EMFF Operational Programme 2014-2020

Marine Biodiversity Scheme

Marine Institute Cetacean Monitoring

During the Western European Shelf Pelagic Acoustic Survey. June - July 2018

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
This measure is part-financed by the European Maritime and Fisheries Fund

Foras na Mara
Marine Institute

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Marine Institute

EMFF

Stradbally, Castlegregory, Tralee, Co. Kerry

Email: enquiries@emeraldmarine.eu

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 Celtic Explorer during the annual Western European Shelf Pelagic Acoustic Survey (WESPAS), running from 9th to 28th of June and the 3rd to 24th July 2018.

A standard, single platform line transect survey methodology was employed by the cetacean survey team 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 2-3 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 272 hours and 18 minutes of survey effort was conducted over the course of the WESPAS 2018 survey, 132 hours and 45 minutes of survey effort was conducted on Leg 1, while 139 hours and 33 minutes of survey effort was conducted on Leg 2 of the survey. In total, 255 hours and 25 minutes of survey effort were conducted using a line transect methodology, while 16 hours and 52 minutes of effort were conducted using the point sampling methodology.

A total of 171 sightings, were recorded throughout the survey. This includes 47 sightings recorded as auxiliary sightings and 42 sightings recorded as incidental sightings. From the total 171 sightings, marine mammals accounted for 132 sightings. Decomposing marine mammal carcasses were also sighted on two occasions. The remaining 37 sightings consisted of other marine megafauna. The marine mammal sightings included; 2 whale species, 6 dolphin species, 1 seal species, and a number of sightings which could not be identified to species level. Mixed species sightings were recorded on two separate occasions.

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.,* 2014). 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, 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 WESAPS is an acoustic survey undertaken by the Fisheries Ecosystems Advisory Services (FEAS) department of the Marine Institute of Ireland. The survey has been undertaken annually since 2016 with the present survey being the third survey in the series. Prior to 2016, the survey was organised as two separate surveys; the Malin Shelf acoustic survey and the boarfish survey. The Malin Shelf acoustic survey has been carried out annually since 2008 and reports on the annual abundance of summer feeding aggregations of herring to the west of Scotland and to the north and west of Ireland from 54°N to 58°30'N (O'Donnell, et al., 2017). The boarfish survey was carried out from 2011 using a chartered fishing vessel and reports on the abundance of spawning aggregations of boarfish from 47°N to 57°N (O'Donnell, et al., 2017). Since 2016, these surveys were combined and undertaken on-board the RV *Celtic Explorer* over a 42 day period during the summer months under the unified Western European Shelf Pelagic Acoustic Survey title. The WESPAS provides stratified relative stock abundance estimates of herring (*Clupea harengus*), boarfish (*Capros aper*) and horse mackerel (*Trachurus trachurus*) as part of a national stock assessment (O'Donnell, et al., 2017).

The WESPAS provides a unique opportunity for surveillance of the summer distribution of cetaceans in shelf 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 Celtic Explorer during the annual Western European Shelf Pelagic Acoustic Survey (WESPAS), running from 9th to 28th of June and the 3rd to 24th July 2018.

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 survey team. Survey transect were undertaken at speeds of 5-10 knots, with fishing activity being conducted at speeds of 2-3 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.

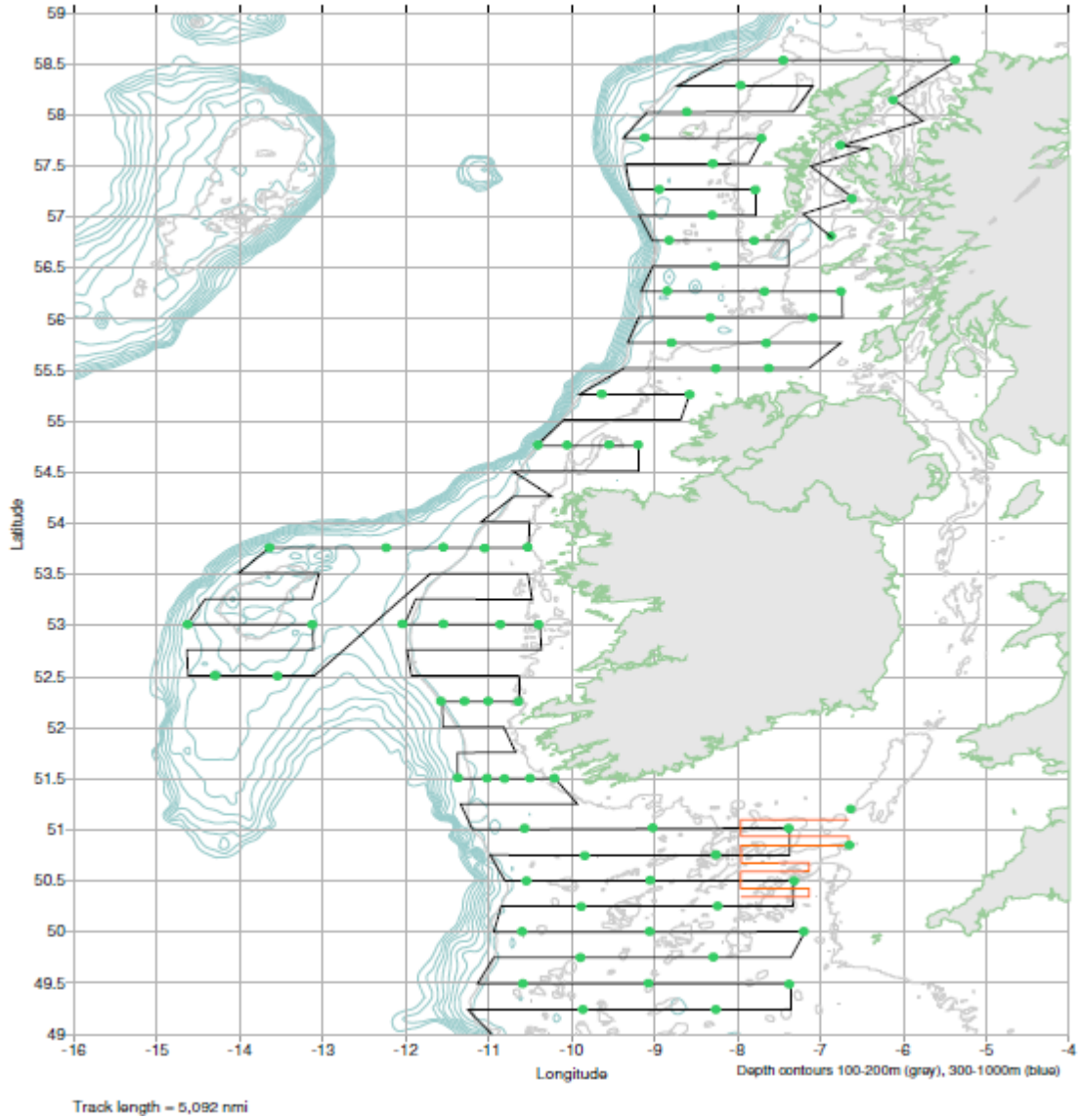

Figure 1: The planned WESPAS 2018 cruise track showing locations of oceanographic stations and additional survey effort strata in the Celtic sea (Source: Marine Institute, 2018).

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 cetacean survey team included two experienced observers, with one observer deployed on each survey leg.

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 crow's nest (deck height 17 m above sea level) or the bridge (deck height 10 m above sea level) depending on weather conditions. Observations were preferably conducted from the crow's nest, as greater platform height increases detection probability (Cominelli, et al., 2016), however, as in previous surveys aboard the R.V. Celtic Explorer, access to the crow's nest was dependent on weather conditions (O'Donnell, *et al*., 2015; 2016). 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 7D DSLR camera with a Sigma AF 100-400mm F5-6.3 DG OS HSM 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 IFAW Logger 2000™ (IFAW, 2000) data collection software was configured for optimum use on the survey. Logger was used to record all positional, environmental and sightings data. Using a portable GPS receiver with USB connection, the Logger software automatically recorded the ship's position directly into a Microsoft Access database every 10 seconds. The input of environmental data was automatically prompted by Logger every 15 minutes, at which point the cetacean observer input data such as; wind speed, wind direction, sea state, swell, visibility, cloud cover and precipitation. The data was then time stamped by Logger and saved in the Access database. If environmental conditions changed at any point, the cetacean observer on watch input 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 using Logger's environmental update tab.

The GPS position of each cetacean sighting was time stamped and digitally marked using Logger. 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 Logger 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 was initially detected by the observer while 'on effort', 2) Auxiliary Sighting: Any sighting occurring while the cetacean observer was 'on effort' which was 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 was 'off effort' or any sighting occurring while the cetacean observer was 'on effort' which was not 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 oceanographic sampling 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 272 hours and 18 minutes of survey effort was conducted over the course of the WESPAS 2018 survey, 132 hours and 45 minutes of survey effort was conducted on Leg 1, while 139 hours and 33 minutes of survey effort was conducted on Leg 2 of the survey. In total, 255 hours and 25 minutes of survey effort were conducted using a line transect methodology, while 16 hours and 52 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 8 hours and 38 minutes while the average daily survey effort was 7 hours and 9 minutes. No effort watches were conducted on the 22nd of July as the vessel was stationary within Killary harbour for calibration of the vessel's acoustic survey equipment. Cetacean survey effort was greatly reduced on the 14th of July 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 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 also restricted on the 3rd and 23rd of July due to transiting to/from port. A graph of daily effort is provided in *Figure 2 b*elow.

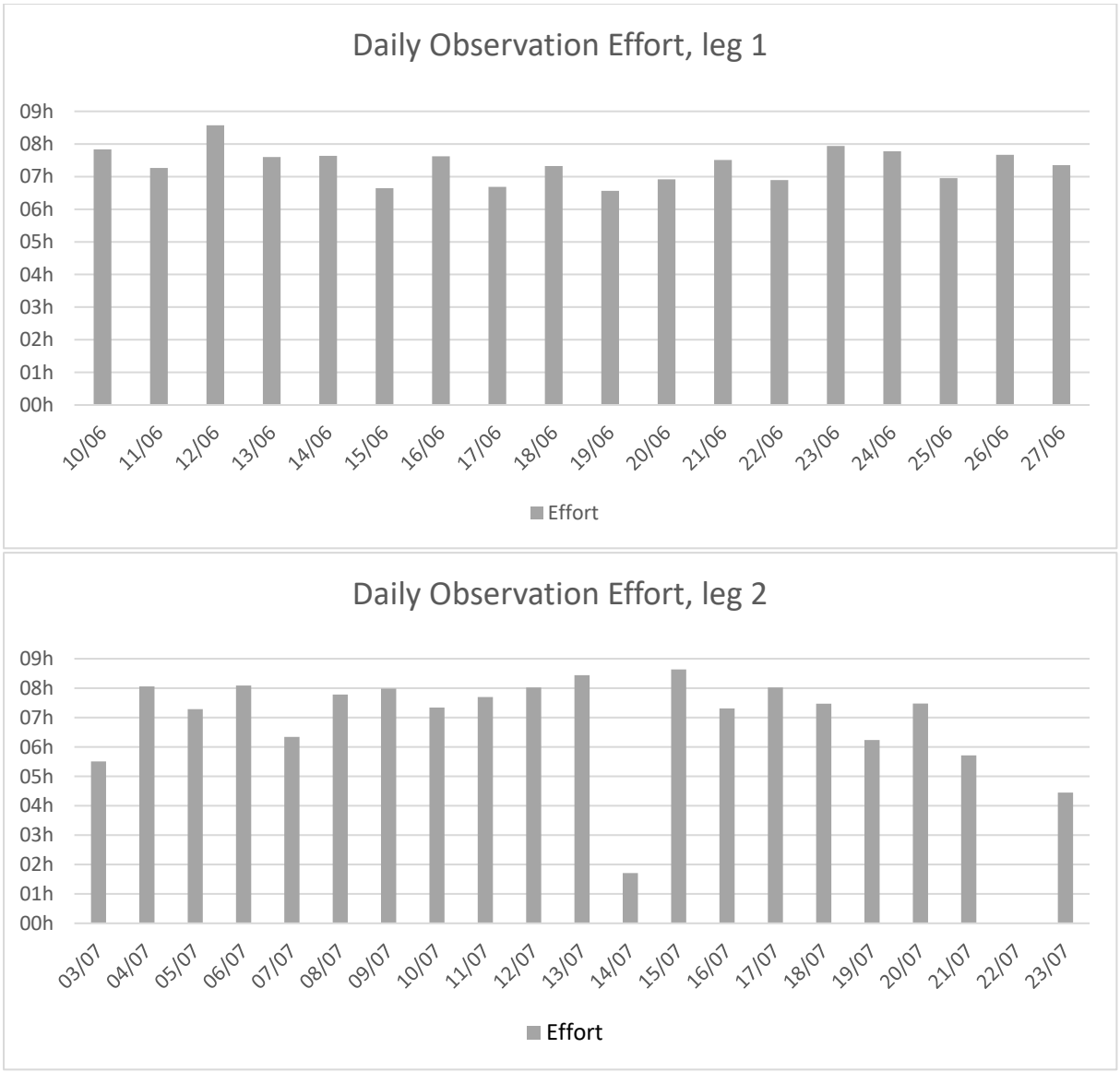

Figure 2: Daily visual effort undertaken during the survey.

Environmental Conditions

Environmental conditions were generally moderate to very good throughout the survey, however, on a number of occasions cetacean survey effort was restricted due to environmental conditions. Environmental conditions were recorded a total of 1698 times over the course of the survey. 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 differs from the Beaufort scale in that it 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 155 hours (57%) of observation effort. WMO sea state 3 accounted for over 77 hours (29%) of observation effort (*Fig. 3*).

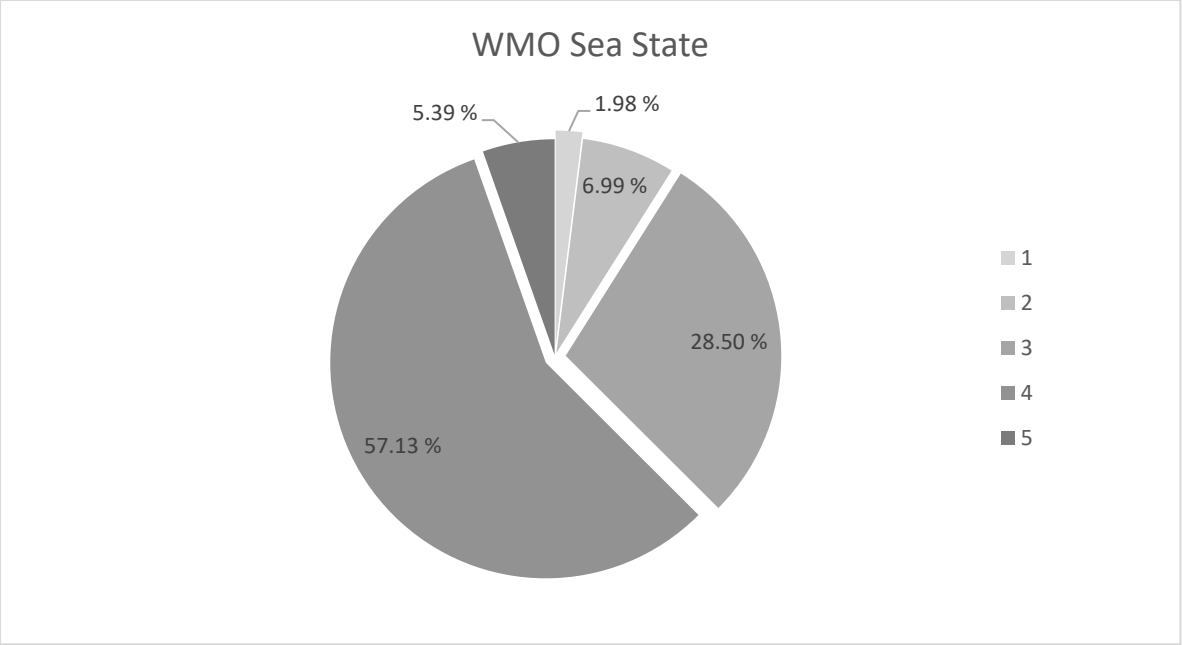

Figure 3: WMO sea state recorded during survey effort.

The most frequently recorded Beaufort sea state was also a sea state 4, accounting for over 104 hours (38%) of survey effort, while sea state 3 accounted for 57 hours (21%) of survey effort and sea state 5 accounted for 46 hours (17%) of survey effort. Sea state 2 was also frequently recorded, accounting for 36 hours (13%) of recorded conditions (*Fig. 4*).

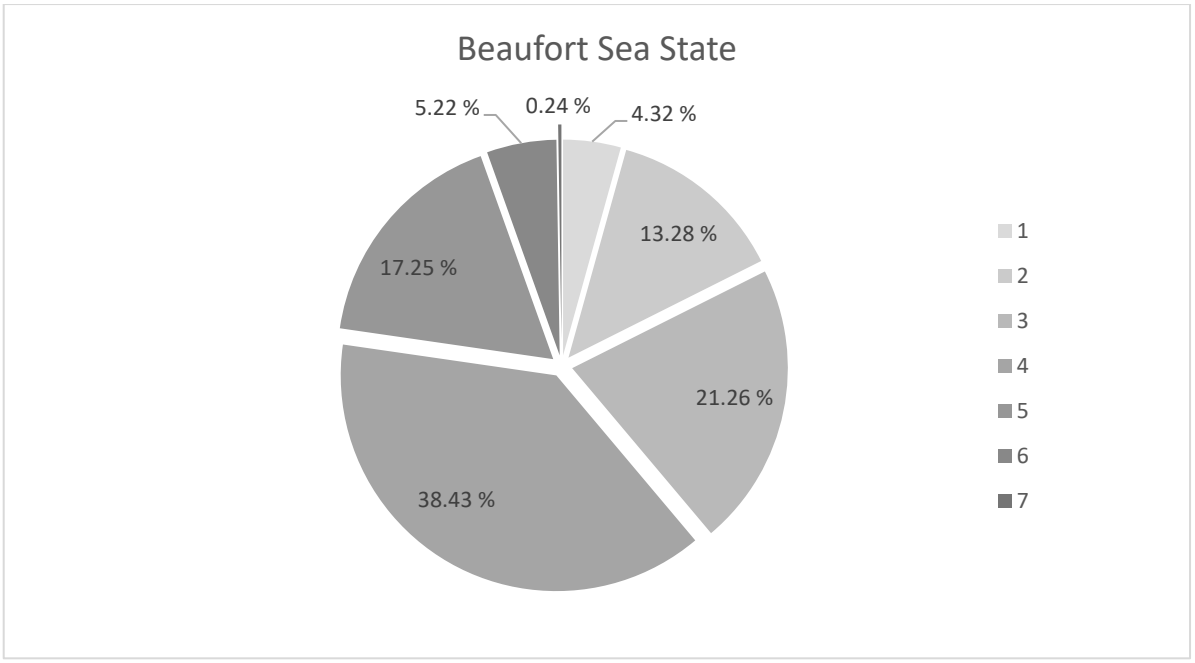

Figure 4: Beaufort sea state recorded during survey effort.

Swell

A swell height of greater than 1.1-2 meters was most frequently recorded throughout the survey, being recorded on over 152 hours (56%) of survey effort. A swell height of 0.1-1 meters accounted for the majority of the remaining survey hours (78 hours / 29%) (*Fig. 5*).

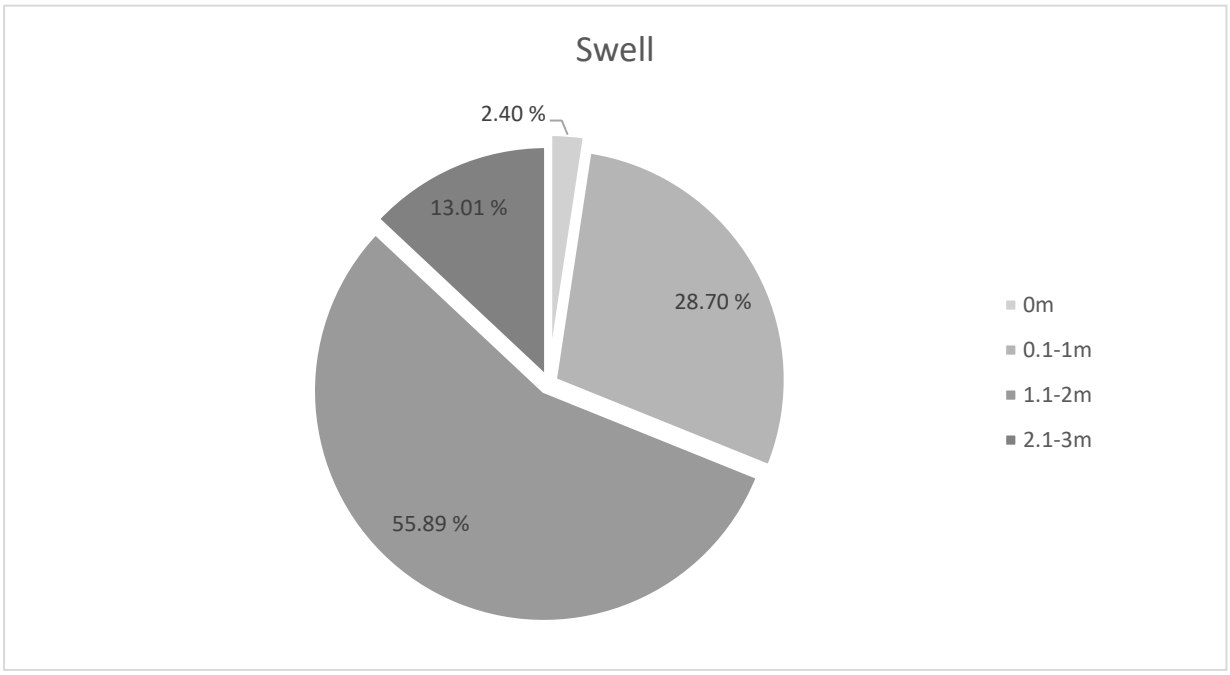

Figure 5: Swell height recorded during survey effort.

Visibility

Visibility was generally very good during cetacean survey effort. The most frequently recorded visibility was 11-15km, being recorded over 159 hours (58%) of survey effort, while visibility of 16-20km was recorded over 57 hours (21%) of survey effort (*Fig. 6*).

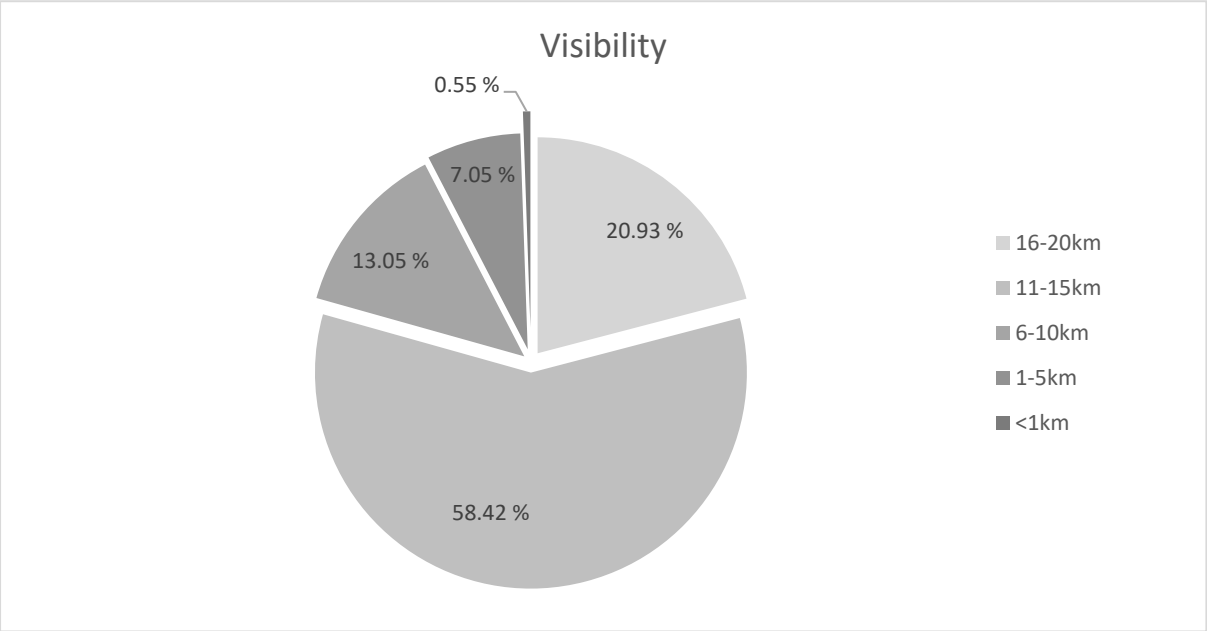

Figure 6: Visibility recorded during survey effort.

Sightings

A total of 171 sightings were recorded on the survey, reaching a total of 995 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 megafaunal groups recorded during line transect and point sampling effort watches as well as those recorded while 'off effort'.

128 cetacean sightings were recorded during the survey. The cetacean sightings included; 2 whale species, 6 dolphin species and a number of sightings which could not be identified to species level. Mixed species cetacean sightings were recorded on two separate occasions.

Five pinniped sightings were recorded on the survey, 3 sightings were identified as grey seals (*Halichoerus grypus*), while a further 2 sightings could not be identified to species level.

Decomposing marine mammal carcasses were also sighted on two occasions.

The remaining 36 sightings consisted of other marine megafauna. Species' of other marine megafauna encountered on the survey, included 3 species of shark, leatherback turtles (*Dermochelys coriacea*), and ocean sunfish (*Mola mola*).

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

Common Name	Species name	No. of Sightings	No. of individuals	Group Size
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	1	3	3
Bottlenose dolphin	*Tursiops truncatus*	5	105	8-45
Common dolphin	*Delphinus delphis*	33	368	2-50
Common/ striped dolphin	*D. delphis/ S. coeruleoalba*	1	1	1
Humpback whale	*Megaptera novaeangliae*	1	1	1
Long finned pilot whale	*Globicephala melas*	3	20	4-11
Minke whale	*Balaenoptera acutorostrata*	43	51	1-8
Mix (Bottlenose dolphin & pilot whale)	Mix (*T. truncatus & G. melas*)	1	20 & 20	40
Mix (Common dolphin & minke whale)	Mix (*D. delphinus & B. acutorostrata*)	1	100 & 2	102
Risso's dolphin	*Grampus griseus*	5	47	6-15
White beaked dolphin	*Lagenorhynchus albirostris*	4	10	2-3
Unid. Baleen Whale	*Mysticeti sp.*	5	5	1
Unid. Cetacean	*Cetacea sp.*	2	2	1
Unid. Dolphin	*Delphinid sp.*	20	192	1-70
Unid. Large Whale		2	2	1
Unid. Small Whale		1	1	1
	Total	**128**	**950**	
Grey Seal	*Halichoerus grypus*	3	4	1-2
Unidentified Seal	*Phocid sp.*	2	2	1
	Total	**5**	**6**	
Decomposing Carcass	Unid. marine mammal	2	2	1
	Total	**2**	**2**	
Basking shark	*Cetorhinus maximus*	1	1	1
Blue shark	*Prionace glauca*	4	4	1
Leatherback turtle	*Dermochelys coriacea*	2	2	1
Ocean sunfish	*Mola mola*	25	25	1
Porbeagle shark	*Lamna nasus*	1	1	1
Tuna sp.	*Thunnus sp.*	1	1	1
Unidentified Fish	*Teleost sp.*	1	2	2
Unidentified Shark	*Selachii sp.*	1	1	1
	Total	**36**	**37**	

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

From the total of 171 sightings, 82 (48%) were recorded as primary sightings, 47 (27.5%) were recorded as auxiliary sightings, while 42 (24.6%) were recorded as incidental sightings. Incidental sightings could be recorded while the cetacean observer was either 'on' or 'off' effort. Of the 42 incidental sightings recorded, 23 (54.8%) were recorded while 'off effort' and 19 (45.2%) were recorded while 'on effort'.

Of the total 171 sightings, 147 (86%) were recorded while conducting line transect watches, 23 sightings (13.5%) were recorded 'off effort', while 1 sighting (0.6%) was recorded while conducting a point sampling watch.

From the 147 sightings recorded during line transect effort, 81 (55.1%) were recorded as primary sightings, 47 (32%) were recorded as auxiliary sightings and 19 (12.9%) were recorded as incidental sightings. A breakdown of all species encountered during line transect effort watches is presented in *Table 3* and includes all marine mammal sightings as well as sightings of other marine megafauna.

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
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	1	0	0
Bottlenose dolphin	*Tursiops truncatus*	2	3	0
Common dolphin	*Delphinus delphis*	16	7	1
Common/ striped dolphin	*D. delphinus/ S. coeruleoalba*	0	1	0
Humpback whale	*Megaptera novaeangliae*	1	0	0
Long finned pilot whale	*Globicephala melas*	2	1	0
Minke whale	*Balaenoptera acutorostrata*	23	10	2
Mix (Bottlenose dolphin & pilot whale)	Mix (*T. truncatus & G. melas*)	0	1	0
Risso's dolphin	*Grampus griseus*	2	2	0
White beaked dolphin	*Lagenorhynchus albirostris*	4	0	0
Unid Baleen Whale	*Mysticeti sp.*	2	2	0
Unid Cetacean	*Cetacea sp.*	0	0	1
Unid Dolphin	*Delphinid sp.*	8	6	3
Unid Large Whale		0	0	2
Unid Small Whale		0	1	0
	Total	**61**	**34**	**9**
Grey Seal	*Halichoerus grypus*	2	1	0
Unidentified Seal	*Phocid sp.*	2	0	0
	Total	**4**	**1**	**0**
Decomposing Carcass	Unid. marine mammal	1	1	0
	Total	**1**	**1**	**0**
Basking shark	*Cetorhinus maximus*	1	0	0
Blue shark	*Prionace glauca*	1	2	1
Leatherback turtle	*Dermochelys coriacea*	1	1	0
Ocean sunfish	*Mola mola*	11	8	6
Porbeagle shark	*Lamna nasus*	0	0	1
Tuna sp.	*Thunnus sp.*	0	0	1
Unidentified Fish	*Teleost sp.*	1	0	0
Unidentified Shark	*Selachii sp.*	0	0	1
	Total	**15**	**11**	**10**

Point sampling was conducted at 36 oceanographic stations (*Figure 9*). A further primary sighting (0.6% of all sightings) was recorded during one of these point sampling watches (*Table 4*).

Table 4: Summary of all sightings recorded during point sampling effort on the survey, including primary, auxiliary and incidental sightings.

Common Name	Species name	Primary sightings	Auxiliary sightings	Incidental Sightings
Common dolphin	*Delphinus delphis*	1	0	0
	Total	**1**	**0**	**0**

A total of 23 sightings were recorded while 'off effort' during the survey (*Table 5*). As no effort was being recorded when these animals were detected, each sighting was recorded as an incidental sighting.

Table 5: Summary of all sightings recorded while 'off effort' during the survey.

Common Name	Species name	Incidental Sightings
Common dolphin	*Delphinus delphis*	8
Minke whale	*Balaenoptera acutorostrata*	8
Mix (Common dolphin & minke whale)	Mix (*D. delphinus* & *B. acutorostrata*)	1
Risso's dolphin	*Grampus griseus*	1
Unid Baleen Whale	*Mysticeti sp.*	1
Unid Cetacean	*Cetacea sp.*	1
Unid Dolphin	*Delphinid sp.*	3
	Total	**23**

The distribution of all sightings of marine mammals and other marine megafauna recorded during line transect survey effort can be seen in *Figures 7* and *8* respectively.

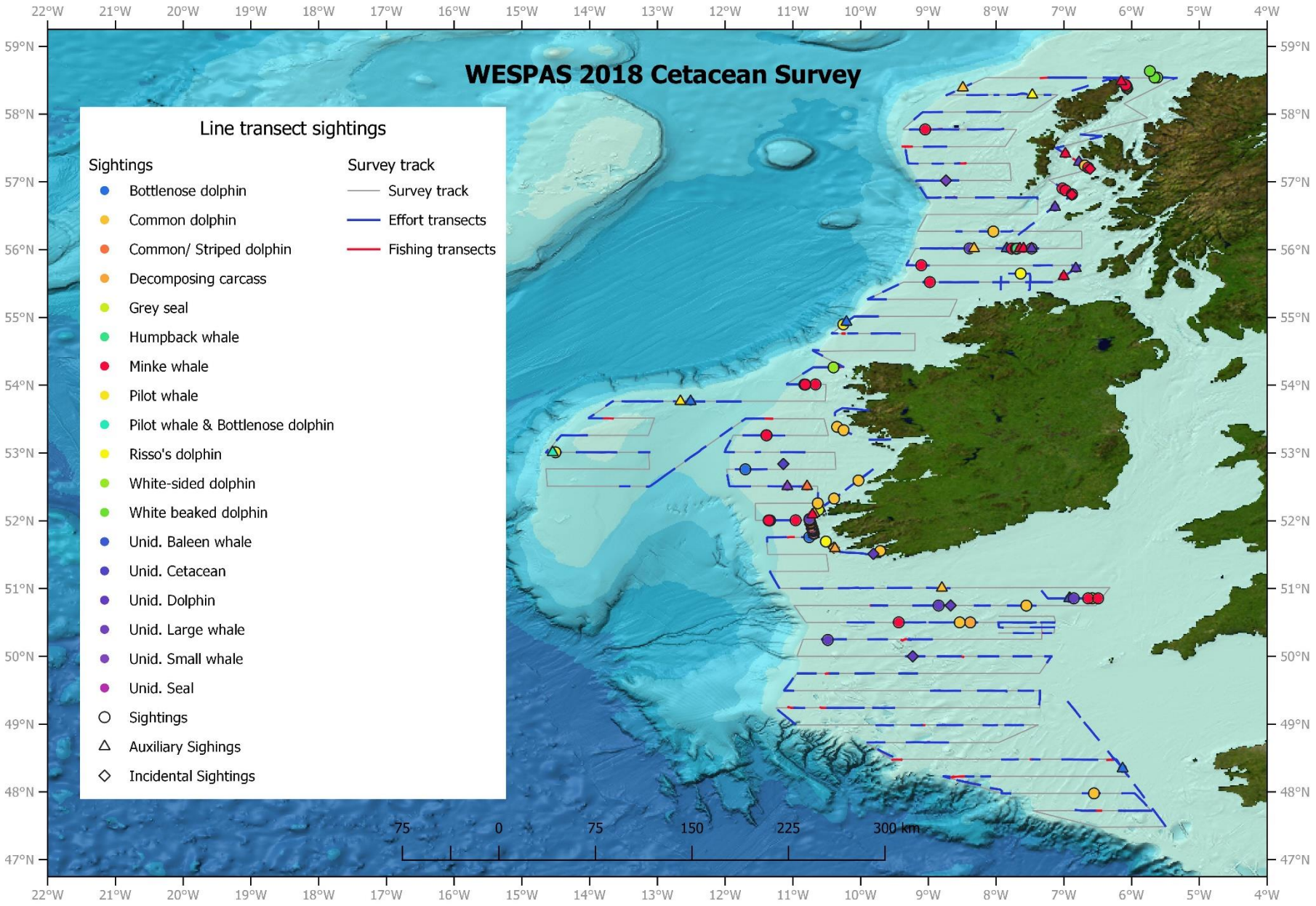

Figure 7: Distribution of marine mammal sightings recorded during line transect watches on the survey. Transects are categorised as effort conducted while on a standard line transect or effort conducted during fishing operations, and are overlaid on the survey track line.

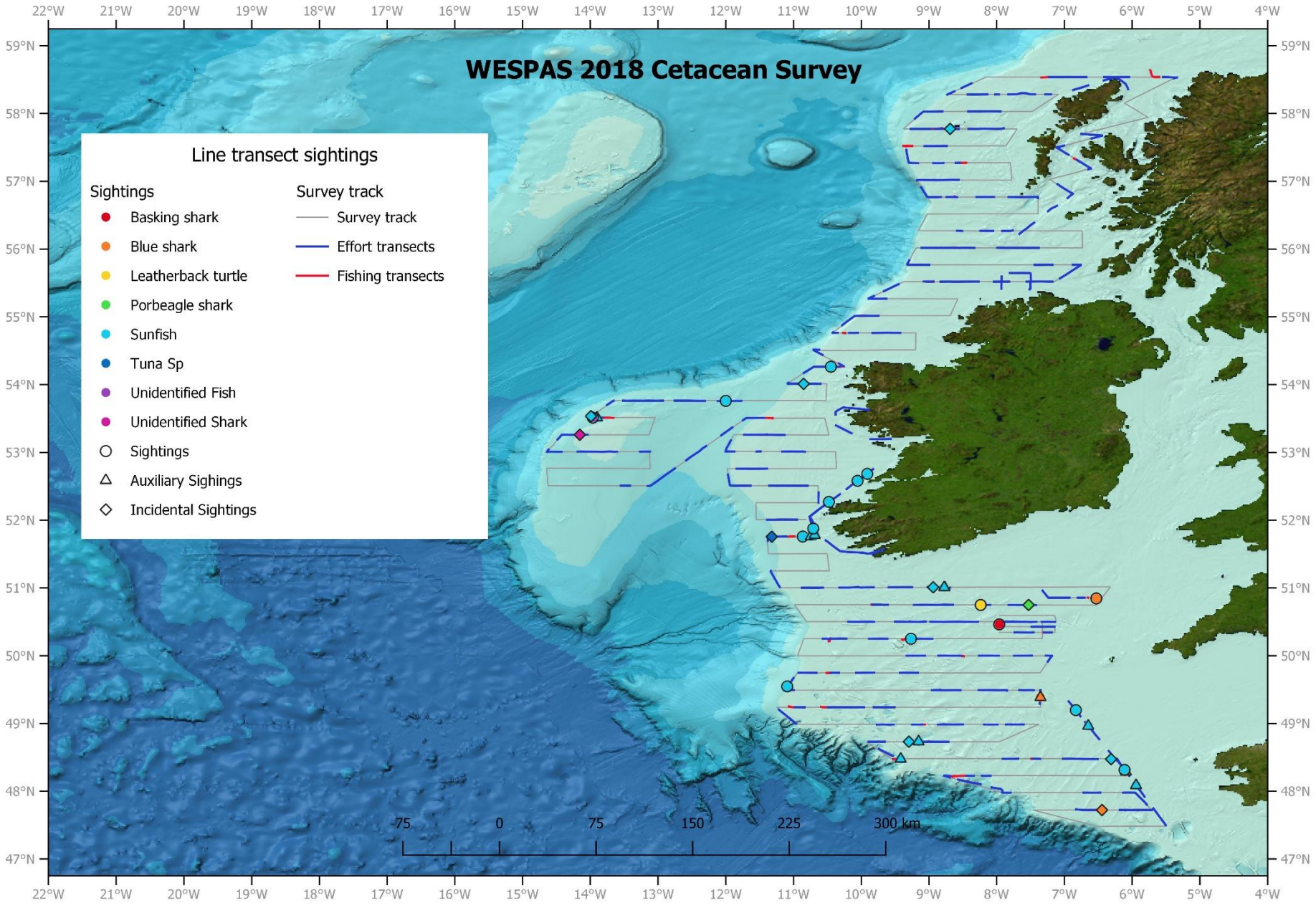

Figure 8: Distribution of other marine megafauna sightings recorded during line transect watches on the survey. Transects are categorised as effort conducted while on a standard line transect or effort conducted during fishing operations, and are overlaid on the survey track line.

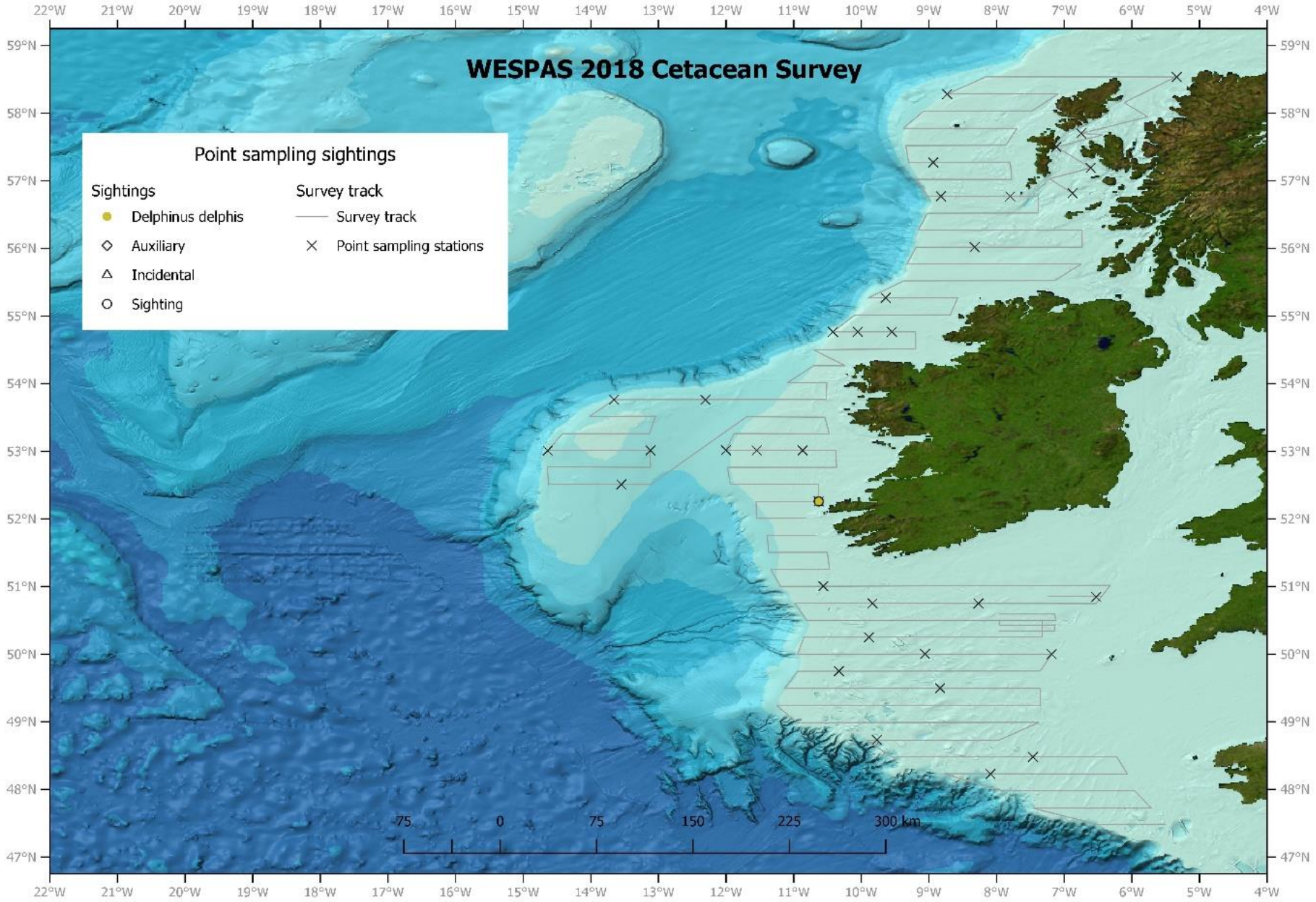

Figure 9: Location of oceanographic stations where point sampling watches were conducted and the distribution of all sightings recorded during point sampling watches on the survey, including primary, auxiliary and incidental sightings of all megafaunal groups.

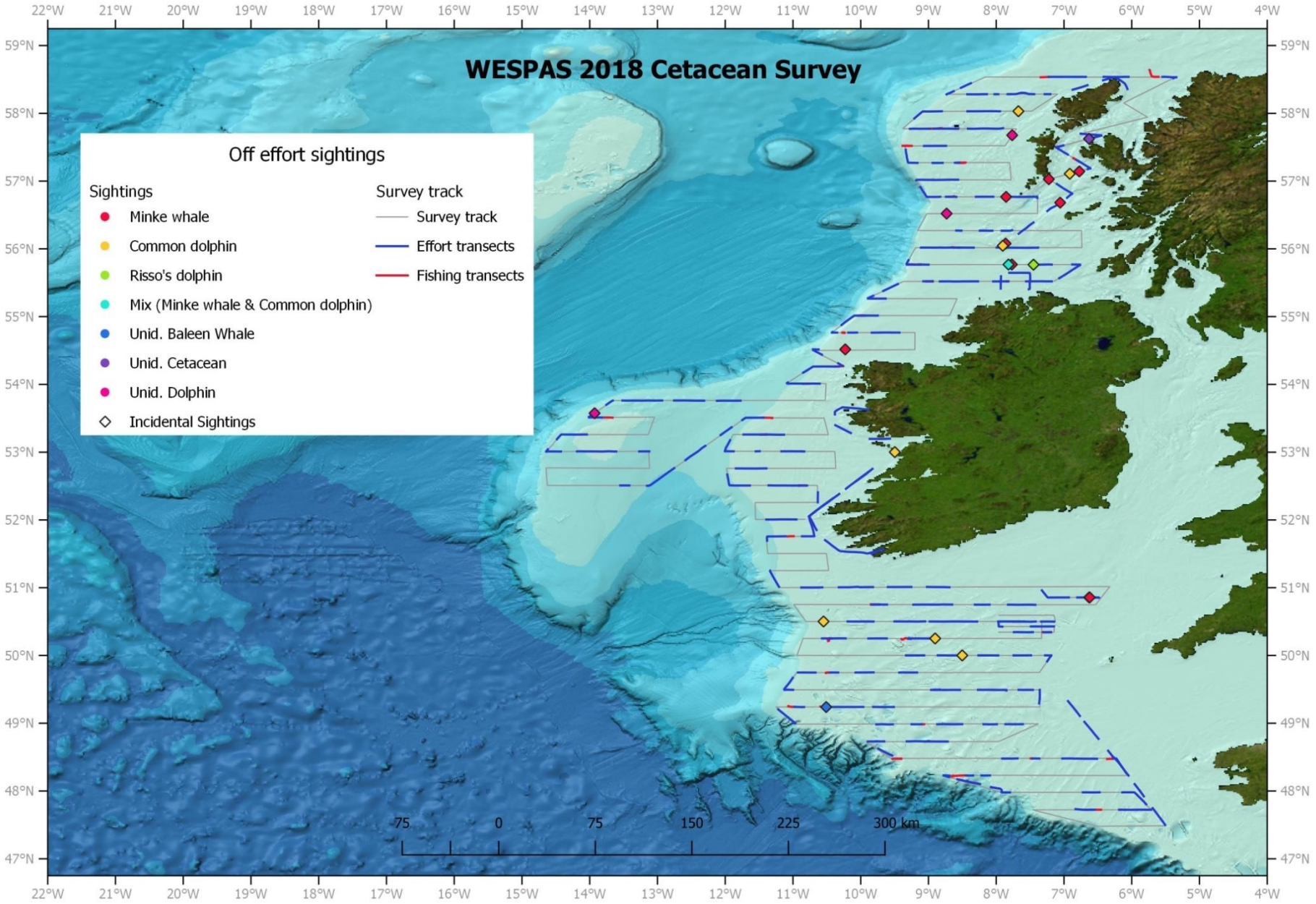

Figure 10: Distribution of all 'off effort' sightings recorded during the survey, including primary, auxiliary and incidental sightings of all megafaunal groups, overlaid with all observer effort.

Minke whales (*Balaenoptera* acutorostrata) were the most frequently encountered species accounting for 44 sightings (26% of all sightings) comprising of 53 individuals in total (including those recorded in mixed species groups). Minke whales were frequently encountered on the more northerly transects in the Celtic sea (north of approximately 50^0N), throughout the waters to the west and north of Ireland and the waters west of Scotland and within the Minch. Particularly high abundances were observed in the waters west of the Skelligs and the Blaskets. A total of 21 marine mammal sightings were recorded during this effort transect, including 6 sightings of individual minke whales. Other areas of note for minke whale sightings were the Stanton bank area, and the north and south ends of the Minch. For example, an incidental sighting of 10 individuals was recorded on the 21st July while transiting from the end of the survey transects in the Minch to Killary harbour.

Common dolphins (*Delphinus delphis*) were the second most frequently observed and most abundant species. Common dolphins were encountered on 34 occasions, accounting for 20% of all sightings (including those recorded in mixed species groups). These sightings, including the mixed species sighting, consisted of a total of 468 individuals (43% of all encountered individuals) with a group size range of 2-100 individuals (mean group size of 14 individuals). The observed distribution of common dolphins was broadly similar to that of the minke whale, in fact a mixed species assemblage of common dolphin and minke whale was recorded on one occasion where the two species were observed feeding together. Common dolphins were frequently encountered on the more northerly transects in the Celtic sea (north of approximately 50^0N), throughout the waters to the west and north of Ireland and the waters west of Scotland. The area west of the Skelligs and the Blaskets was also found to be rich with common dolphins. A total of 6 common dolphin sightings were recorded in this area, totalling 114 individuals.

Unidentified dolphin (*Delphinid sp.*) was the third most frequently encountered species group and the second most abundant species group. Unidentified dolphins were encountered on 20 occasions, accounting for 12% of all sightings. These sightings consisted of a total of 192 individuals (19% of all encountered individuals).

Other delphinid species encountered included bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*) and white-beaked dolphin (*Lagenorhynchus albirostris*). Bottlenose dolphins were sighted on 5 occasions (3% of all sightings), with a further sighting of a mixed species group of bottlenose dolphins and long-finned pilot whales (*Globicephala melas*) also recorded. The total abundance of bottlenose dolphins was 125 individuals (including those recorded with the pilot whales) and accounted for 12% of all individuals encountered. Risso's dolphins were also encountered on 5 occasions (3% of all sightings), totalling 47 individuals (5% of all encountered). White-beaked dolphins were encountered on 4 occasions (2% of all sightings), totalling 10 individuals (1% of all encountered). Pilot whales were sighted on 3 occasions (2% of all sightings), with the further sighting of a mixed species group of bottlenose dolphins and long-finned pilot also recorded. A small group of 3 Atlantic white sided dolphins (*Lagenorhynchus acutus*) were also sighted on one occasion (<1% of all sightings or individuals).

A single sighting of a humpback whale (*Megaptera novaeangliae*) was recorded in an area of high cetacean activity in the vicinity of the Stanton bank on the 13th July. A number of sightings of individual large baleen whales also occurred in this area concurrent with the humpback whale sighting, unfortunately these animals could not be identified to species level due to distance and environmental conditions.

The grey seal (*Halichoerus grypus*) was sighted on 3 occasions, with each sighting comprising of either a single individual or a pair of individuals. Unidentified seals were recorded on 2 occasions, with each sighing comprising of a single individual.

The ocean sunfish (*Mola mola*) were the third most frequently encountered species overall, and the most frequently encountered species of marine megafauna excluding marine mammals. The sunfish were spotted on 25 separate occasions, accounting for 15% of all sightings, with each sighting consisting of a lone individual (3% of encountered individuals).

A number of elasmobranch species were also encountered including; blue shark (*Prionace glauca*), porbeagle shark (*Lamna nasus*) and basking shark (*Cetorhinus maximus*). Lone leatherback turtles (*Dermochelys coriacea*) were encountered on two occasions.

Discussion

As in previous surveys, a large number of number of sightings, from a broad range of taxa and species groups, and a high abundance of animals were observed over the course of this year's survey. However, the total number of sightings recorded on the WESPAS 2018 were substantially lower than the total numbers recorded in both 2016 and 2017. 279 marine mammal sightings totalling 1722 individuals were recorded in 2016, while 155 marine mammal sightings of 1307 individuals were recorded in 2017 (*Table 6*). This compares to 132 marine mammal sightings of 956 individuals recorded in 2018. However, there was significantly more effort recorded in both 2016 and 2017, 334 hours and 343 hours respectively, compared to 272 hours of observation effort in 2018.

In total, 9 different marine mammal species were identified on WESPAS 2018. In comparison, 10 marine mammal species were sighted on WESPAS 2017, while 13 different marine mammal species were sighted on WESPAS 2016 (*Table 6*). Harbour porpoise (*Phocoena phocoena*), fin whale (*Balaenoptera physalus*) and killer whale (*Orcinus orca*) were each recorded on both the 2016 and 2017 WESPAS surveys. Striped dolphin (*Stenella coeruleoalba*) and Sowerby's beaked whale (*Mesoplodon bidens*) were both recorded on the 2016 survey but were absent from both the 2017 and 2018 surveys. While the common seal (*Phoca vitulina*) was the only species recorded in 2017 which was absent from both the 2016 and 2018 surveys. 2017 marked the first year in which white-sided dolphin were recorded on the WESPAS. In total, 15 different marine mammal species have been encountered over the WESPAS series of surveys.

This year's survey saw a notable increase in the number of minke whale sightings reported when compared to previous years. In total 43 sightings comprising of 51 individuals were recorded in 2018 compared to 22 sightings of 25 individuals in 2017, and 29 sightings of 31 individuals in 2016. However, the starkest comparison between the surveys was the change in the recorded occurrence of the common dolphin. In 2018, common dolphins were encountered on 33 occasions, accounting for 19% of all sightings and consisting of a total of 468 individuals. In 2017, common dolphins were encountered on 66 occasions and accounted for 979 individuals, while in 2016, 162 sightings of a total of 1290 individuals were reported.

While all three surveys cover the same area of the European western shelf using similarly spaced transects beginning at a randomly located point, it should be noted that the 2016 survey differs from both the 2017 and 2018 surveys in that it was undertaken in a north-south direction whereas the 2017 and 2018 surveys were undertaken in a south-north fashion. It should also be noted that while

the 2018 survey used a single cetacean observer for the duration of the survey. This was not the case in 2016 where a single observer was deployed on Leg 1 of the survey with 2-3 observers used for Leg 2. In 2017, the survey was split into to 4 survey legs, with 2 observers deployed on Legs 1-3 and a single observer deployed on Leg 4.

Table 6: Cetacean sighting records from the Western European Shelf Pelagic Acoustic Survey from 2016-2018 (O'Donnell et al., 2016; O'Donnell et al., 2017)

		2018		**2017**		**2016**	
Common Name	**Species name**	**No. of Sightings**	**No. of ind.**	**No. of Sightings**	**No. of ind.**	**No. of Sightings**	**No. of ind.**
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	1	3				
Bottlenose dolphin	*Tursiops truncatus*	6	125	7	63	7	93
Common dolphin	*Delphinus delphis*	34	468	66	979	162	1290
Common/ striped dolphin	*D. delphinus/ S. coeruleoalba*	1	1				
Fin whale	*Balaenoptera physalus*			4	5	4	5
Harbour porpoise	*Phocoena phocoena*			5	9	4	7
Humpback whale	*Megaptera novaeangliae*	1	1	2	3	2	2
Killer whale	*Orcinus orca*			1	3	1	1
Long finned pilot whale	*Globicephala melas*	4	40			15	95
Minke whale	*Balaenoptera acutorostrata*	44	52	22	25	29	31
Risso's dolphin	*Grampus griseus*	5	47	7	56	2	7
Sowerby's beaked whale	*Mesoplodon bidens*					1	3
Striped dolphin	*Stenella coeruleoalba*					2	11
White beaked dolphin	*Lagenorhynchus albirostris*	4	10			14	95
Unid Baleen Whale	*Mysticeti sp.*	5	5	3	3	5	6
Unid Beaked Whale	*Ziphiidae sp.*					1	1
Unid Cetacean	*Cetacea sp.*	2	2	3	3	4	7
Unid Dolphin	*Delphinid sp.*	20	192	20	142	18	59
Unid Large Whale		2	2				
Unid Small Whale		1	1	3	3	2	2
	Total	**128**	**950**	**143**	**1294**	**273**	**1715**
Grey Seal	*Halichoerus grypus*	3	4	7	7	6	7
Common Seal	*Phoca vitulina*			2	3		
Unidentified Seal	*Pinniped sp.*	2	2	3	3		
	Total	**5**	**6**	**12**	**13**	**6**	**7**
Decomposing Carcass	*Unid. marine mammal*	2	2				
	Total	**2**	**2**				
Basking shark	*Cetorhinus maximus*	1	1	2	2	6	8
Blue shark	*Prionace glauca*	4	4	8	8		
Leatherback turtle	*Dermochelys coriacea*	2	2	1	1		

Ocean sunfish	*Mola mola*	25	25	12	18		
Porbeagle shark	*Lamna nasus*	1	1				
Thresher shark	*Alopias vulpinus*			1	1		
Tuna sp.	*Thunnus sp.*	1	1				
Unidentified Fish	*Teleost sp.*	1	2	1	1		
Unidentified Shark	*Selachii sp.*	1	1	4	4		
	Total	**36**	**37**	**29**	**35**	**6**	**8**
	Grand Total	**171**	**995**	**184**	**1342**	**285**	**1730**

The sightings recorded in 2018 were observed to be highly patchy for a number of species. As can be seen from *Figure 7*, marine mammals, in general, were rarely encountered in the southern Celtic sea and Bay of Biscay areas (south of approximately 50^0N). In contrast, areas such as the waters west of the Skellig and Blasket islands, and Stanton bank showed an impressive abundance and diversity of marine mammal species. The area west of the Skelligs and the Blaskets was surveyed on the 27th June as the vessel transited back to port. Intense marine mammal and sea bird activity was observed in the area at the time, suggesting high prey availability in the area. A total of 21 marine mammal sightings were recorded during this effort transect, including sightings of 3 dolphin species (common, bottlenose and Risso's), minke whales and grey seals. A total of 6 sightings of individual minke whales were recorded in this area during this transect. Additionally, 6 common dolphin sightings were recorded, totalling 114 individuals. A single sighting each of bottlenose dolphins (17 individuals) and Risso's dolphins (8 individuals) were also recorded as well as a further 3 sightings of unidentified dolphins (totalling 37 individuals). 2 sightings of solitary grey seals were recorded as well as a further sighting of an individual unidentified seal. Similarly, while crossing the Stanton bank on the 13th July a high density of cetaceans was encountered over a relatively small area. In total 9 cetacean sightings were recorded, including 5 minke whale sightings, 1 humpback whale sighting, 2 sightings of unidentified large baleen whale and 1 sighting of unidentified dolphins. This area was transited again on the 21st July, at which time a high density of minke whales were recorded (1 or 2 sightings of 10 individuals). The availability and distribution of prey is a key factor affecting the distribution of cetaceans, (MCR, 2011). As feeding behaviour was observed on all three of these sighting events, and also on a number of other occasions, it is likely that much of the observed patchy distribution of cetaceans was related to prey availability.

A large number of auxiliary sightings were recorded during line transect watches in the present survey. In fact, all 47 auxiliary sightings (32% of line transect sightings) were recorded during line transect watches. Theses auxiliary sightings were initially detected by other scientific crew or the vessel crew. On the WESPAS survey, a number of other scientists conduct regular visual watches for other marine species. There were two seabird observers and two jellyfish observers deployed on each leg of the WESPAS survey in 2018. The seabird observers generally conducted watches from the monkey island with one observer conducting a visual watch while the other records data. The seabird survey uses a strip transect methodology with effort concentrated from the trackline out to a perpendicular distance of 300 meters to either the port or starboard of the vessel track (O'Donnell, et al., 2017), however, all seabirds encountered outside of the transect strip are also recorded. The jellyfish survey follows a similar methodology, although with effort concentrated much closer to the vessel (<100m). The jellyfish survey consisted of a single observer conducting a watch from the bow on either port or starboard side of the vessel while also recording data. On a number of occasions

the two jellyfish observers conducted simultaneous watches from the bow, with one observer watching to port while the other watched to starboard. Both jellyfish and seabird teams followed a similar daily shift pattern to that of the cetacean team. The jellyfish observation platform on the bow and the seabird observation platform on the monkey island are both within visual and audible range of the cetacean observer. As it was not possible to avoid visual or aural cues of cetacean sightings detected from other platforms, care was taken to log all such sightings as auxiliary sightings.

Considering the high degree of overlap, in both the shift patterns and the area surveyed by all three survey teams, it is unsurprising that a large number of auxiliary sightings were initially detected by the other survey teams. A number of the oceanographers and fisheries scientists aboard also spent considerable time conducting casual visual marine mammal watches from the monkey island or crow's nest. Some of this broader scientific team aboard were also qualified and experienced cetacean observers, and thus were responsible for the initial detection of a number of sightings. A total of 26 sightings (55.3% of auxiliary sightings) were initially detected by scientists other than the cetacean or seabird observer teams, while the seabird team alone were responsible for initially detecting 19 sightings, which is 40.4% of all auxiliary sightings. The remaining 4.3% of auxiliary sightings (n=2) were detected initially by members of the ship's crew.

A look at the numbers of incidental sightings reveals a similar story. A total of 42 incidental sightings were recorded on the survey, 23 (55%) were recorded while the cetacean observer was 'off effort', while 19 (45%) were recorded while the cetacean observer was 'on effort'. The 23 incidental sightings recorded 'off effort' were recorded either during periods of unfavourable environmental conditions or outside of the cetacean observers shift. The 19 incidental sightings recorded while the cetacean observer was 'on effort' were detected by persons other than the cetacean observer but were not spotted by the cetacean observer.

The occurrence of 'on effort' incidental sightings indicates 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). The presence of perception and availability bias has implications for the calculation of g(0) (the proportion of animals on the trackline detected) and thus puts constraints on the use of the data set from the present survey for any future determination of absolute abundances (Barlow, 2015).

The occurrence of 'on effort' auxiliary sightings could also indicate some degree of perception/ availability bias. 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 visual surveyors cannot be ascertained.

The existence of an availability bias was particularly evident for species such as sunfish and blue sharks. It was at times difficult to detect these species when completely submerged from the crow's nest, particularly in periods of high glare, however, these species could sometimes be more readily detected from platforms closer to the water. This led to a number of sunfish in particular being detected by the observation teams on lower platforms, while often remaining invisible from the cetacean observer's observation platform on the crow's nest.

The use of a single cetacean observer further exacerbates the issue of perception bias and leads to higher auxiliary and 'on effort' incidental sighting rates. Cetacean survey effort is concentrated in an arc from 60^0 either side of the trackline out to the horizon (which can be over 15km away), leaving the total area to be surveyed by the single cetacean observer at greater than $100km^2$. 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. The use of a single observer conducting visual watches while also recording data was problematic on a number of occasions, particularly in areas of high marine mammal activity. For example, of the 21 marine mammal sightings recorded while surveying the waters west of the Skellig and Blasket islands on the 27th June, 7 were recorded as auxiliary sightings. 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 spent 'off effort'. The surveys in both 2016 and 2017 achieved significantly more cetacean survey effort than this year's survey (23% and 26% more hours respectively) by using larger cetacean survey teams.

The WESPAS provides an excellent opportunity for the collection of data on the summer distribution, abundance and behaviour of cetaceans in Irish shelf waters. However, the amount and quality of data collected is confounded by factors such as environmental conditions and cetacean survey design. Although the weather was quite good throughout the survey, poor weather did reduce the total number of cetacean survey hours undertaken on a number of occasions. However, environmental conditions, particularly sea states of 4 or greater, likely affected the detection probability of many species, particularly those with inconspicuous surfacing behaviours (Cominelli, et al., 2016). 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 practical 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 WESPAS 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 additional cetacean observers.

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Finally, the cetacean observers wish the MRV Celtic Explorer, the Explorer crew and the Marine Institute staff all the best for future surveys. Both, the Explorer crew and the Marine Institute staff have been a pleasure to work with and the cetacean observers look forward to future collaborations.

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Managing Authority EMFF 2014-2020	Specified Public Beneficiary Body
Department of Agriculture Food & the Marine Clogheen, Clonakilty, Co. Cork. P85 TX47 Tel: (+)353 (0)23 885 9500 www.agriculture.gov.ie/emff	Marine Institute Rinville, Oranmore, Co. Galway, H91 R673 Phone: (+)353 (0)91 38 7200 www.marine.ie

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An Roinn Talmhaíochta, Bia agus Mara
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Foras na Mara
Marine Institute