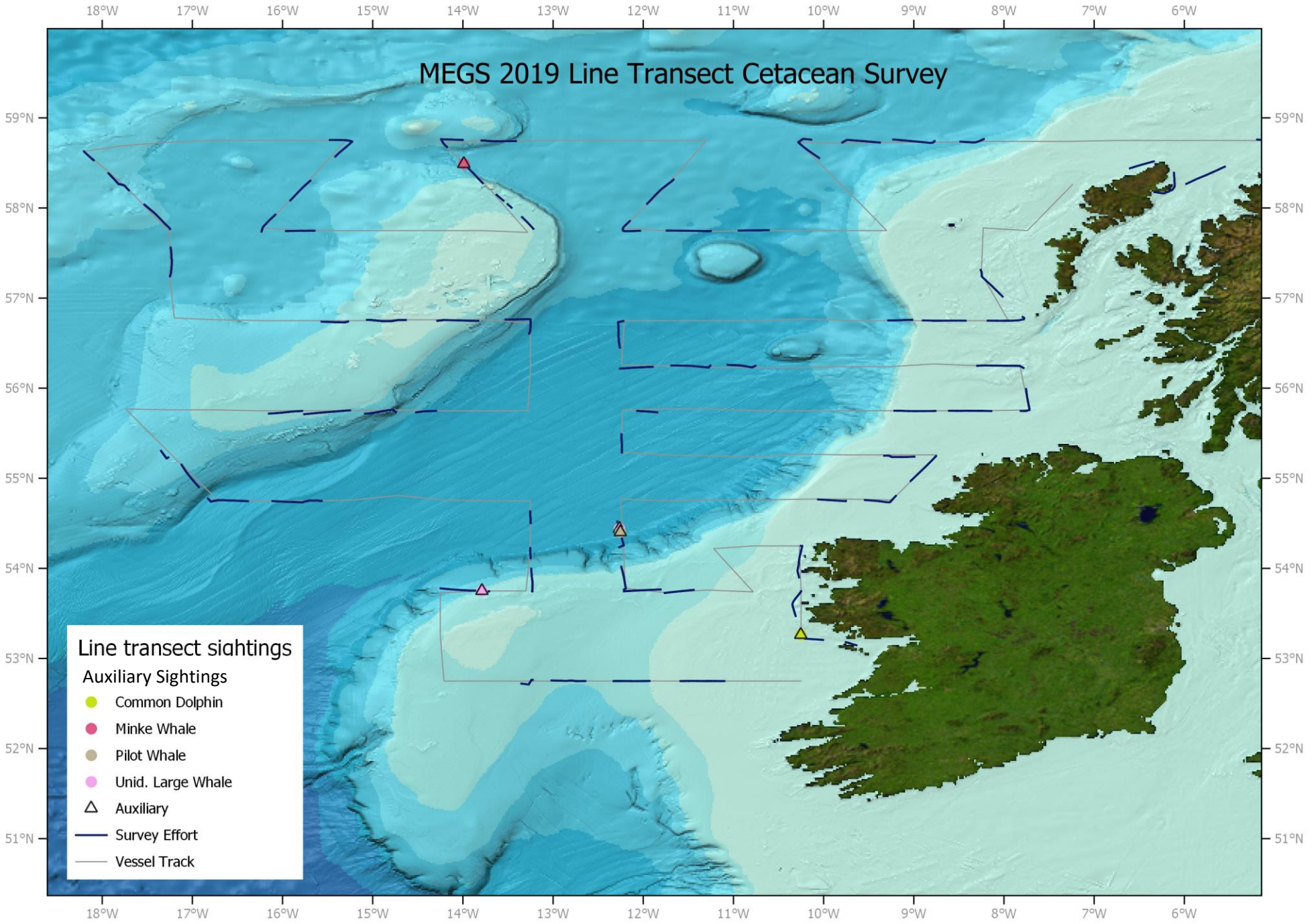

Figure 6: Distribution of all auxiliary sightings recorded during line transect watches on the survey. Cetacean survey effort transects are overlaid on the vessels track line.

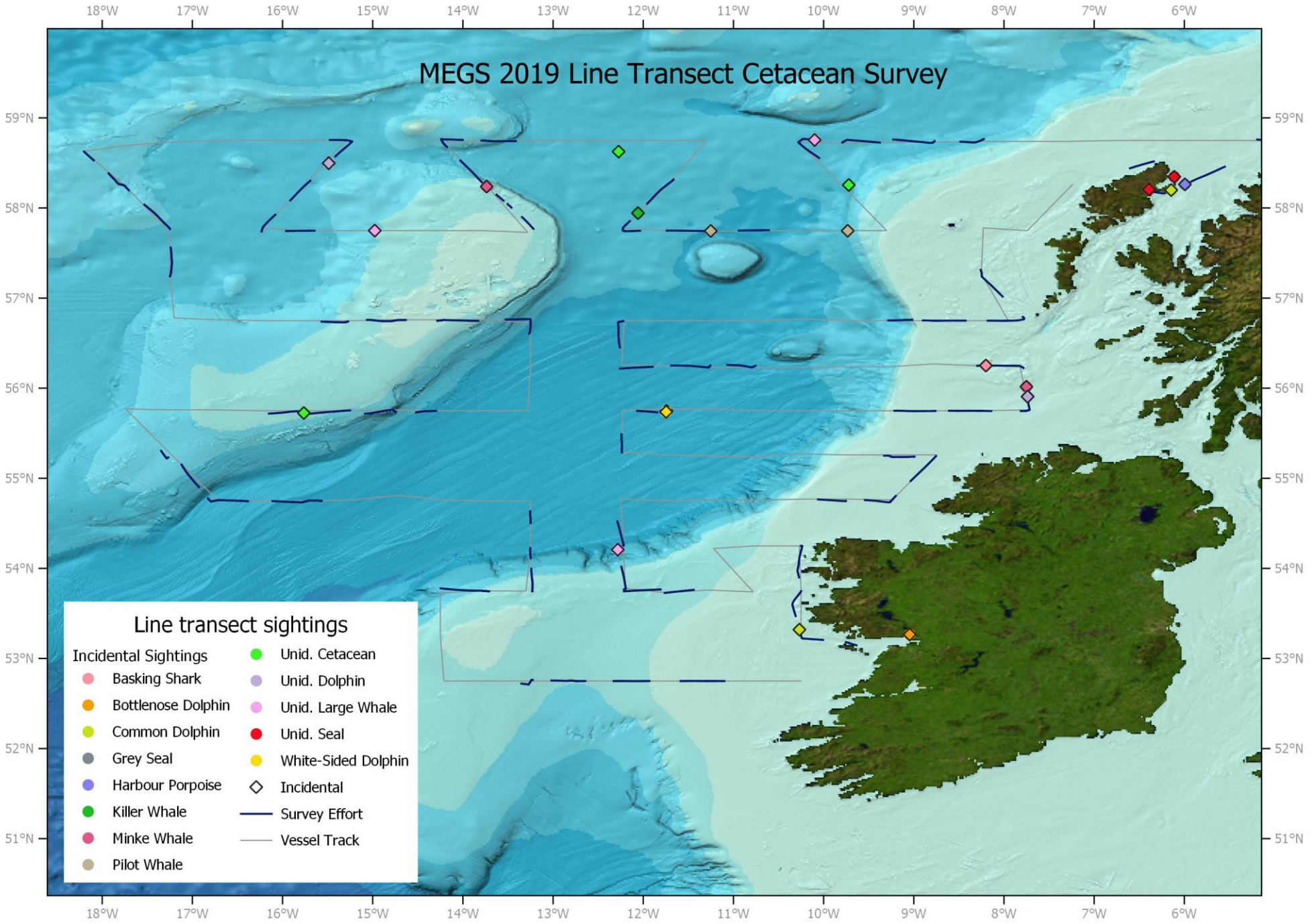

Figure 7: Distribution of all incidental sightings recorded throughout the survey. Cetacean survey effort transects are overlaid on the vessels track line.

Minke whales (*Balaenoptera* acutorostrata) were the most frequently encountered species accounting for 11 sightings (17% of all sightings) comprising of 14 individuals in total (7% of encountered individuals). Minke whales were frequently encountered on the more northerly transects in to the west and north of Ireland (north of approximately 56^0N). Particularly high abundances were observed on Stanton bank, where 8 of the 11 minke whale sightings and 11 of the 14 individuals were recorded. Another area of note for minke whale sightings were the northern slopes of the Rockall bank area where two sightings were recorded.

Unidentified dolphin (*Delphinid sp.*) were the second most frequently observed and third most abundant species group. Unidentified dolphins were encountered on 10 occasions, accounting for 15% of all sightings. These sightings, including the mixed species sighting, consisted of a total of 32 individuals (16% of all encountered individuals) with a group size range of 1-10 individuals (mean group size of 3 individuals).

The third most frequently observed species were pilot whales (*Globicephala melas*). Pilot whales were encountered on 9 occasions, accounting for 14% of all sightings. Pilot whales were also the most abundant species encountered, accounting for 31% of all individuals counted (64 individuals). Of the 9 pilot whale sightings, 3 were recorded within two hours on 16/06/19 in the waters north west of Hatton bank. A further 4 sightings were recorded in this area over the course of the day and included 3 sightings of unidentified dolphins and 1 sighting of an unidentified large whale.

The second most abundant species were common dolphins (*Delphinus delphis*). Common dolphins accounted for 27% of all individuals counted (56 individuals) during the 8 sightings of the species. Of the 8 sightings, 3 occurred in the Stanton bank area concurrent with the high density of minke whale sightings mentioned above.

Other delphinid species encountered included bottlenose dolphin (*Tursiops truncatus*), Atlantic white-sided (*Lagenorhynchus acutus*), white-beaked dolphin (*Lagenorhynchus albirostris*) and orca (*Orcinus orca*), with 1 sighting of each species recorded.

A numbered of sightings of large whale were also recorded during the survey, unfortunately these animals could not be identified to species level due to distance and/or environmental conditions. One such sighting was identified as a fin/sei whale (*Balaenoptera physalus/ borealis*), however due to poor sea state, definitive identification was not possible.

The grey seal (*Halichoerus grypus*) was sighted on 6 occasions, with each sighting comprising of a single individual. Unidentified seals were recorded on 5 occasions. Four of these sightings consisted of a single individual, while 1 sighting recorded a group of 5 individuals hauled out on rocks at Stornoway.

A single elasmobranch species was also encountered. It was an incidental sighting recorded by a crew member who identified it as a probable basking shark (*Cetorhinus maximus*).

Discussion

As in previous fisheries surveys in Irish waters, a large number of sightings, from a broad range of taxa and species groups, and a high abundance of animals were observed over the course of the present survey. In total, 10 different marine mammal species were identified on MEGS 2019. Minke whale, common dolphin and pilot whale were the most commonly encountered and most abundant species recorded in the current survey. These species have also been commonly encountered in other recent cetacean surveys aboard the Celtic Explorer. Minke whales were the most commonly encountered cetacean species during the Western European Shelf Pelagic Acoustic Survey (WESPAS) in 2018 (Power and O'Sullivan, 2018b), while common dolphins were the most frequently encountered species during WESPAS 2019 (Power, 2019). The WESPAS is an annual survey covering shelf waters around Ireland's Atlantic coasts conducted during June and July, overlapping with some of the shelf waters surveyed during MEGS. Pilot whales were among the most commonly encountered and abundant species on the Blue Whiting Acoustic Survey (BWAS) in 2018 (Power and O'Sullivan, 2018a). The BWAS is conducted annually in deep water habitats along Ireland's Atlantic margins, overlapping with some of the deeper waters surveyed during MEGS.

The sighting rate and species recorded in this year's MEGS compare well with those recorded during leg 2 of the 2016 survey which covered a similar survey area. In total 65 sightings were recorded in 2019 while 66 sightings were recorded in 2016 (*Table 5*). This year saw 8 cetacean species' and 1 seal species recorded, while on the 2016 survey there were 10 cetacean species' and 1 seal species encountered. Fin whale, Sowerby's beaked whale (*Mesoplodon bidens*) and sperm whale (*Physeter macrocephalus*) were each recorded in 2016 but were not recorded in this year's survey. While Atlantic white-sided dolphin were recorded in the present survey but were not sighted during leg 2 of MEGS 2016. It should be noted that there were substantial differences between the two surveys in the total survey effort, number of observers deployed and recorded environmental conditions. In 2016, two observers were deployed and recorded a total of 210 hours of survey effort, while this year a single observer was deployed, recording 133 hours of survey effort. The environmental conditions recorded varied widely also. The weather conditions were generally very good during the 2016 survey, with a Beaufort sea state of 3 or less recorded on over 70% of the survey. In comparison, the weather this year was quite poor with a Beaufort sea state of 4 or greater recorded for 77% of the survey and a Beaufort sea state of 5 or greater recorded over 54% of the survey. The inclement weather conditions encountered during the survey, particularly sea states of 4 or greater, likely affected the detection probability of many species, particularly those with inconspicuous surfacing behaviours (Palka, 1996; Cominelli, et al., 2016), such as beaked whales and harbour porpoise. The poor weather conditions also impacted negatively on species identification, leading to increased numbers of sightings recorded as unidentified large whale or unidentified dolphin.

Table 5: Cetacean sighting records from the Mackerel Egg Surveys in 2016 and 2019 (Craig, et al., 2016).

		2019		**2016**	
Common Name	*Species name*	*No. of Sightings*	*No. of individuals*	*No. of Sightings*	*No. of individuals*
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	1	5	-	-
Bottlenose dolphin	*Tursiops truncatus*	1	1	2	4
Common dolphin	*Delphinus delphis*	8	56	14	129
Fin or Sei whale	*Balaenoptera physalus/borealis*	1	1	-	-
Fin whale	*Balaenoptera physalus*	-	-	7	12
Harbour Porpoise	*Phocoena phocoena*	1	1	3	4
Killer whale	*Orcinus orca*	1	1	1	1
Long finned pilot whale	*Globicephala melas*	9	64	7	46
Minke whale	*Balaenoptera acutorostrata*	11	14	7	7
Sowerby's beaked whale	*Mesoplodon bidens*	-	-	2	3
Sperm whale	*Physeter macrocephalus*	-	-	6	8
White beaked dolphin	*Lagenorhynchus albirostris*	1	4	2	9
Unidentified cetacean	*Cetacea sp.*	3	4	-	-
Unidentified dolphin	*Delphinid sp.*	10	32	1	1
Unidentified whale		-	-	5	5
Unidentified large whale		6	6	-	-
	Total	**53**	**189**		
Grey Seal	*Halichoerus grypus*	6	6	9	10
Unidentified Seal	*Phocid sp.*	5	9	-	-
	Total	**11**	**15**	**9**	**10**
Basking shark	*Cetorhinus maximus*	1	1	-	-
	Total	**1**	**1**	**-**	**-**

The sightings recorded during MEGS 2019 were observed to be quite patchy for a number of species, as can be seen from *Figures 4-7*. Stanton bank, in particular showed an impressive abundance and diversity of marine mammal species. Intense marine mammal and sea bird activity was observed in the area, suggesting high prey availability. A total of 20 marine mammal sightings were recorded while surveying Stanton bank. These consisted of 8 sightings of minke whales (11 individuals in total), 3 common dolphin sightings, totalling 42 individuals, as well as a further 3 sightings of unidentified dolphins. 4 sightings of solitary grey seals were also recorded, as well as a further 2 sightings of individual unidentified seals.

A number of auxiliary sightings were recorded during line transect watches in the present survey. All 6 auxiliary sightings (18% of line transect sightings) were initially detected by crew members during line transect watches. A total of 25 incidental sightings (38% of all sightings) were recorded on the survey, all of which were recorded while the cetacean observer was 'off effort'. 20 (80%) were

recorded by members of the ships' crew, while the cetacean observer detected the remaining 5 (20%). These incidental sightings were recorded either during periods of unfavourable environmental conditions or outside of the cetacean observers shift.

The occurrence of 'on effort' auxiliary sightings may indicate the existence of some perception bias (Marsh and Sinclair 1989), where animals surface within the visual range of the cetacean observer but are not detected (Barlow, 2015) and/or availability bias (Marsh and Sinclair 1989), where animals within the survey area are not visible to the observer (Barlow, 2015). However it is not possible to determine to what extent this may have occurred as the proportion of the auxiliary sightings which would have been detected by the cetacean observer in the absence of other crew cannot be ascertained. The presence of perception and availability bias has implications for the calculation of g(0) and thus puts constraints on the use of the data set from the present survey for any future determination of absolute abundances.

The use of a single cetacean observer further exacerbates the issue of perception bias and leads to higher auxiliary and incidental sighting rates. The use of paired cetacean observers conducting simultaneous visual watches (one observing to port, while the other observers to starboard) would have a positive impact in reducing perception bias in future surveys. Ideally a third observer would be used to record data, as it is not possible to maintain a constant visual watch while also recording data. Considering the long day length at these latitudes during the summer months, the use of a single observer also leads to a large amount of time 'off effort', and thus, an increase in incidental sightings.

The MEGS provides an excellent opportunity for the collection of data on the summer distribution, abundance and behaviour of cetaceans in both Irish continental shelf and deep water habitats. However, the amount and quality of data collected is confounded by factors such as environmental conditions and cetacean survey design. The use of a larger dedicated cetacean team on future surveys could improve data collection and contribute to a more robust dataset, to better inform policy decisions and advance the scientific understanding of cetaceans in Ireland's shelf water habitats. The additional use of PAM could have a positive effect on the detection rate and could help over-come some of the issues surrounding the visual detection of certain species in poor sea states (MCR, 2011; Ryan, *et al.,* 2012).

Recommendations

An increase to the number of cetacean observers on-board would be recommended for this survey. The use of three cetacean observers would allow a rotational system of two cetacean observers on-effort, while one observer records data. This approach would increase effort coverage of the survey area but would not be sufficient to cover all daylight hours. This approach could be used to conduct survey effort over a 10-12 hour period but with breaks in effort required during meal times and for rest periods to avoid observer fatigue.

To maximize the potential of the survey, a team of six cetacean observers would be required. This would allow the survey to be conducted using two teams of three working on opposite shifts. This approach should allow full coverage of all survey areas during daylight hours with two observers maintaining a visual watch at all times. However, the authors appreciate the constraints on using such a large cetacean survey team.

Both approaches outlined above would facilitate more sufficient coverage, which should increase the chances of detecting animals, while also ensuring that all cetacean observers get sufficient breaks/periods of rest. Sufficient breaks/periods of rest are highly important for cetacean observers for maintaining full concentration during all effort times and not becoming at risk of suffering fatigue.

It would also be recommended to incorporate PAM into the survey design. Given the survey tracks, the MEGS is an ideal survey for collecting data on the summer distribution of cetaceans in Irish shelf waters. However, weather conditions are not always conducive to visual observations. The addition of PAM would be an excellent supplement to visual observations and would remove all down time due to weather as PAM can collect data irrespective of all but the most severe weather. Furthermore, the use of PAMguard's Logger forms would allow a single cetacean observer to act as both PAM operator and data recorder simultaneously. The quantity and quality of data collected could thereby be greatly increased with the use of either three of six cetacean observers.

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