EMFF Operational Programme 2014-2020

Marine Biodiversity Scheme

Marine Institute Cetacean Monitoring

During the Celtic Sea Herring Acoustic Survey

10th - 28th October 2019

Lead Agency: Marine Institute

Lead Partners: National Parks and Wildlife Service,

Authors: Emerald Marine

Citation: Power, J. (2019). Cetacean Monitoring undertaken during the Celtic Sea Herring Acoustic Survey (CSHAS) 10th- 28th October 2019

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

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

EMFF

Operational Programme	European Maritime and Fisheries Fund (EMFF) Operational Programme 2014-2020
Priority	Union Priority 1 Sustainable Development of Fisheries Union Priority 6 Fostering the implementation of the Integrated Maritime Policy
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
Measure	Marine Biodiversity Scheme
Project No.	MB/2019/09
EMFF Certifying Body	Finance Division, Department of Agriculture, Food and the Marine
Managing Authority	Marine Agencies & Programmes Division, Department of Agriculture, Food and Marine
Specified Public Beneficiary Body	Marine Institute
Grant Rate	100%
EU Co-Financing Rate	50%
Legal Basis	Article 29, 40 & 80 EMFF
Details	Report to the Marine Institute Emerald marine

This project or operation is part supported by the Irish government and the European Maritime & Fisheries Fund as part of the EMFF Operational Programme for 2014-2020

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Marine Institute

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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 Celtic Explorer during the annual Celtic Sea Herring Acoustic Survey (CSHAS), running from the 10th to the 28th of October 2019.

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. In total, 107 hours and 27 minutes of survey effort was conducted over the course of CSHAS 2019. In total, 103 hours and 50 minutes of survey effort were conducted using a line transect methodology, while 1 hours and 23 minutes of effort were conducted using the point sampling methodology. A further 2 hours and 13 minutes of effort were conducted as a casual watch.

A total of 204 sightings, were recorded throughout the survey. This includes 145 primary sightings, 38 sightings recorded as auxiliary sightings, 20 sightings recorded as incidental sightings, and 1 re-sighting of previously encountered individuals. From the total 204 sightings, marine mammals accounted for 163 sightings. The marine mammal sightings included; 1 whale species, 1 dolphin species, 1 porpoise species, 1 seal species and a number of sightings which could not be identified to species level. The remaining 41 sightings consisted of other marine megafauna.

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, *RV Celtic Explorer* and *RV 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 CSHAS is an acoustic survey undertaken by the Fisheries Ecosystems Advisory Services (FEAS) department of the Marine Institute of Ireland to determine an age stratified relative abundance of herring (*Clupea harengus*) within the survey area as part of a national stock assessment. CSHAS also aims to determine estimates of biomass and abundance of sprat (*Sprattus sprattus*) within the survey area (O'Donnell, et al., 2018a).

The survey has been undertaken annually since 1989 and since 2004 has been fixed in October and carried out on the *RV Celtic Explorer*. Since 2016 the CSHAS survey has used an updated survey design, covering an extended area of the Celtic sea with each survey employing parallel transects spaced equally at 8 nautical miles, beginning in an east-west fashion for an initial pass of the survey area before a second pass is conducted in a west-east fashion at a 4 nautical mile offset. The survey also incorporates secondary high resolution adaptive surveys focusing on areas of high abundance (O'Donnell, et al., 2016a; 2017a; 2018a).

The CSHAS provides a unique opportunity for surveillance of the autumn distribution of cetaceans in shelf water habitats along Ireland's Celtic sea 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 *RV Celtic Explorer* during the annual Celtic Sea Herring Acoustic Survey (CSHAS), running from the 10th to the 28th of October 2019.

Methodology

Given the presented survey transects for the 2018 survey (*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.

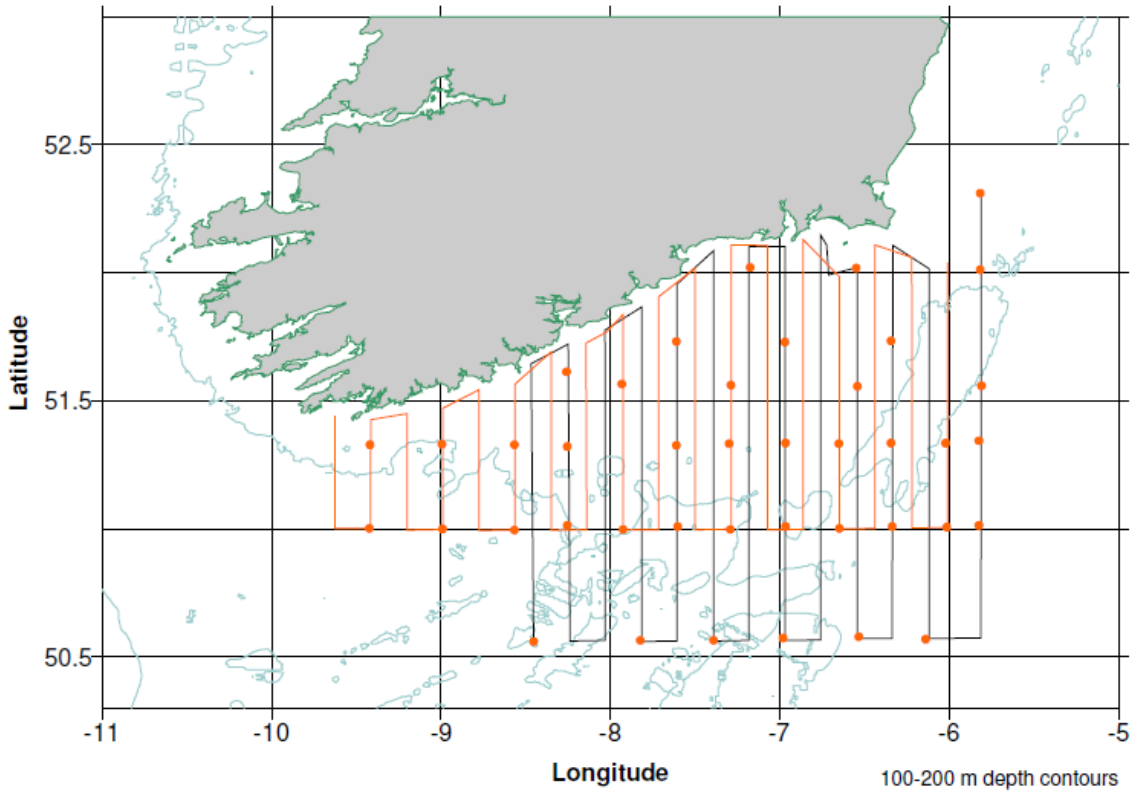

Figure 1: *The CSHAS 2018 cruise track (Source: Marine Institute, 2019).*

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. A single experienced cetacean observer was deployed for the duration of the survey.

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 were 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 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 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

In total, 107 hours and 27 minutes of survey effort was conducted over the course of CSHAS 2019. In total, 103 hours and 50 minutes of survey effort were conducted using a line transect methodology, while 1 hours and 23 minutes of effort were conducted using the point sampling methodology. A further 2 hours and 13 minutes of effort were conducted as a casual watch.

The observer's survey effort was maximized and optimized during the prevailing hours of daylight. The maximum recorded daily survey effort was 7 hours and 21 minutes while the average daily survey effort was 5 hours and 39 minutes. No effort watches were conducted on the 19th of October due to a port call for a crew change. Cetacean survey effort was greatly reduced on the 18th of October 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 10th and 28th of October due to transiting to/from port. A graph of daily effort is provided in *Figure 2 b*elow.

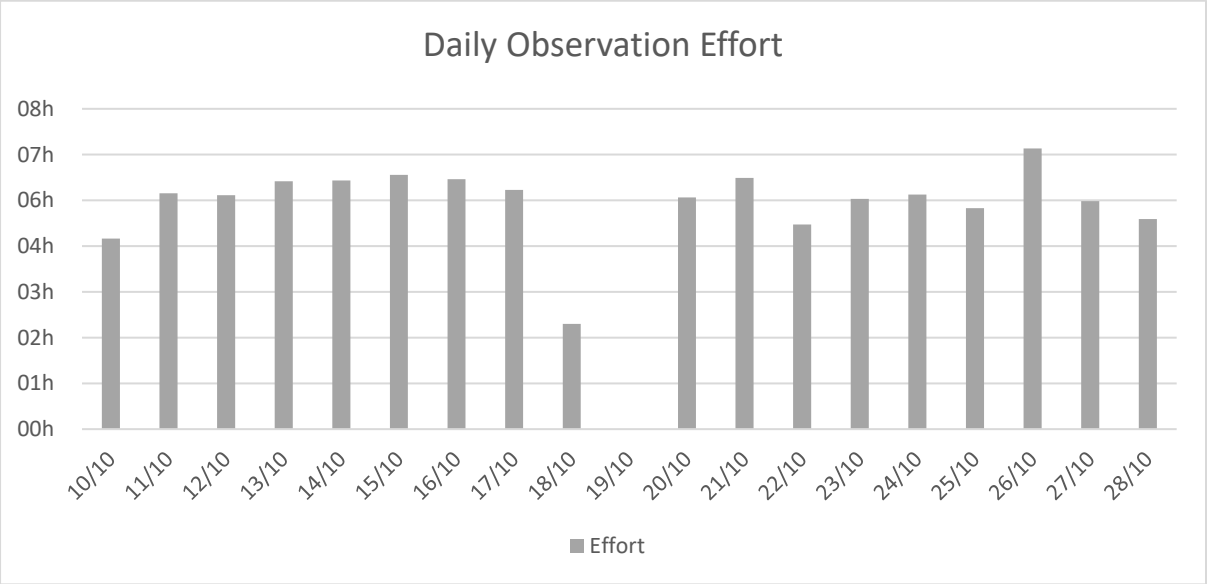

Figure 2: Daily visual effort undertaken during the survey.

Environmental Conditions

Environmental conditions were generally moderate to good 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 was judged in terms of the total state of agitation of the sea with wave height in meters used as an additional guide. Beaufort sea state was recorded in terms of Beaufort wind force and was judged based on the effect of the wind on the sea surface.

The most frequently recorded WMO sea state was 4 (moderate), accounting for almost 59 hours (55%) of observation effort. WMO sea state 3 accounted for over 25 hours (24%) of observation effort (*Fig. 3a*).

The most frequently recorded Beaufort sea state was also a sea state 4, accounting for almost 34 hours (32%) of survey effort, while sea state 5 accounted for nearly 28 hours (26%) of survey effort. Sea state 3 accounted for 18 hours (17%) of survey effort, while Sea state 6 was also frequently recorded, accounting for over 17 hours (16%) of recorded conditions (*Fig. 3b*).

Swell

A swell height of 1.1-2 meter was most frequently recorded throughout the survey, being recorded on over 54 hours (51%) of survey effort. A swell height of 0.1-1 meters was recorded over almost 30 survey hours (29%), while swell of over 2 meters was recorded over 20 hours (19%) (*Fig. 3c*).

Visibility

Visibility was generally very good during cetacean survey effort. The most frequently recorded visibility was 16-20km, being recorded over 65 hours (61%) of survey effort, while visibility of 11-15km was recorded over 29 hours (27%) of survey effort (*Fig. 3d*).

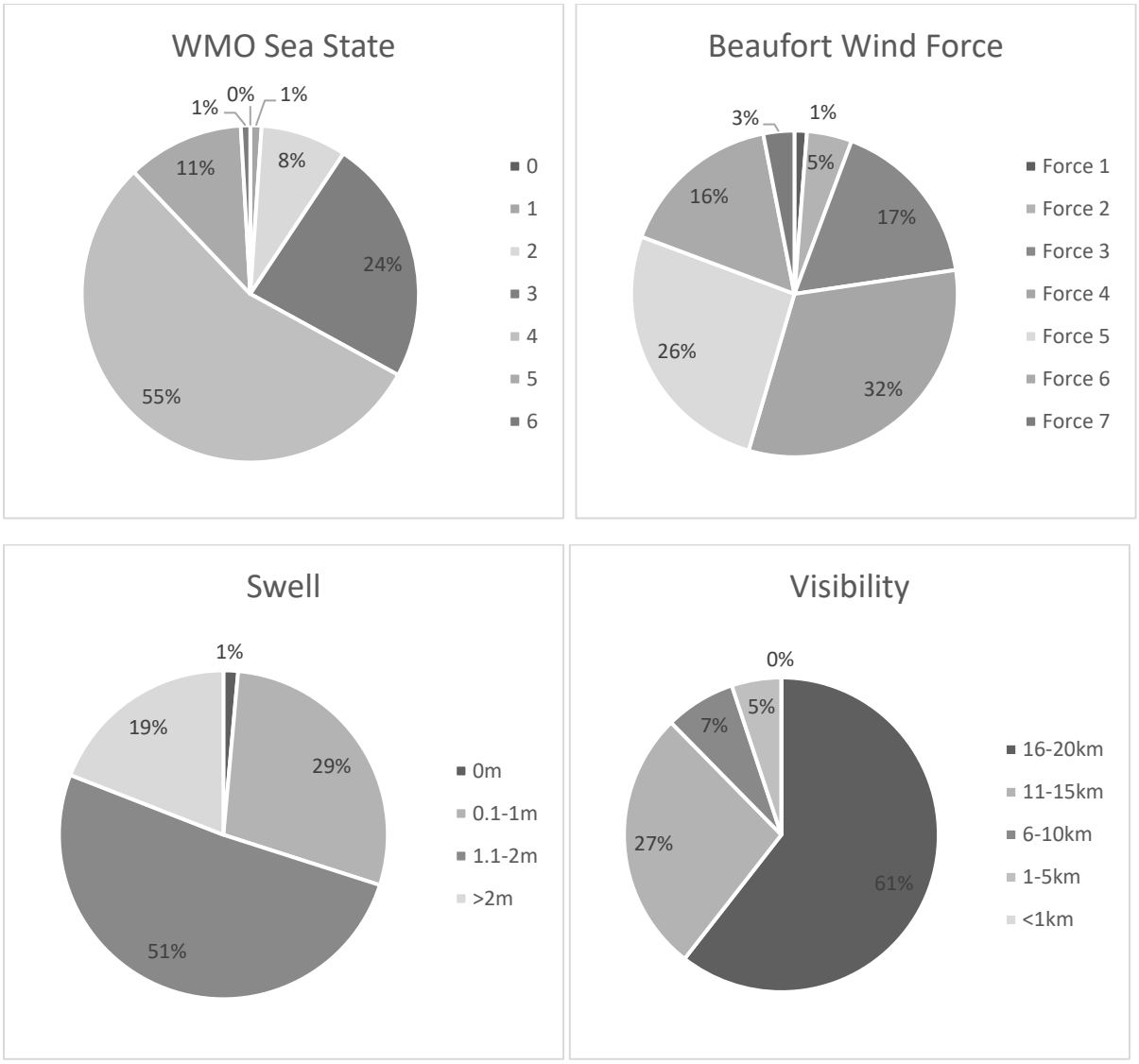

Figure 3: Summary of environmental conditions recorded on the CSHCSHAS 2019; a) WMO sea state, b) Beaufort sea state/ wind force, c) Swell height (meters), d) Visibility (kilometres).

Sightings

A total of 204 sightings were recorded on the survey, reaching a total of 3205 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'.

From the total 204 sightings, marine mammals accounted for 163 sightings. The marine mammal sightings included; 1 whale species, 1 dolphin species, 1 porpoise species, 1 seal species and a number of sightings which could not be identified to species level.

The remaining 41 sightings consisted of other marine megafauna. Species' of other marine megafauna encountered on the survey consisted of Bluefin tuna (*Thunnus thynnus*) and unidentified tuna species.

An additional 6 sightings of Portuguese man o' war (*Physalia physalis*) were also recorded during survey effort. These six sightings are not included in the overall sightings tallies.

Table 2: Summary of all sightings recorded on the survey, including primary, auxiliary and incidental sightings of all megafauna groups and also including Portuguese man o' war sightings.

Common Name	*Species name*	*No. of Sightings*	*No. of individuals*	*Group Size*
Common dolphin	*Delphinus delphis*	3	57	14-28
Harbour porpoise	*Phocoena phocoena*	63	1705	1-800
Fin/ Blue/ Sei whale	*Balaenoptera physalus /borealis /musculus*	4	15	1-6
Fin whale	*Balaenoptera physalus*	1	4	4
Unidentified baleen whale	*Mysticeti sp.*	2	11	5-6
Unidentified dolphin	*Delphinidae sp.*	16	18	1-2
Unidentified small whale		1	1	1
	Total	**160**	**1757**	
Grey seal	*Halichoerus grypus*	3	3	1
	Total	**3**	**3**	
Bluefin tuna	*Thunnus thynnus*	36	1422	3-250
Tuna sp.	*Thunnus sp.*	5	23	1-10
	Total	**3**	**3**	
	Grand Total	**204**	**3205**	
Portuguese man o' war	*Physalia physalis*	6	6	1
	Total	**6**	**6**	

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 204 sightings, 145 (71.1%) were recorded as primary sightings, 38 (18.6%) were recorded as auxiliary sightings, while 20 (9.8%) were recorded as incidental sightings (*Table 3*). As defined in the survey methods, incidental sightings could be recorded while the cetacean observer was either 'on' or 'off' effort. Of the 20 incidental sightings recorded, 12 (60%) were recorded while 'off effort' and 8 (40%) were recorded while 'on effort'. A single re-sighting of a pod of common dolphins was also recorded during the survey and is excluded from further analysis.

Table 3: Summary of all marine megafauna sightings recorded on the survey presented as primary, auxiliary and incidental sightings.

Common Name	***Species name***	***Primary sightings***	***Auxiliary sightings***	***Incidental sightings***
Common dolphin	*Delphinus delphis*	98	28	14
Harbour porpoise	*Phocoena phocoena*	1	1	1
Fin/ Blue/ Sei whale	*Balaenoptera physalus /borealis /musculus*	1	1	0
Fin whale	*Balaenoptera physalus*	1	2	0
Unidentified baleen whale	*Mysticeti sp.*	1	3	1
Unidentified dolphin	*Delphinidae sp.*	4	0	1
Unidentified small whale		1	0	0
	Total	**107**	**35**	**17**
Grey seal	*Halichoerus grypus*	2	0	1
	Total	**2**	**0**	**1**
Bluefin tuna	*Thunnus thynnus*	31	3	2
Tuna sp.	*Thunnus sp.*	5	0	0
	Total	**36**	**3**	**2**
	Grand Total	**145**	**38**	**20**

Of the total 203 sightings (excluding the re-sighting), 191 (93.1%) were recorded while conducting line transect watches, while 14 sightings (6.9%) were recorded as 'off effort' incidental sightings. Point sampling was conducted at 6 oceanographic stations. No sightings were recorded while conducting point sampling watches.

From the 191 sightings recorded during line transect effort, 145 (75.9%) were recorded as primary sightings, 38 (19.9%) were recorded as auxiliary sightings and 6 (3.1%) were recorded as incidental sightings. A breakdown of all species encountered during line transect effort watches is presented in *Table 4* and includes all marine mammal sightings as well as sightings of other marine megafauna.

Table 4: 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*	98	28	4
Harbour porpoise	*Phocoena phocoena*	1	1	1
Fin/ Blue/ Sei whale	*Balaenoptera physalus /borealis /musculus*	1	1	0
Fin whale	*Balaenoptera physalus*	1	2	0
Unidentified baleen whale	*Mysticeti sp.*	1	3	0
Unidentified dolphin	*Delphinidae sp.*	4	0	0
Unidentified Small Whale		1	0	0
	Total	**107**	**35**	**5**
Grey seal	*Halichoerus grypus*	2	0	1
	Total	**2**	**0**	**1**
Bluefin tuna	*Thunnus thynnus*	31	3	0
Tuna sp.	*Thunnus sp.*	5	0	0
	Total	**36**	**3**	**0**
	Grand Total	**145**	**38**	**6**

The distribution of all sightings of marine mammals and other marine megafauna recorded during line transect survey effort can be seen in *Figures 4* and *5* respectively.

A total of 14 sightings were recorded while 'off effort' during the survey (*Table 5 & Figure 7*). 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*	10
Unidentified baleen whale	*Mysticeti sp.*	1
Unidentified dolphin	*Delphinidae sp.*	1
	Total	**12**
Bluefin tuna	*Thunnus thynnus*	2
	Total	**2**
	Grand Total	**14**

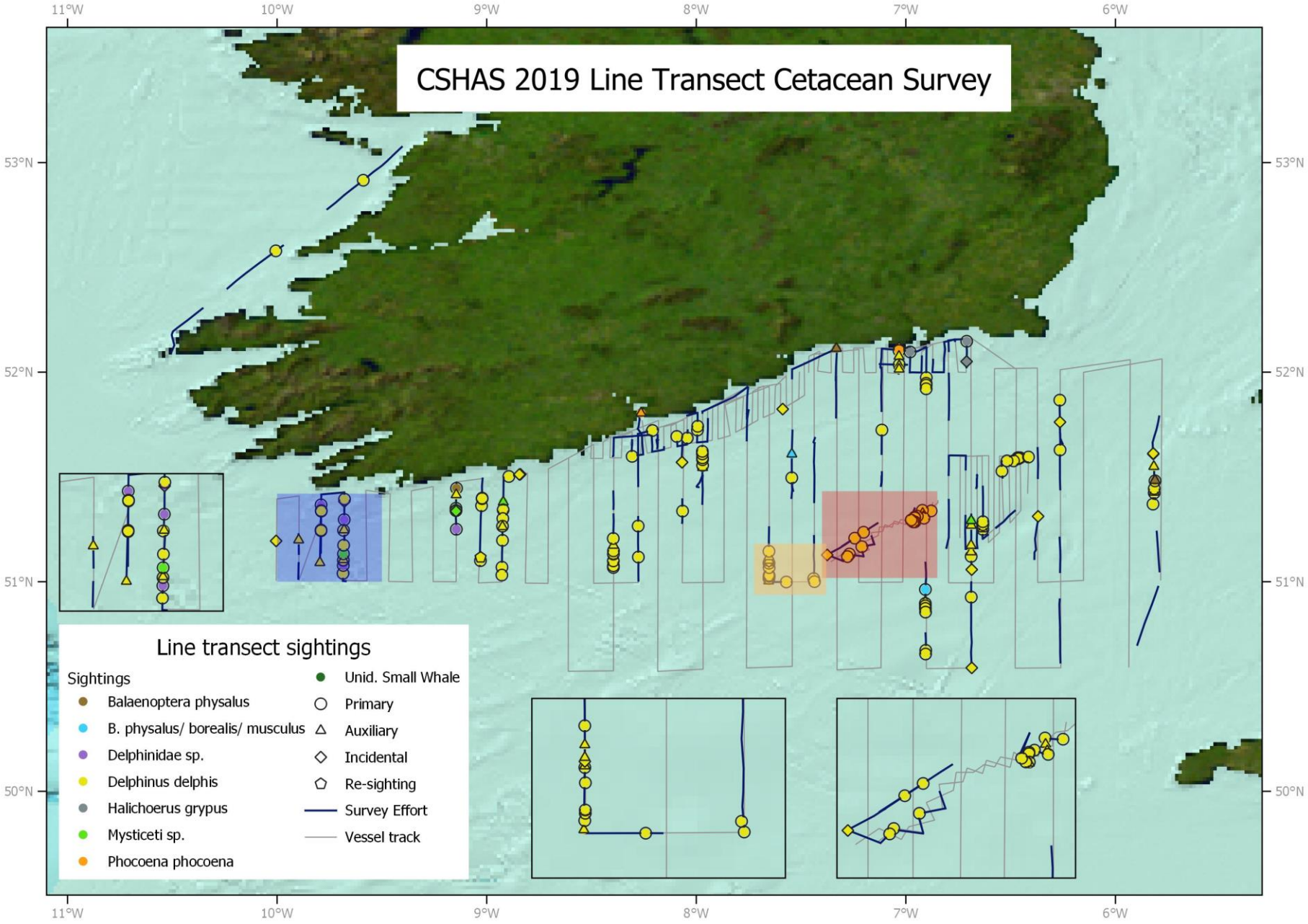

Figure 4: Distribution of marine mammal sightings recorded during line transect watches on the survey, including primary, auxiliary and incidental sightings. Cetacean survey effort transects are overlaid on the vessels track line.

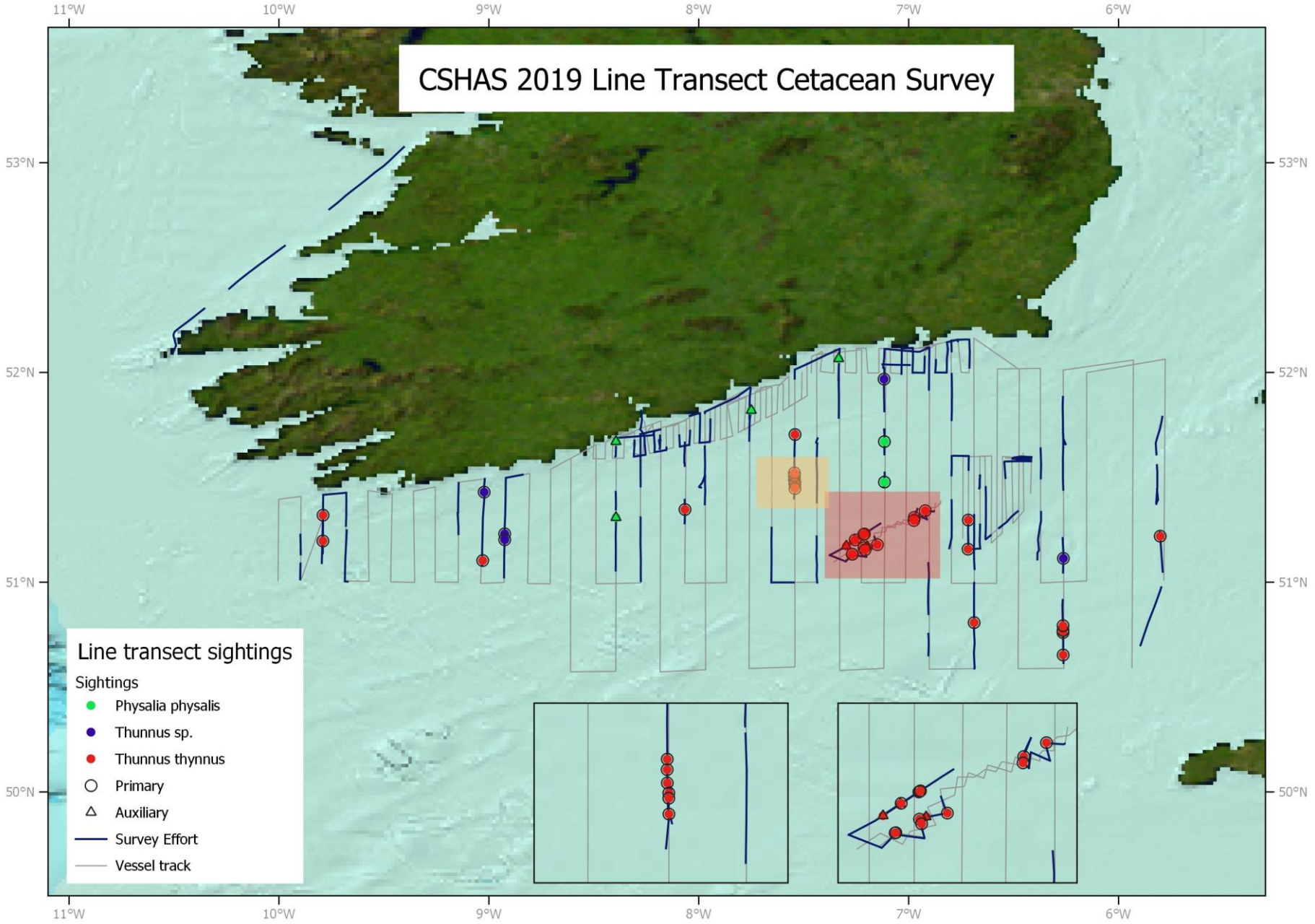

Figure 5: Distribution of other marine mega- and macro-fauna sightings recorded during line transect watches on the survey, including primary, auxiliary and incidental sightings. Cetacean survey effort transects are overlaid on the vessels track line.

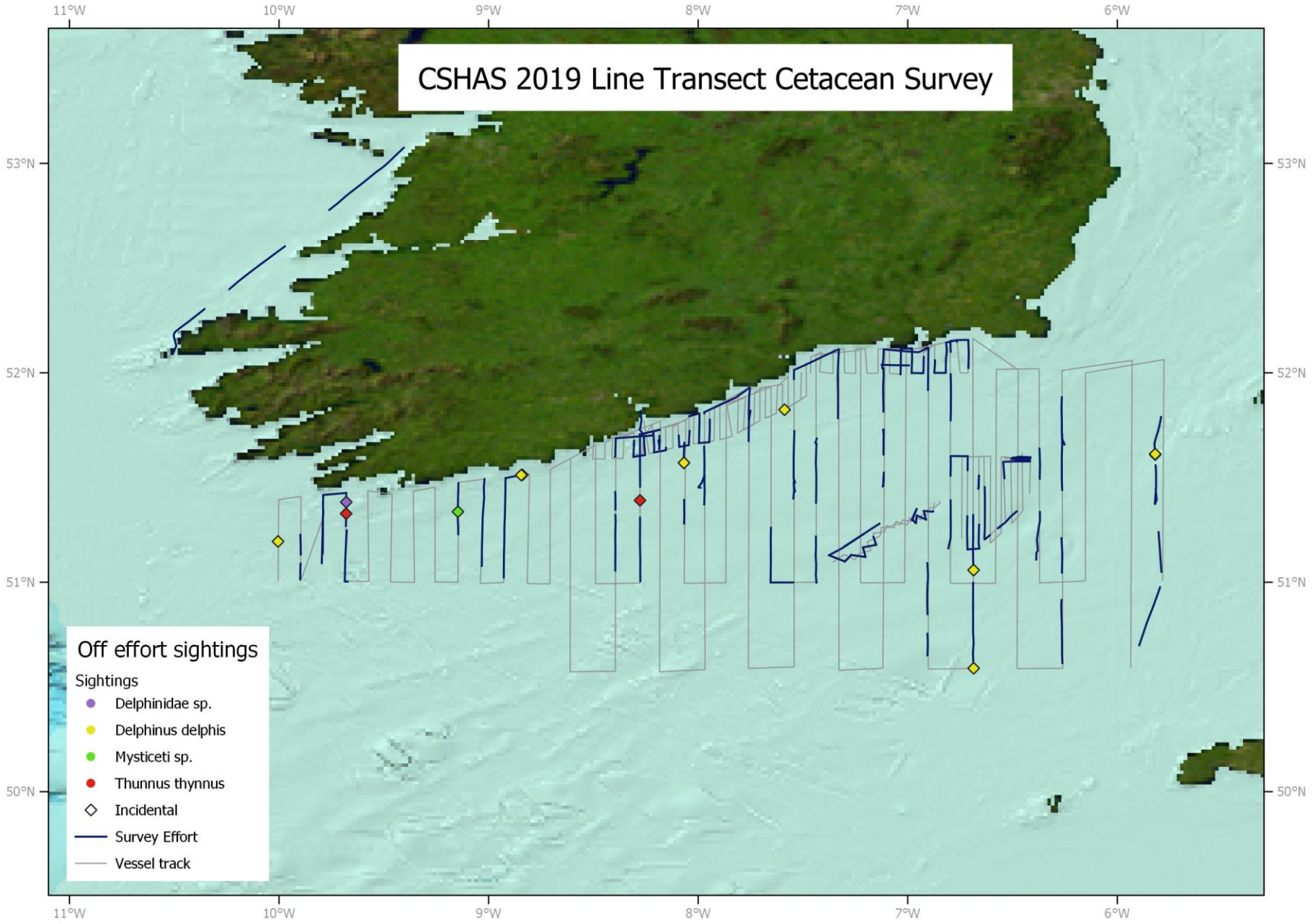

Figure 7: Distribution of all incidental sightings recorded while 'off effort' on the survey. Cetacean survey effort transects are overlaid on the vessels track line.

Delphinid species

Common dolphins (*Delphinus delphis*) were the most frequently encountered and most abundant species recorded on the survey. Common dolphins were encountered on 141 occasions, accounting for 69.1% of all sightings. These sightings consisted of a total of 1672 individuals (52.2% of all encountered individuals) with a group size range of 1-250 individuals (mean group size of 11 individuals). Common dolphins were regularly encountered throughout the Celtic sea, without numerous sightings recorded on most survey days. Common dolphins were recorded in particularly high numbers in areas such as the Trench, Labadie bank and Fastnet. For instance, 22 common dolphin sightings were recorded on the 22nd October while conducting a high resolution adaptive survey over the Trench.

A number of sightings of unidentified dolphins (*Delphinid sp.*) were recorded during the survey. Unidentified dolphins were encountered on 5 occasions, accounting for 2.5% of all sightings. These sightings consisted of a total of 66 individuals (2.1% of all encountered individuals). Unfortunately these sightings could not be reliably identified to species level due to the sighting conditions and/or the distance involved.

Harbour porpoise (*Phocoena phocoena*) were encountered on three occasions during the survey, with these sightings comprising a total of 6 individuals. The harbour porpoise were recorded off Brownstown head (2 sightings) and off Whitegate (1 sighting).

Whale species

Large baleen whales were encountered on a number of occasions during the survey. Fin whales (*Balaenoptera physalus*) were encountered on were recorded on 3 occasions (1.5% of all sightings) and totalled 3 individuals (0.1% of individuals). Other encounters with large baleen whale could not be reliably identified to species, these included 2 sightings identified as fin/ blue/ sei whale (*Balaenoptera sp.*) (1.0% of all sightings) and 5 sightings identified as unidentified large baleen whale (*Mysticeti sp.*) (2.5% of all sightings). Unfortunately the weather conditions at the time of these sightings and/or the distance involved prevented positive identification of the animals. The majority of these large whale sightings occurred in areas of high cetacean activity (common dolphins) in areas such as Fastnet, Labadie bank and the Smalls. However, a single fin whale was sighted off Bunmahon. A single sighting of a lone unidentified small whale (*Cetacean sp.*) was also recorded.

Pinniped species

The grey seal (*Halichoerus grypus*) were sighted on 3 occasions (1.5% of all sightings) with each sighting comprising a single individual. All of these sightings occurred in vicinity of Hook head.

Other mega- and macro-fauna species

Other marine megafauna encountered included; blue fin tuna (*Thunnus thynnus*) and unidentified tuna species (*Thunnus sp.*). Bluefin tuna (*Thunnus thynnus*) were the most frequently encountered species of marine megafauna excluding marine mammals, and the second most frequently observed species overall. Bluefin tuna were encountered on 36 occasions, accounting for 17.6% of all sightings. These sightings consisted of a total of 1422 individuals (44.4% of all encountered individuals).

Unidentified tuna were encountered on 5 occasions, accounting for 2.5% of all sightings. These sightings consisted of a total of 23 individuals (0.7% of all encountered individuals). Tuna were widely distributed across the survey area, however, a number of areas of particularly high densities were observed, such as the Rigs and the Trench.

An additional 6 sightings of Portuguese man o' war (*Physalia physalis*) were also recorded during survey effort.

Discussion

Since 2016 the CSHAS survey has used an updated survey design, covering an extended area of the Celtic sea employing parallel transects spaced equally at 8 nautical miles. The survey conducts two passes of the survey area offset at 4 nautical miles, while also conducting high resolution adaptive surveys within the bounds of the main survey area. A cetacean survey has been conducted each year since the updated survey design was implemented. Cetacean survey effort has varied across the time series of surveys since 2016. During the present survey a total of 107 hours and 27 minutes of survey effort was conducted. A total of 88 hours and 2 minutes of survey effort were recorded in 2018, and 132 hours and 7 minutes of survey effort were recorded in 2017, while 135 hours and 2 minutes of survey effort were recorded in 2016. The number of cetacean observers deployed has also varied over recent surveys. A single observer was deployed in both the present survey and the 2017 survey. However, in both 2018 and 2016, 1-2 observers were deployed with 1 observer deployed on leg 1 and 2 observers deployed on leg 2.

This year, as in previous surveys, a large number of number of sightings and a high abundance of animals were observed over the course of the survey. The total number of sightings recorded over the course of the 2019 survey was slightly higher than the total numbers recorded in recent years, with the present survey recording 204 sightings of 3205 individuals. In contrast, in 2018, 172 sightings totalling 1236 individuals were recorded, while 154 sightings totalling 829 individuals were recorded in 2017. However, the diversity of marine mammals species encountered was lower in the present survey than that of previous year's surveys. In total, 4 different marine mammal species were identified on CSHAS 2019. In comparison, 7 different marine mammal species were identified on CSHAS 2018, while 8 marine mammal species were sighted on CSHAS 2017. On CSHAS 2016, 7 different marine mammal species were recorded (*Table 6*).

This year's survey was largely dominated by two species, common dolphin and bluefin tuna. CSHAS 2019 saw a notable increase in the number of common dolphin sightings reported when compared to the previous two years, however the sighting rate for common dolphins in 2019 was more in line with that recorded in 2016. This year saw 141 sightings of 1672 individuals recorded while in 2018, common dolphins were encountered on 66 occasions, consisting of a total of 893 individuals. In 2017 and 2016, common dolphins were encountered on 97 occasions (628 individuals) and 133 occasions (2039 individuals) respectively. Conversely, humpback and minke whales were noticeably absent from this years' survey, having been sighted on all previous surveys since 2016. (*Table 6*).

Table 6: Cetacean sighting records from Western European Shelf Pelagic Acoustic Survey from 2016-2019 (O'Donnell et al., 2016a; O'Donnell et al., 2017a; O'Donnell et al., 2018a).

		2019		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.*	*No. of Sightings*	*No. of ind.*
Bottlenose dolphin	*Tursiops truncatus*	-	-	1	11	-	-	1	6
Common dolphin	*Delphinus delphis*	141	1672	66	893	97	628	133	2039
Fin/ blue/ sei whale	*Balaenoptera sp.*	2	2	-	-	-	-	-	-
Fin whale	*Balaenoptera physalus*	3	3	14	20	4	17	16	21
Harbour porpoise	*Phocoena phocoena*	3	6	1	4	5	4	*22**	*191**
Humpback whale	*Megaptera novaeangliae*	-	-	1	1	2	2	2	2
Minke whale	*Balaenoptera acutorostrata*	-	-	1	1	4	4	19	22
Risso's dolphin	*Grampus griseus*	-	-	-	-	2	4	-	-
Unidentified Baleen Whale	*Mysticeti sp.*	5	7	-	-	-	-	-	-
Unidentified Cetacean	*Cetacea sp.*	-	-	-	-	-	-	-	-
Unidentified Dolphin	*Delphinid sp.*	5	66	20	3	4	23	1	6
Unidentified Large Whale		-	-	2	4	6	6	*22**	*191**
Unidentified Small Whale		1	1	1	1	1	3	-	-
	Total	**160**	**1757**	**92**	**944**	**136**	**706**	**216**	**2387**
Grey Seal	*Halichoerus grypus*	3	3	1	1	7	7	3	3
Common seal	*Phoca vitulina*	-	-	-	-	1	1	-	-
Unidentified Seal	*Pinniped sp.*	-	-	1	1	-	-	-	-
	Total	**3**	**3**	**2**	**2**	**8**	**8**	**3**	**3**
Albacore tuna	*Thunnus alalunga*	-	-	1	3	-	-	-	-
Basking shark	*Cetorhinus maximus*	-	-	-	-	-	-	1	1
Blue shark	*Prionace glauca*	-	-	-	-	-	-	4	4
Bluefin tuna	*Thunnus thynnus*	36	1422	22	107	-	-	7	13
Tuna sp.	*Thunnus sp.*	5	23	55	180	10	115	-	-
Unidentified Fish	*Teleost sp.*	-	-	-	-	-	-	-	-
Unidentified Shark	*Selachii sp.*	-	-	-	-	-	-	-	-
	Total	**41**	**1445**	**78**	**290**	**10**	**115**	**12**	**18**
	Grand Total	**204**	**3205**	**172**	**1236**	**154**	**829**	**285**	**1730**

**Possible error in reported data due to duplication of figures*

The sightings recorded in 2019 were observed to be somewhat patchy for a number of species. Both common dolphin and Bluefin tuna were regularly encountered throughout the Celtic sea, however, both species were most abundant in the vicinity of fishing grounds such as the Trench, the Rigs and Fastnet. For example, 22 common dolphin sightings and 15 bluefin tuna sightings were recorded while conducting a high resolution adaptive survey over the Trench on the 22nd October, with both species observed feeding together on a number of occasions during this period.

Feeding baleen whales were also recorded on a number of occasions, and showed some overlap in distribution with the large dolphin and tuna aggregations. Intense sea bird activity was also observed in many of these areas at the time. The high levels of cetacean and seabird activity and feeding behaviour observed in these 'hotspots' suggests abundant feeding opportunities and high prey availability. This was further confirmed on the survey by the presence of sprat 'marks' detected near the surface using the ships acoustic survey equipment.

A large number of auxiliary sightings were recorded during line transect watches in the present survey. In fact, 38 auxiliary sightings (19.9% 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 CSHAS survey, a number of other scientists conduct regular visual watches for other marine species. There were two seabird observers deployed on CSHAS 2019. 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 seabird team followed a similar daily shift pattern to that of the cetacean team. The seabird observation platform on the monkey island is 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 the monkey island, 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 both survey teams, it is unsurprising that a large number of sightings were initially detected by the seabird survey team. The seabird team were responsible for initially detecting all 38 auxiliary sightings.

A look at the numbers of incidental sightings reveals a similar story. A total of 20 incidental sightings were recorded on the survey, 14 (70%) were recorded while the cetacean observer was 'off effort', while 6 (30%) were recorded while the cetacean observer was 'on effort'. The 14 incidental sightings recorded 'off effort' were recorded either during periods of unfavourable environmental conditions or outside of the cetacean observers shift. The 6 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) and thus puts constraints on the use of the data set from the present survey for any future determination of absolute abundances.

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 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 arc from 60^0 either side of the trackline out to the horizon (which can be up to 18km 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.

The CSHAS provides an excellent opportunity for the collection of data on the autumn distribution, abundance and behaviour of cetaceans in the Celtic sea. 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. Environmental conditions, 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). 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. Breaks could be staggered to facilitate meal times and adequate rest periods to avoid observer fatigue. This approach would increase effort coverage of the survey area and would be sufficient to cover all daylight hours. However, the authors appreciate the constraints on using such a large cetacean survey team.

The approach 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 CSHAS is an ideal survey for collecting data on the autumn 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 a team of three cetacean observers.

Acknowledgments

The cetacean observers would like to thank Captains Anthony Hobin and Denis Rowan, and chief scientist, Ciaran O'Donnell, along with the crew of the Celtic Explorer for their support and professional conduct during the survey.

The cetacean observers would also like to thank the marine, and galley crew, for their hospitality, and also the marine crew for providing the cetacean observers with access to the bridge.

Finally, the cetacean observers wish the RV *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.

References

Berrow, S.D. (2001). *Biological diversity of cetaceans (whales, dolphin and porpoises) in Irish waters*. In J.D. Nunn (ed.), Marine biodiversity in Ireland and adjacent waters*. Proceedings of a conference 26–27 April, 2001,* 115–119. Belfast. Ulster Museum

Berrow, S. *et al*., (2011). *Inshore Boat-based Surveys for Cetaceans – Irish Sea.* Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group. pp.24.

Buckland, S.T., et al., (2001). I*ntroduction to Distance Sampling: Estimating Abundance of Biological Populations.* Oxford University Press, Oxford, UK.

Cominelli, S., *et al.,* (2016). *Fin Whale Seasonal Trends in the Pelagos Sanctuary, Mediterranean Sea*. The Journal of Wildlife Management 80(3):490–499; 201

Department of the Environment, Heritage and Local Government (DEHLG) (2009). *Conservation Plan for Cetaceans in Irish Waters. A*vailable online: http://www.npws.ie/publications/speciesactionplans/2009_Cetaceans_CP.pdf

Hammond, P.S. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation 164 (2013) 107-122.

Heinemann, D. (1981). *A Range Finder for Pelagic Bird Censusing*. Journal of Wildlife Management 45(2): 489-493.

Kawakami, T. (1980). *A review of sperm whale food.* Sci. Rep. Whales Res. Inst. 32, 119-218.

Mackey, M., *et al*., (2004). *Cetaceans and Seabirds of Ireland's Atlantic Margin. Volume I – Seabird distribution, density & abundance*. Report on research carried out under the Irish Infrastructure Programme (PIP): Rockall Studies Group (RSG) projects 98/6 and 00/13, Porcupine Studies Group project P00/15 and Offshore Support Group (OSG) project 99/38. 95pp

Marine Institute (2019). *Celtic Sea Herring Acoustic Survey Cruise plan*.

MCR (2011). *Final Report for an Acoustic Survey of Beaked Whales Conducted from R/V Song of the Whale in the Rockall Trough, September to October 2010 and March 2011*. Marine Conservation Research Ltd., Essex, UK. http://www.marineconservationresearch.co.uk/wp-content/Downloads/Final%20Report%20SOTW%20beaked%20whale%20survey%20Rockall%20Trough%202010.pdf

NPWS, (2013). *The Status of EU Protected Habitats and Species in Ireland.* Species Assessments Volume 3. Version 1.0. National Parks & Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland. Available online: http://www.npws.ie/publications/article17assessments/article172013assessmentdocument s/Article17PrintVol3reportspeciesv11.pdf.

O'Brien, J., *et al*., (2014). *Cetaceans on the Frontier 6.* Final report to the Marine Institute, Rinville, Galway.

NPWS, (2014). *Guidance to Manage the Risk to Marine Mammals from Man-Made Sound Sources in Irish Waters*. National Parks and Wildlife Service, Dublin.

Ó Cadhla, O., *et al*., (2004). *Cetaceans and Seabirds of Ireland's Atlantic Margin, Volume II – Cetacean distribution & abundance*. Report on research carried out under the Irish Infrastructure Program (PIP): Rockall Studies Group (RSG) projects 98/6 and 00/13, Porcupine Studies Group project P00/15 and Offshore Support Group (OSG) project 99/38. 82pp.

O'Donnell, C., et al., (2015). *Blue Whiting Acoustic Survey Cruise Report, 2015*. FSS Survey Series: 2015/01.

O'Donnell, C., et al., (2018a). *Celtic Sea Herring Acoustic Survey Cruise Report*, *2018*. (https://oar.marine.ie/bitstream/handle/10793/1385/CSHAS%20Cruise%20Report%202018.pdf)

O'Donnell, C., et al., (2017a). *Celtic Sea Herring Acoustic Survey Cruise Report*, *2017*. (https://oar.marine.ie/bitstream/handle/10793/1338/CSHAS Cruise Report 2017_Final.pdf)

O'Donnell, C., et al., (2016a). *Celtic Sea Herring Acoustic Survey Cruise Report*, *2016*. (http://oar.marine.ie/bitstream/10793/1194/1/CSHAS%20Cruise%20Report%202016.pdf)

O'Donnell, C., *et al*., (2018b). *Western European Shelf Pelagic Acoustic Survey Cruise Report, 2018*. (http://oar.marine.ie/bitstream/10793/1380/1/WESPAS%20Cruise%20Report%202018.pdf)

O'Donnell, C., *et al*., (2017b). *Western European Shelf Pelagic Survey Cruise Report, 2017*. (http://oar.marine.ie/bitstream/10793/1326/1/WESPAS%20Cruise%20Report%202017.pdf)

O'Donnell, C., *et al*., (2016b). *Western European Shelf Pelagic Survey Cruise Report, 2017*. (http://oar.marine.ie/bitstream/10793/1179/1/WESPAS%20Cruise%20Report%202016.pdf)

Oudejans, M.G. (2014). *Cetacean monitoring undertaken during the Blue Whiting Acoustic Survey (BWAS) 2014.* Report to the National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland. Dúlra Research, Belmullet, Co. Mayo. 16pp.

Pollock, C.M., et al., (1997). The distribution of sea-birds and cetaceans in the waters around Ireland. JNCC Report No. 267

Rogan E & Berrow, S.D., (1995). *The management of Irish waters as a whale and dolphin sanctuary*. In A.S. Blix, L. Walløe & Ø. Ulltang. (eds.) Whales, seals, fish and man. Elsevier Science. Amsterdam. pp. 671-681.

Ryan, C. *et al.*, (2010). *Inshore Boat-based Surveys for Cetaceans*. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group. pp.33.

Ryan, C. et al., (2012). Final report for trans-Atlantic research passages conducted from R/V Song of the Whale, summer 2012. Marine Conservation Research International, Essex, U.K.

SCANS-II (2008). *Small Cetaceans in the European Atlantic and North Sea.* Final Report to the European Commission under project LIFE04NAT/GB/000245. Available from SMRU, Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife, KY16 8LB, UK.

Tasker, M.L., et al., (1984). Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardised approach. Auk 101: 567-577.

Teloni, V., et al., (2008). Shallow food for deep divers: Dynamic foraging behaviour of male sperm whales in a high latitude habitat. Journal of Experimental Marine Biology and Ecology 354, 119-131.

Temple, H.J. and Terry, A. (2007). *The Status and Distribution of European Mammals*. Luxembourg: Office for Official Publications of the European Communities. viii + 48pp,

Wall D., et al., (2006). Summer Distribution and Relative Abundance of Cetaceans off the West Coast of Ireland. Biology and Environment: Proceedings of the Royal Irish Academy. Vol. 106B, No. 2, 135-142.

Wall D., et al., (2013). Atlas of the distribution and relative abundance of marine mammals in Irish offshore waters 2005 - 2011. Irish Whale and Dolphin Group, Merchants Quay, Kilrush, Co Clare.

Whooley, P., (2016). *Bowhead whale: a new species for Irish waters, update*. Report II, June 1st 2016. Available at: http://www.iwdg.ie/news/?id=2631

WMO, (2011). *Manual on Codes, International Codes Volume I.1* Annex II to the WMO Technical Regulations, Part A – Alphanumeric Codes, WMO-No. 306. Updated in 2017, 2011 edition

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This project or operation is part supported by the Irish government and the European Maritime & Fisheries Fund
as part of the EMFF Operational Programme for 2014-2020

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

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

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