

Marine Institute Seabird Monitoring

During the Blue Whiting Acoustic Survey

21st March - 7th April 2021

Lead Agency: Marine Institute

Lead Partners: National Parks and Wildlife Service,

Authors: Emerald Marine

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Executive Summary

Irish waters represent one of the most important marine habitats for seabirds in Europe and are utilized by a wide range of seabird species. However, the at-sea abundance and distribution of many of the seabird species occurring in Irish waters remains poorly understood. Under the EU Birds Directive, there is a requirement on member states to conduct surveillance of seabirds occurring within their waters. The Department of Housing, Local Government and Heritage (DHLGH), through the Marine Institute, commissioned a seabird survey from the MRV Celtic Explorer during the annual Blue Whiting Acoustic Survey (BWAS), running from the 21st March to the 7th April 2021.

A standard line transect survey methodology was employed by the seabird observer with additional visual point sampling at fishing locations and 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 seabird 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 300m. A total of 89 hours and 44 minutes of survey effort was conducted over the course of BWAS 2021. In total, 65 hours and 16 minutes of survey effort were conducted using a line transect methodology, while 20 hours and 16 minutes of effort were conducted using the point sampling methodology. A further 4 hours and 11 minutes of effort were conducted as a casual watch.

A total of 1417 seabird observations were recorded throughout the survey, totalling 29448 individuals. In total, 1822 seabirds were recorded as "in transect", while 9235 were recorded "off transect". The species encountered included 18 species from 7 families. A further 39 sightings of terrestrial birds were also recorded, comprising of 687 individuals from 10 different species.

Introduction

Irish waters represent one of the most important marine habitats for seabirds in Europe and are utilized by a wide range of seabird species (Mackey, *et al.*, 2004; Mitchell, *et al.*, 2004; Pollock, *et al.*, 1997). 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 seabirds. Ireland's rugged and exposed coastline provide ample and diverse nesting habitats for a range of seabirds, and Ireland's coast hosts a number of large seabird colonies of significance at a European level (Mackey, *et al.*, 2004). At present, there are twenty-four species of seabirds known to breed in Ireland (Mitchell, *et al.*, 2004; *Table 1*).

In 1930, legal protection for birds, including most seabird species, in Ireland began with the enactment of the Wild Birds (Protection) Act. The 1976 Wildlife Act provides a legal framework for the conservation of Irish wildlife and their habitats, conferring specific protection on all bird species, including seabirds, from death, injury or disturbance at nest sites.

Seabirds in Ireland are also protected under EC Council Directive (2009/147/EEC) on the conservation of birds commonly referred to as the EU Birds Directive. The Birds Directive relates to the conservation of all wild bird species occurring in EU member states, it covers the protection and management of the birds, their nests, eggs and habitat, and mandates the creation of Special Protection Areas (SPAs) (Article 3, EC Council Directive 2009/147/EEC). A number of seabirds are listed under Annex I of the Birds Directive as species requiring special conservation measures concerning their habitat in order to ensure their survival in their natural range (Article 4, EC Council Directive 2009/147/EEC). Since 1993 the EU has funded Species Action Plans for species listed in Annex 1 of the Birds Directive, including the Balearic shearwater (*Puffinus mauretanicus*) and roseate tern (*Sterna dougallii*), providing key information on the status, ecology and threats to species as well as key steps to ensure their conservation. Seabirds gain further protection under the 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, through the establishment of the 'Natura 2000' network; a coherent network of SPAs and Special Areas of Conservation (SACs). Article 6 of the Habitats Directive defines how Natura 2000 sites are managed and protected, and establishes the requirement to conduct appropriate assessments in Natura 2000 sites before plans or projects likely to impact the site are conducted.

Ireland is also a signatory to the Bern convention on the conservation of European wildlife and natural habitats, the Bonn convention on the conservation of migratory species of wild animals, and the OSPAR convention for the protection of the marine environment in the North-East Atlantic, each affording further protection to seabirds.

Despite the importance Ireland holds for nesting and feeding seabirds, quantitative data on the population status and distribution, particularly the at sea distribution, of many of the seabird species occurring in Ireland remains poorly understood (Mackey, *et al.*, 2004). Under the EU Birds Directive, there is a requirement on member states to identify and classify habitats for the establishment of SPAs for seabirds, including foraging habitats within their waters.

Table 1: Breeding seabird numbers in Ireland and Britain 1998-2002 as recorded during the Seabird 2000 census and percentage change in numbers since The Seabird Colony Register (SCR) 1985-1988 (Source: Mitchell, et al., 2004).

Species	Latin name	Northern Ireland	Republic of Ireland	All- Ireland total	GB & Ireland Total	Percentage change since SCR Census (1985-88) ¹
Fulmar	<i>Fulmarus glacialis</i>	5,992	32,918	38,910	537,991	0%
Manx Shearwater ²	<i>Puffinus puffinus</i>	4,633	32,545	37,178	332,267	
European Storm petrel ²	<i>Hydrobates pelagicus</i>	0	99,065	99,065	124,775	
Leach's Storm petrel ²	<i>Oceanodroma leucorhoa</i>	0	310	310	48,357	
Gannet	<i>Morus bassanus</i>	0	32,758	32,758	259,311	39%
Cormorant	<i>Phalacrocorax carbo</i>	663	4,548	5,211	13,681	7%
Shag	<i>Phalacrocorax aristotelis</i>	301	3,426	3,727	32,306	-25%
Arctic Skua	<i>Stercorarius parasiticus</i>	0	0	0	2,136	-37%
Great Skua	<i>Stercorarius skua</i>	0	1	1	9,635	26%
Mediterranean Gull	<i>Larus melanocephalus</i>	2	3	5	113	
Black-headed Gull	<i>Larus ridibundus</i>	10,107	3,876	13,983	141,890	2%
Common Gull	<i>Larus canus</i>	557	1,060	1,617	49,780	39%
Lesser Black-backed Gull	<i>Larus fuscus</i>	1,973	2,876	4,849	116,684	42%
Herring Gull	<i>Larus argentatus</i>	714	5,521	6,235	149,177	-17%
Great Black-backed Gull	<i>Larus marinus</i>	76	2,243	2,319	19,713	-6%
Kittiwake	<i>Rissa tridactyla</i>	13,060	36,100	49,160	415,995	-23%
Sandwich Tern	<i>Sterna sandvicensis</i>	1,954	1,762	3,716	14,252	-11%
Roseate Tern	<i>Sterna dougallii</i>	4	734	738	790	44%
Common Tern	<i>Sterna hirundo</i>	1,704	2,485	4,189	14,497	-2%
Arctic Tern	<i>Sterna paradisaea</i>	767	2,735	3,502	56,123	-29%
Little Tern	<i>Sterna albifrons</i>	0	206	206	2,153	-25%
Guillemot	<i>Uria aalge</i>	98,546	138,108	236,654	1,559,484	32%
Razorbill ³	<i>Alea torda</i>	24,084	27,446	51,530	216,087	23%
Black Guillemot ⁴	<i>Cephus grylle</i>	1,174	3,367	4,541	42,683	
Atlantic Puffin	<i>Fratercula arctica</i>	1,610	19,641	21,251	600,751	19%

¹ inland colonies were not surveyed during the SCR Census (1985-88)

² not surveyed during the SCR Census (1985-88)

³ counts of individuals

⁴ counts of pre-breeding adults; pre-breeding surveys were not conducted in the Republic of Ireland during the SCR Census (1985-88).

Since 1994, a number dedicated studies on seabirds have been conducted in Ireland, providing data on the presence, distribution and abundance of the numerous seabird species in coastal and offshore waters (e.g. Pollock et al. 1997; Mackey, *et al.*, 2004; O'Brien, *et al.*, 2016). In recent years, the Marine Institute has facilitated the surveillance of seabirds in Irish waters by providing berths for seabird observers on-board the national research vessels, *RV Celtic Explorer* and *RV Celtic Voyager*, during oceanographic and fisheries surveys (O'Donnell, *et al.*, 2020; 2019; 2018). Fisheries acoustic surveys are particularly suited to the conduction of seabird surveys as the vessel spends the majority of the survey travelling at a steady speed along pre-determined survey tracks.

Acoustic surveys targeting blue whiting (*Micromesistius poutassou*) spawning and post spawning aggregations in the north east Atlantic have been carried out by the Institute of Marine Research (IMR) Norway since the early 1970s (O'Donnell, *et al.*, 2018). Since 2004, Ireland has participated in an International coordinated survey program along with vessels from Norway, Russia, the Netherlands and the Faroes (O'Donnell, *et al.*, 2018). Owing to the highly migratory nature of the stock a large geographical area along the Atlantic margin of the British Isles is surveyed annually, with surveys timed to coincide with peak spawning of the blue whiting stock (O'Donnell, *et al.*, 2018).

The Blue Whiting Acoustic Survey (BWAS) provides a unique opportunity for surveillance of seabirds in deep water habitats along Ireland's Atlantic margins which can be difficult to reach by other means. The waters of Ireland's Atlantic margin are highly productive owing to the upwelling of nutrient rich oceanic waters, and support large and diverse species' assemblages (Mackey et al., 2004). The availability and distribution of prey is a key factor affecting the distribution of seabirds, and the complex bathymetry and hydrology of the Atlantic margin maintain a heterogeneous marine environment, making it a key habitat for seabirds (Mackey et al., 2004).

Department of Housing, Local Government and Heritage (DHLGH), through the Marine Institute, commissioned a seabird survey from the *RV Celtic Explorer* during the annual Blue Whiting Acoustic Survey (BWAS), running from the 21st March to the 7th April 2021.

Methodology

The seabird survey was conducted from the 21st March to the 7th April 2021 using a single seabird observer per survey leg. The seabird observer conducted visual survey effort while also recording all survey data. Given the presented survey transects for the 2021 survey (*Figure 1*), a standard line transect survey methodology was determined to be most suitable and was employed by the seabird surveyor. Survey transect were undertaken at speeds of 5-10 knots, with fishing activity being conducted at speeds of 2-3 knots.

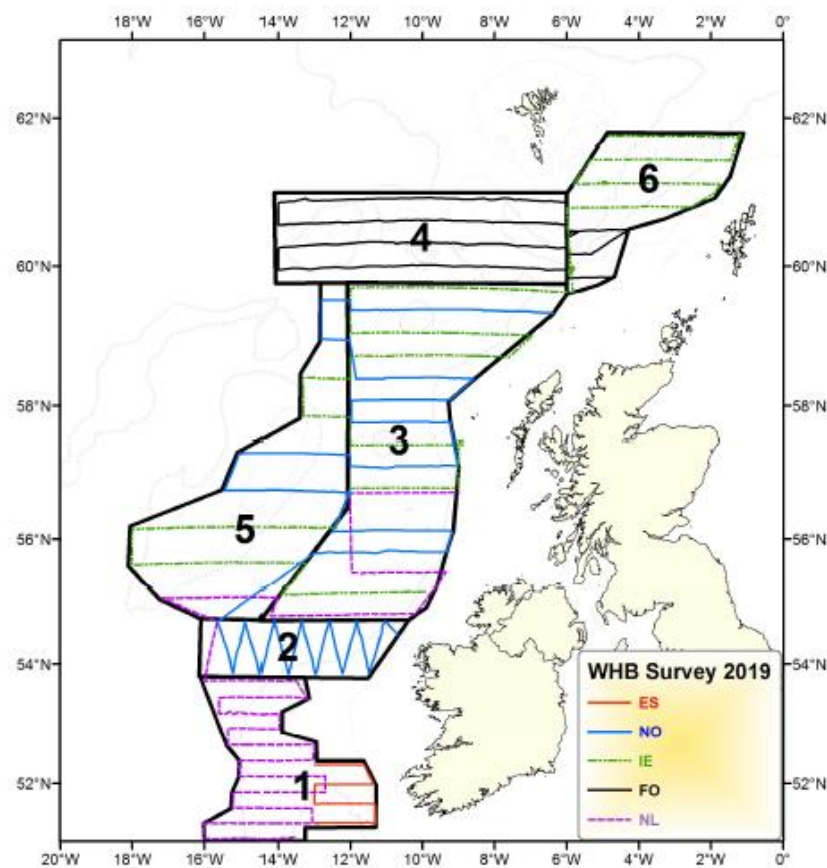


Figure 1: Representative cruise track of the international co-ordinated survey program. Vessel nationality are represented by; ES: Spain, NO: Norway, IE: Ireland, FO: Faroe Islands, NL: Netherlands (Source: Marine Institute, 2021).

Visual survey watches were conducted using a standard line transect survey design while the vessel was travelling at a consistent speed and heading. Additional visual point sampling (e.g., at oceanographic sampling stations or fishing stations) was also employed, however line transect survey effort was prioritised by the observer. Observations for seabirds were conducted from the monkey island (deck height 12 m above sea level). The 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 300m. Regular breaks were taken by the observer to avoid observer fatigue and its associated negative consequences.

Line transect survey methodology

The line transect data collection methodology was based on that originally proposed by Tasker *et al.* (1984) with later adaptations applied to allow correction factors to be applied for missed birds (Camphuysen *et al.*, 2004). The method employed used a single platform line transect survey design with sub-bands to survey birds associated with the water, while flying birds were surveyed using a 'snapshot' technique. Observer effort was concentrated in a bow-beam arc of 90° to one side (i.e., to port or starboard) of the vessel's track-line, however, all seabirds observed outside this area were also recorded.

Survey effort for seabirds associating with the water were concentrated within a survey strip of 300m running parallel and adjacent to the vessels track-line and extending to the horizon. All birds surveyed within this region were recorded as 'in-transect' and assigned to one of four distance sub-bands (A: 0-50m, B: 50-100m, C: 100-200m, D: 200-300m) according to their perpendicular distance from the track-line. This approach allows for the evaluation of biases caused by specific differences in detection probability with increasing distance from the trackline (Camphuysen *et al.* 2004). Seabirds occurring outside of this survey strip were recorded as 'off-transect' and assigned to a separate sub-band (E: >300m). The perpendicular distance to an animal was estimated using a fixed interval range finder (Heinemann, 1981), ensuring each animal was allocated to the correct distance sub-band.

Flying birds were surveyed using 'snapshots', where instantaneous counts of flying birds within a survey quadrant of 300m x 300m were conducted. The periodicity of these 'snapshots' was vessel speed dependent but timed to allow counts to occur as the vessel passes from one survey quadrant to the next. This method minimises biases in counts of flying birds relative to the movement of the vessel (Pollock *et al.*, 2000, Camphuysen *et al.* 2004).

Seabirds remaining with the vessel for more than 2 minutes were deemed to be associating with the vessel (Camphuysen *et al.* 2004) and were recorded as such. Seabirds seen associating with other vessels (i.e. fishing vessels) were also recorded as such.

Searching for seabirds was done with the naked eye, however, Leika Ultravid 8x42 HD binoculars were used to confirm parameters such as species identification, age, moult, group size and behaviour (Mackey *et al.* 2004). A Canon EOS 7D Mark II DSLR camera with a Canon EF 100-400mm F4.5-5.6 IS II USM telephoto lens was used to visually document other information of scientific interest. Data was also collected on all migratory/ transient waterfowl and terrestrial birds encountered.

Data collection and recording

The Cybertracker (<https://cybertracker.org>) data collection software package (Version 3.514) was configured for optimum use on the survey. Cybertracker was used to record all positional, environmental and seabird observation 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 regularly recorded using Cybertracker, including at the start of each seabird survey transect, and included data such as; wind speed, wind direction, sea state, swell, visibility, cloud cover and precipitation. The data was time stamped with GPS data by Cybertracker and saved in the

Access database. If environmental conditions changed at any point, the seabird observer recorded an environmental update of the above listed data. Each line transect was assigned a unique transect number, and a new transect was started anytime the vessel activity changed (i.e. changing from on-transect to inter-transect). Each subsequent seabird observation was also assigned to this unique transect number. Ancillary information (such as line changes, changes in survey activity, other vessel activity, etc.) were also recorded on Cybertracker.

The GPS position of each seabird record was time stamped and digitally marked using Cybertracker. Observational data such as; species identification, distance band, group size, composition, heading, age, moult, behaviour and any associations with cetaceans or other vessels were also recorded on the time stamped Cybertracker sighting record page. Where species identification could not be confirmed, observations were recorded at an appropriate taxonomic level (i.e. large gull sp., *Larus sp.*, commic tern, etc.).

Additional visual point sampling was conducted at oceanographic sampling stations and fishing shoot/haul locations. Point sampling survey effort for seabirds was conducted in 360° arc around the vessel. Data recording methodology remained similar for both point sampling and line transect methods.

Results

Effort

A total of 89 hours and 44 minutes of survey effort was conducted over the course of BWAS 2021. In total, 65 hours and 16 minutes of survey effort were conducted using a line transect methodology, while 20 hours and 16 minutes of effort were conducted using the point sampling methodology. A further 4 hours and 11 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 11 hours and 09 minutes while the average daily survey effort was 4 hours and 59 minutes. No effort watches were conducted on the 28th or 29th of March or on the 4th or 5th of April as the vessel was sheltering from adverse weather. Seabird survey effort was greatly reduced on the 23rd, 26th, 27th and 31st of March due to weather conditions exceeding the specified weather limits for observations. A graph of daily effort is provided in *Figure 2* below.

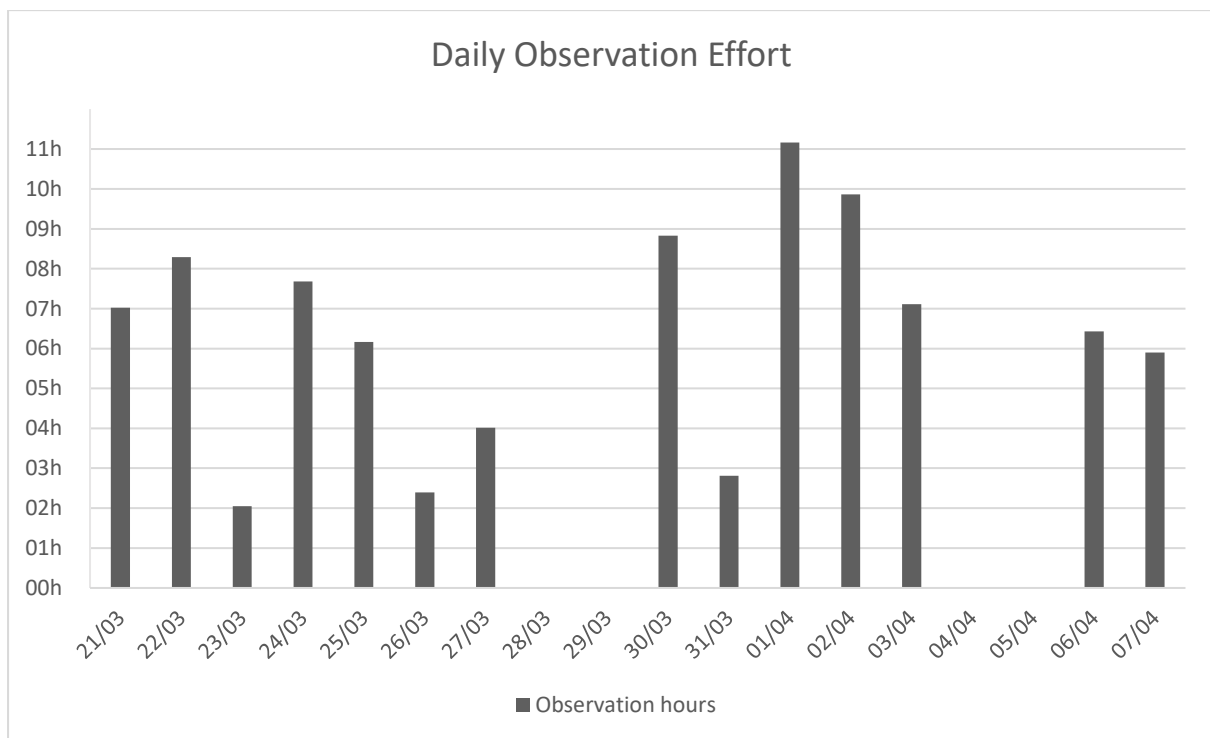


Figure 2: Daily visual effort undertaken during the survey.

Environmental Conditions

Environmental conditions were generally moderate to poor throughout the survey. On a number of occasions seabird survey effort was severely restricted due to environmental conditions. The vessel was also forced to take shelter for a number of days due to adverse weather. 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 wind force/ sea state and was judged based on the effect of the wind on the sea surface.

WMO sea states 3, 4 and 5 were the most common sea states recorded. The most frequently recorded WMO sea state was 3, accounting for 31.5 hours (35%) of observation effort, while WMO sea state 5 accounted for over 28 hours (31%). WMO sea state 4 accounted for 20 hours (23%) of observation effort (*Fig. 3a*).

The most frequently recorded Beaufort wind force/ sea state was a sea state 2, accounting for 23 hours (26%) of survey effort. However, Beaufort sea states 5 and 6 were the next most frequently recorded, accounting for 18 hours (20%) and 21 hours (23%) respectively.

Swell

A swell height of over 2 meter was most frequently recorded throughout the survey, being recorded over almost 39 hours (43%) of survey effort. A swell height of 0.1-1 meters was recorded over almost 27 survey hours (30%), while swell of over 1.1-2 meters was recorded during over 23 hours (27%) of survey effort (*Fig. 3c*).

Visibility

Visibility was generally very good during seabird survey effort. The most frequently recorded visibility was 11-15km, being recorded over 68 hours (77%) of survey effort. Visibility of 6-10km was recorded on over 13 hours (15%) of survey effort, while visibility of 1-5km was recorded on over 7 hours (8%) of survey effort (*Fig. 3d*).

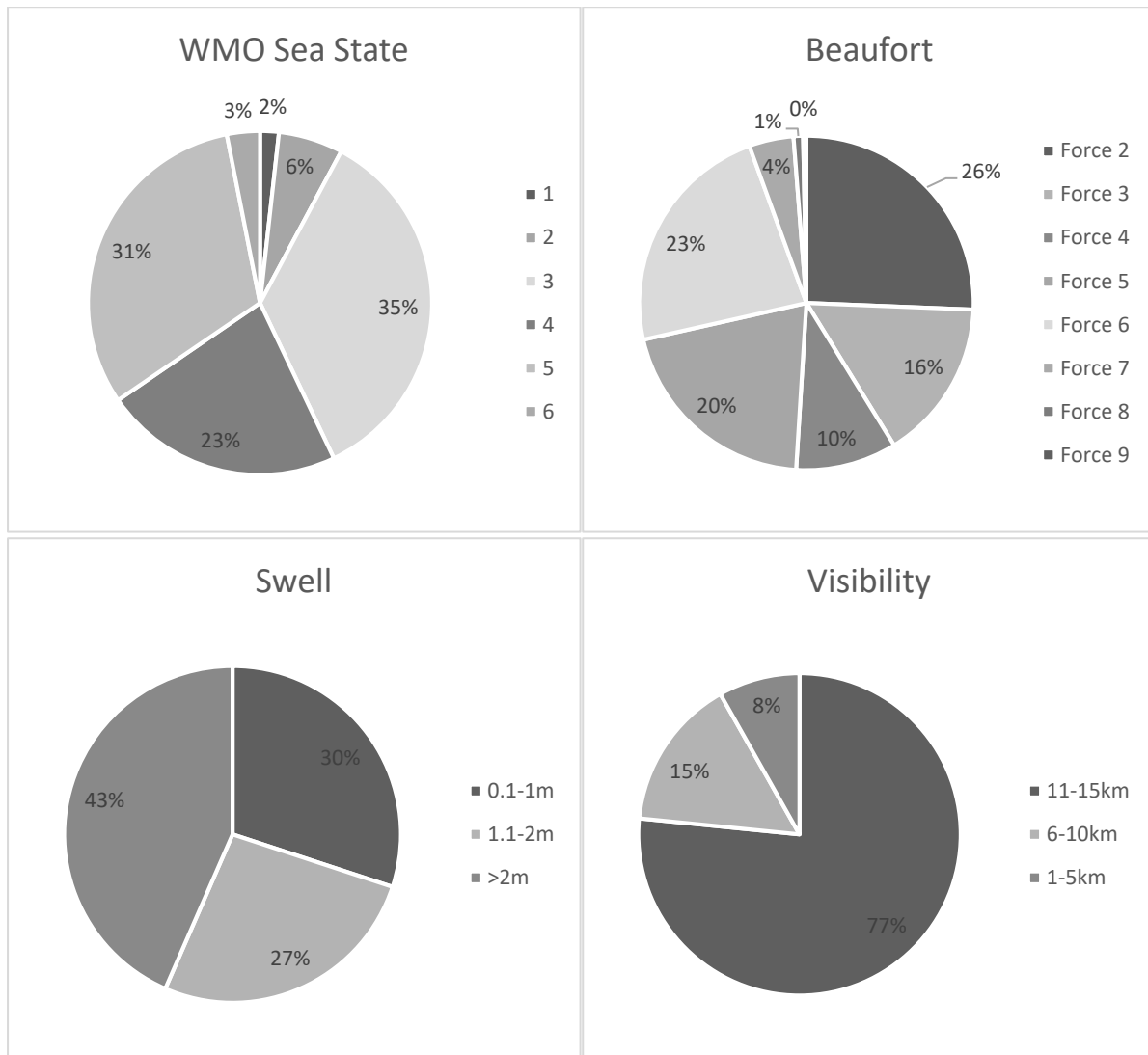


Figure 3: Summary of environmental conditions recorded on the BWAS 2021; a) WMO sea state, b) Beaufort sea state/ wind force, c) Swell height (meters), d) Visibility (kilometres).

Seabird records

A total of 1417 seabird observations were recorded throughout the survey, totalling 29448 individuals, with flock size ranging from 1 up to 2000 for some species (*Table 2*). In total, 1822 seabirds were recorded as “in-transect”, while 27626 were recorded “off-transect”. A summary of all sightings recorded on the survey is presented in *Table 2* and includes sightings recorded during both line transect and point sampling watches. A total of 18 species of seabird were encountered during the survey. A further 39 sightings of terrestrial birds were also recorded, comprising of 687 individuals belonging to 10 species.

Of the 1417 seabird observations recorded during the survey, 1245 were recorded during line transect effort. Of the 18 seabird species recorded during the survey, 14 species were recorded during line transect survey effort. In total, 11057 seabirds were recorded during line transect effort, with 1822 of these recorded as ‘in-transect’. The remaining 9235 seabirds were recorded as ‘off-transect’. A breakdown of all species encountered during line transect effort watches is presented in *Table 3*.

The distribution of all observations of seabird species recorded as ‘in-transect’ during line transect survey effort can be seen in *Figures 4 to 7*. For clarity, and brevity, seabirds recorded during point sampling watches, or those recorded as ‘off-transect’ are not displayed.

Table 2: Summary of all seabird sightings recorded on the survey during both line transect and point sampling watches.

<i>Common Name</i>	<i>Species name</i>	<i>No. of Records</i>	<i>No. of Individuals</i>	<i>Flock Size</i>
Fulmar	<i>Fulmarus glacialis</i>	389	15527	1-2000
Great Shearwater	<i>Puffinus graves</i>	1	1	1
Manx Shearwater	<i>Puffinus puffinus</i>	58	89	1-5
Leach's Petrel	<i>Oceanodroma leucorhoa</i>	1	1	1
Gannet	<i>Morus bassanus</i>	543	11908	1-1000
Pomarine Skua	<i>Stercorarius pomarinus</i>	1	1	1
Great Skua	<i>Stercorarius skua</i>	66	111	1-9
Black-headed Gull	<i>Larus ridibundus</i>	1	1	1
Lesser Black-backed Gull	<i>Larus fuscus</i>	46	382	1-67
Herring Gull	<i>Larus argentatus</i>	4	11	1-5
Great Black-backed Gull	<i>Larus marinus</i>	20	32	1-4
Iceland Gull	<i>Larus glaucoides</i>	1	1	1
Kittiwake	<i>Rissa tridactyla</i>	202	1169	1-62
Guillemot	<i>Uria aalge</i>	35	46	1-4
Black guillemot	<i>Cepphus grylle</i>	1	1	1
Razorbill	<i>Alea torda</i>	13	40	1-15
Little Auk	<i>Alle alle</i>	1	1	1
Puffin	<i>Fratercula arctica</i>	33	124	1-28
Auk sp.	<i>Alcidae sp.</i>	1	2	2
	Total	1417	29448	

Table 3: Summary of all seabird sightings recorded during line transect effort on the survey.

<i>Common Name</i>	<i>Species name</i>	<i>No. of Records</i>	<i>No. of Seabirds</i>	<i>In Transect</i>	<i>Off Transect</i>
Fulmar	<i>Fulmarus glacialis</i>	343	6929	864	6065
Manx Shearwater	<i>Puffinus puffinus</i>	55	86	31	55
Leach's Petrel	<i>Oceanodroma leucorhoa</i>	1	1	1	0
Gannet	<i>Morus bassanus</i>	508	2992	621	2371
Great Skua	<i>Stercorarius skua</i>	43	52	26	26
Lesser Black-backed Gull	<i>Larus fuscus</i>	26	145	20	125
Herring Gull	<i>Larus argentatus</i>	2	8	3	5
Great Black-backed Gull	<i>Larus marinus</i>	14	20	6	14
Kittiwake	<i>Rissa tridactyla</i>	171	613	146	467
Guillemot	<i>Uria aalge</i>	35	46	29	17
Black guillemot	<i>Cephus grylle</i>	1	1	1	0
Razorbill	<i>Alea torda</i>	13	40	19	21
Little Auk	<i>Alle alle</i>	1	1	1	0
Puffin	<i>Fratercula arctica</i>	31	121	54	67
Auk sp.	<i>Alcidae sp.</i>	1	2	0	2
	Total	1245	11057	1822	9235

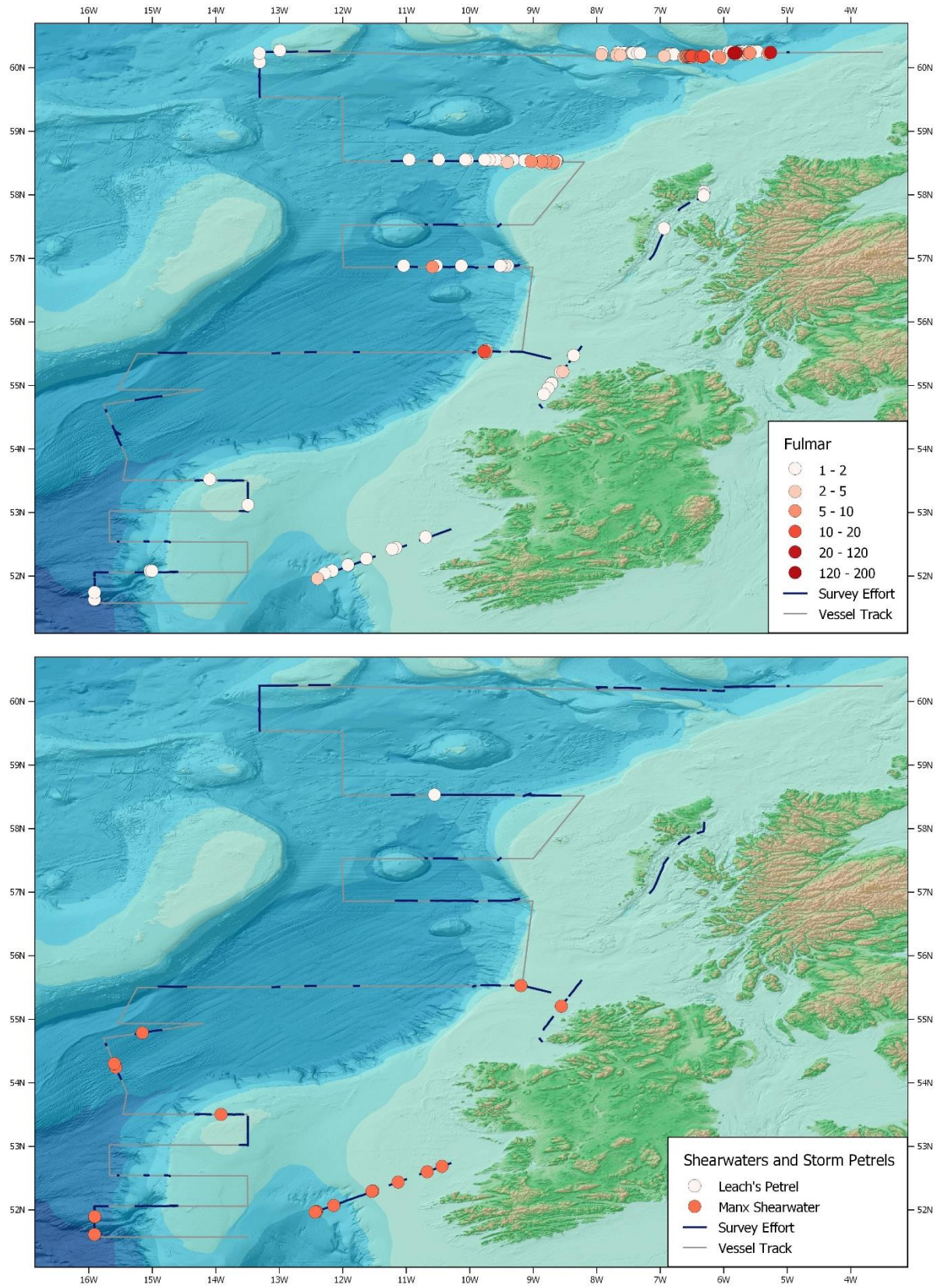


Figure 4: Distribution of a) Fulmar and b) Shearwaters and Storm Petrels recorded as 'in-transect' during line transect survey effort.

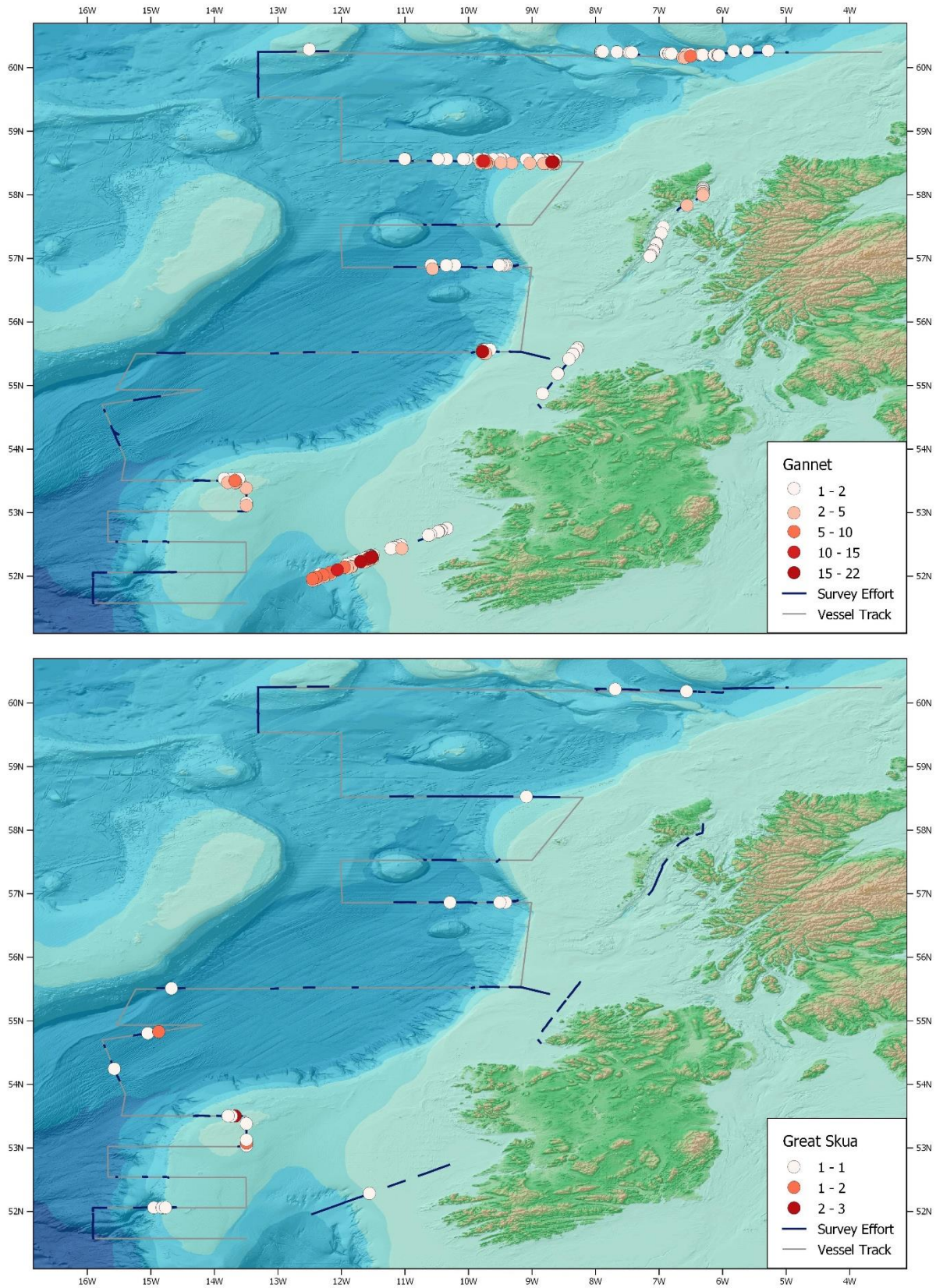


Figure 5: Distribution of a) Gannet and b) Great Skua recorded during as 'in-transect' line transect survey effort.

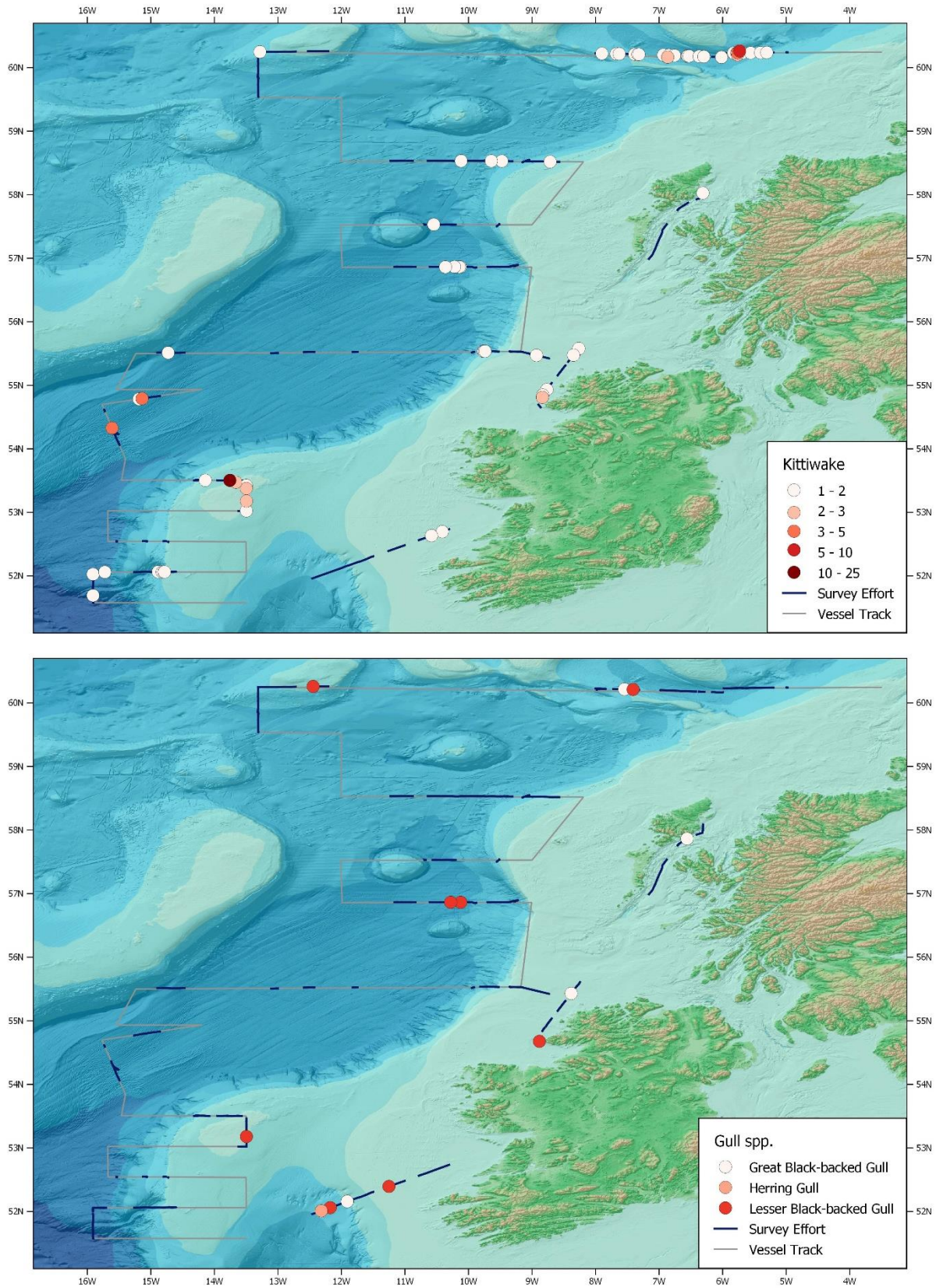


Figure 6: Distribution of a) Kittiwake and b) Gull spp. recorded during as 'in-transect' line transect survey effort.

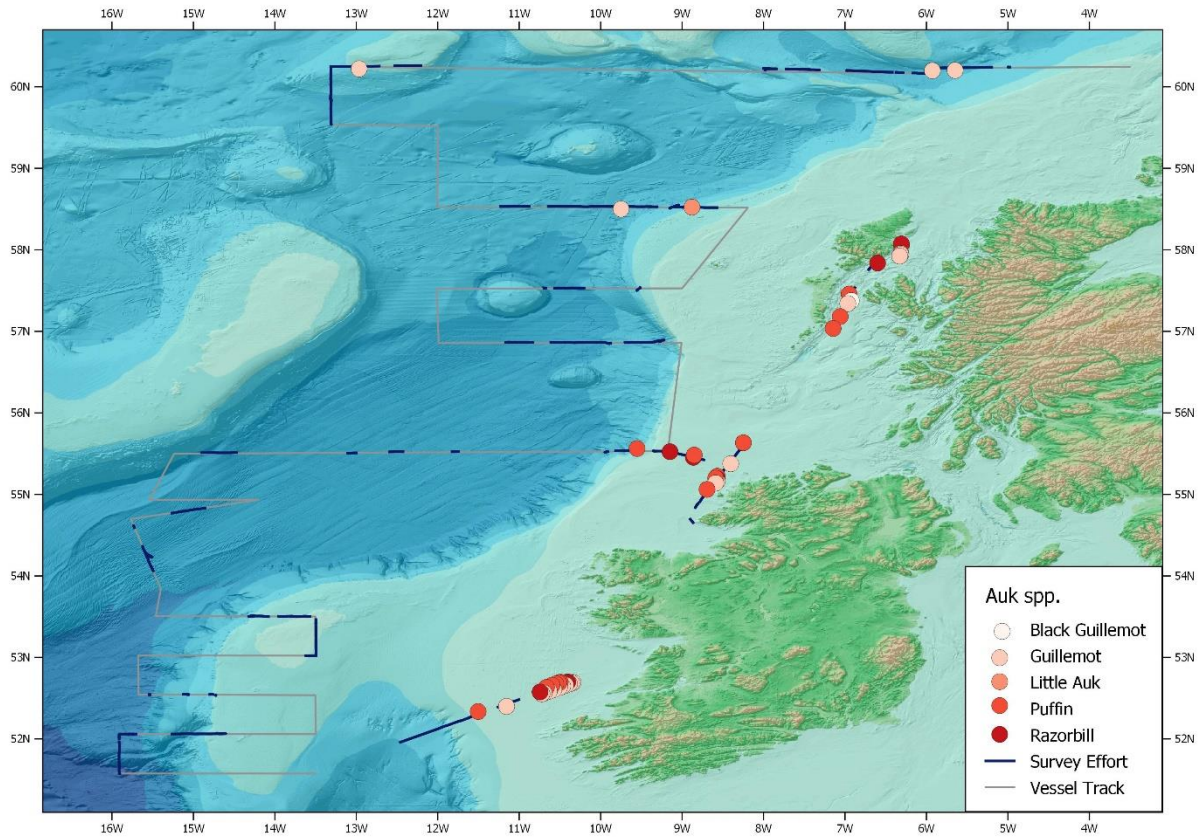


Figure 7: Distribution of Auk spp. recorded during as 'in-transect' line transect survey effort.

Twenty point sampling were conducted at oceanographic or fishing stations. A total of 124 seabird observation were recorded during point sampling effort, comprising 16314 individuals from 13 species (Table 4). All sightings recorded during point sampling watches were recorded as 'off transect'.

Table 4: Summary of all sightings recorded during point sampling effort on the survey.

<i>Common Name</i>	<i>Species name</i>	<i>No. of Records</i>	<i>Off Transect</i>
Fulmar	<i>Fulmarus glacialis</i>	30	6855
Great Shearwater	<i>Puffinus graves</i>	1	1
Manx Shearwater	<i>Puffinus puffinus</i>	3	3
Gannet	<i>Morus bassanus</i>	26	8832
Pomarine Skua	<i>Stercoratius pomarinus</i>	1	1
Great Skua	<i>Stercoratius skua</i>	16	48
Black-headed Gull	<i>Larus ridibundus</i>	1	1
Lesser Black-backed Gull	<i>Larus fuscus</i>	15	146
Herring Gull	<i>Larus argentatus</i>	2	3
Great Black-backed Gull	<i>Larus marinus</i>	5	10
Iceland Gull	<i>Larus glaucooides</i>	1	1
Kittiwake	<i>Rissa tridactyla</i>	21	410
Puffin	<i>Fratercula arctica</i>	2	3
	Total	124	16314

Fulmar

Northern fulmar (*Fulmarus glacialis*) were the second most frequently encountered seabird species on the survey, being recorded on 389 occasions and totalling 15527 individuals. In total, 343 sightings of 6929 individuals were recorded during line transect watches, with 864 individuals recorded as 'in-transect', making fulmars the most abundant species recorded during line transect effort.

Fulmar were found to be broadly distributed in low numbers across much of the survey area however, they were also found to display a somewhat patchy distribution with higher abundances in areas such as the shelf slopes west of the Blaskets, Donegal, and the Faroe-Shetland Channel. In the Faroe-Shetland Channel in particular, huge aggregations of fulmars were recorded with records of 1000-2000 birds recorded on a number of occasions. Although fulmar were widely distributed and one of the most frequently encountered species, they were noticeably absent from certain deeper water habitats such as the southern end of the Rockall Trough.

Shearwaters and Storm Petrels

Two species of shearwater were encountered on the survey; great shearwater (*Puffinus graves*) and Manx shearwater (*Puffinus puffinus*). Of these two species, only Manx shearwater were recorded during line transect survey effort, however, both species were recorded during point sampling watches.

Manx shearwater were recorded on 58 occasions, totalling 89 individuals. Manx shearwater were recorded on 55 occasions (86 individuals) during line transect effort with 31 individuals recorded as 'in-transect'.

Manx shearwater showed a strong southerly distribution, with all birds recorded as 'in-transect' observed in Irish waters south of 56 degrees latitude. A single Manx shearwater was recorded in Scottish waters just north of the Hebrides Terrace Seamount, however, this animal recorded as 'off-transect'.

A single record of a lone great shearwater was recorded during the survey, this occurred on a point watch during fishing activity on the western slopes of the Porcupine Bank.

One species of storm petrel was recorded during the survey; Leach's storm petrel (*Oceanodroma leucorhoa*). This record consisted of a single Leach's petrel, recorded as 'in-transect' during line transect survey effort in the Rockall Trough between the Anton Dohrn Seamount and the Rosemary Bank.

Gannet

Overall, Gannet (*Morus bassanus*) were the most frequently observed seabird species on the survey, being recorded on 543 occasions and totalling 11908 individuals. In total, 508 observations of 2992 individuals were recorded during line transect watches, with 621 individuals recorded as 'in-transect', making gannet the second most abundant species recorded during line transect effort.

Gannet were found to be broadly distributed in low numbers across most of the survey area, although, as with fulmar, a number of large aggregations were recorded in areas such as the shelf slopes west of the Blaskets, Donegal, and the Outer Hebrides. In these areas, large aggregations of gannet were recorded with records of up to 1000 birds recorded on a number of occasions. Although gannet were widely distributed and the most frequently encountered species, they were also noticeably absent from certain deeper water habitats such as west of the Porcupine Bank and the southern Rockall Trough.

Skuas

Two species of skua were encountered on the survey including; great skua (*Stercorarius skua*) and pomarine skua (*Stercorarius pomarinus*). Of these two species, only great skua were recorded during line transect survey effort, however, both species were recorded during point sampling watches.

Great skua were regularly encountered in low numbers throughout the survey (66 records of 111 individuals). During line transect survey effort, great skua were encountered on 43 occasions, totalling 52 individuals. Of these, 26 individuals were recorded as 'in-transect'. Great skua were patchily distributed across much of the survey area in low numbers, however, the Porcupine Bank held some higher numbers.

Only a single individual pomarine skua was recorded during the survey. This individual was recorded during a point sampling watch while the vessel was engaged in fishing activity on the western slopes of the Porcupine Bank.

Gulls

Six species of gull were encountered on the survey including; black-headed gull (*Larus ridibundus*), lesser black-backed gull (*Larus fuscus*), herring gull (*Larus argentatus*), greater black-backed gull (*Larus marinus*), Iceland gull (*Larus glaucoides*) and black-legged kittiwake (*Rissa tridactyla*). Of these six species, all but black-headed gull and Iceland gull were recorded as 'in-transect' during line transect survey effort. Black-headed gull and Iceland gull were each recorded as observations of single individuals made during point sampling watches while the vessel was engaged in fishing activity.

Kittiwake were the most frequently encountered gull species on the survey with a total of 1169 individuals recorded during 202 observations. They were also the most abundant species of gull and one of the more abundant seabird species with 613 individuals recorded during 171 observation while conducting line transect watches. Of these, 146 birds were recorded as 'in-transect'.

Kittiwake were found to be broadly distributed across the entire survey area in low numbers, although they were found to display a somewhat patchy distribution with higher abundances recorded in areas such as the Faroe-Shetland channel and the Porcupine bank. Kittiwake were well represented in deeper waters, including throughout the Rockall trough, however the majority of these encounters were recorded as 'off-transect'.

Although less common overall, lesser black-backed gull (20 birds 'in-transect'), herring gull (3 birds 'in-transect') and greater black-backed gull (6 birds 'in-transect') were occasionally recorded during line transect effort. Lesser black-backed gull were encountered in low numbers across the much of the

survey area, however the most observations were recorded as 'off-transect'. Greater black-backed gull were generally more coastal in their distribution with the notable exception of a number of birds encountered over the Outer Bailey bank, northern Rockall Trough and Faroe-Shetland Channel (many of which were recorded as 'off-transect'). Herring gull were recorded exclusively over deep waters, one record of 3 individuals was recorded as 'in-transect' in the Porcupine Seabight, while a further 3 records were noted in the Rockall Trough west of the Outer Hebrides. The single black-headed gull was encountered just south of the Outer Bailey Bank, while the loan Iceland gull was recorded in the Rockall Trough, both were recorded during point sampling watches.

Auks

All five species of auk known to occur in Irish waters were encountered on the survey. These were; guillemot (*Uria aalge*), black guillemot (*Cephus grylle*), razorbill (*Alea torda*), little auk (*Alle alle*) and Atlantic puffin (*Fratercula arctica*). All auk species were recorded during line transect and puffin were also recorded during point sampling survey effort. All auk species were also recorded as 'in-transect' during line transect watches. A single observations of two auks identified only as auk sp. were also recorded during line transect survey effort, these individuals were recorded as 'off-transect'.

Guillemot were the most frequently encountered of the auk species with all guillemots recorded as 'in-transect' during line transect survey effort (35 observations of 46 individuals). In total, 35 observations of 46 individuals were recorded during line transect watches, with 29 birds recorded as 'in-transect'. Guillemot were recorded almost exclusively in shelf waters along Irish and Scottish Atlantic margins. Guillemot were recorded in highest numbers west of Loop Head, with this area alone accounting for 16 of the recorded observations. Guillemot were absent from most deep water habitats surveyed, with the exception of a sporadic encounters west of the Scottish continental shelf and on the slopes of the Outer Bailey Bank.

Puffin were the second most frequently encountered of the auk species (33 records of 124 individuals). In total, 31 sightings of 121 individuals were recorded during line transect watches, with 54 individuals recorded as 'in-transect', making Puffin the most abundant auk species. Two records of puffin, totalling 3 individuals were also recorded during point sampling effort while the vessel was fishing. Puffin also were almost recorded exclusively in shelf waters along Irish and Scottish Atlantic margins, with only a single record on the continental shelf slope west of Donegal. Puffin too were recorded in highest numbers west of Loop Head, with this area alone accounting for 14 of the puffin records.

Razorbill were less frequently encountered during the survey and were recorded during line transect effort only. In total, 13 observations of 40 individuals were recorded during line transect watches, with 19 individuals recorded as 'in-transect'. Although less abundant, razorbill showed a similar distribution pattern to that of the puffin, however all records occurred in shelf waters.

Black guillemot and little auk were each recorded as observations of single individuals made during line transect watches, both were as 'in-transect'. The black guillemot was recorded in the Minch, while the little auk was encountered over the continental shelf slope to the west of the Outer Hebrides.

Terrestrial/ migratory birds

A number of terrestrial species were also recorded during the survey. These included large migratory flocks of species such as greylag goose (*Anser anser*), pink-footed goose (*Anser brachyrhynchus*), whooper swan (*Cygnus cygnus*) and redwing (*Turdus iliacus*). Other terrestrial species encountered included a hooded crow (*Corvus cornix*) and a snow bunting (*Plectrophenax nivalis*).

Table 5: Summary of all terrestrial/ migratory bird sightings recorded during the survey.

Common Name	Species name	No. of Sightings	No. of Individuals
Greylag Goose	<i>Anser anser</i>	3	43
Hooded Crow	<i>Corvus cornix</i>	1	1
Meadow Pipit	<i>Anthus pratensis</i>	4	5
Oystercatcher	<i>Haematopus ostralegus</i>	2	5
Pink-footed Goose	<i>Anser brachyrhynchus</i>	4	187
Redwing	<i>Turdus iliacus</i>	13	110
Rock Pipit	<i>Anthus spinoletta</i>	1	1
Snow Bunting	<i>Plectrophenax nivalis</i>	1	1
Whooper Swan	<i>Cygnus cygnus</i>	9	333
Woodpigeon	<i>Columba palumbus</i>	1	1
Total		39	687

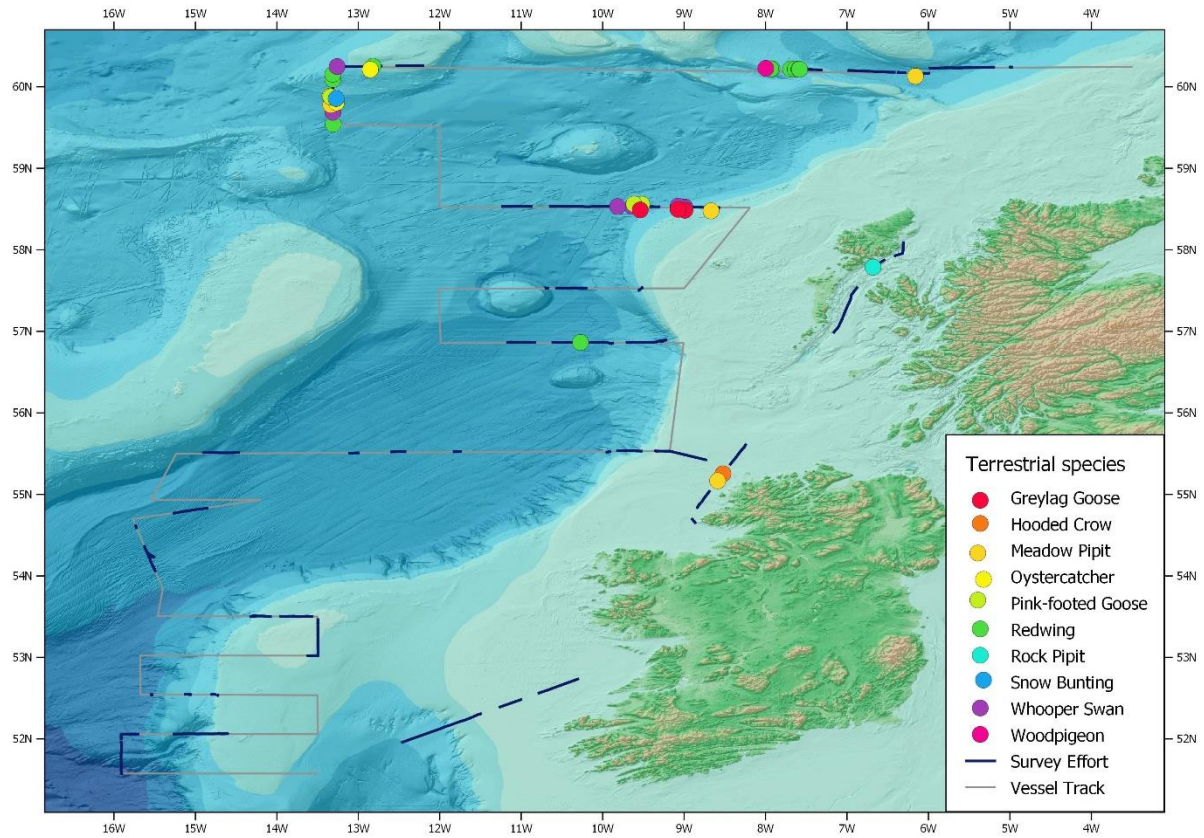


Figure 6: Distribution of terrestrial species recorded during survey effort.

Discussion

Since 2004, Ireland has contributed to the annual International Blue Whiting Spawning Stock (IBWSS) survey in the form of the Blue Whiting Acoustic Survey (O'Donnell, *et al.*, 2018; 2017; 2015; 2014). The Irish BWAS has been undertaken aboard the *RV Celtic Explorer* each year, with seabird surveyors frequently deployed also. However, the number of seabird surveyors deployed has varied across the time series of the BWAS. The present survey marks the first occasion that the NPWS have commissioned a seabird survey during the BWAS, with a single seabird surveyor being deployed for the duration of the survey. As the seabird survey during was conducted using a single seabird surveyor, the level and detail of data collected was affected at times. Survey effort was focused on the correct identification, enumeration, distance estimation and recording of species encountered while ancillary data such as age, moult stage and behaviour was de-prioritised.

As has been the case in previous years (O'Donnell, *et al.*, 2018; 2017; 2015; 2014), weather was an important factor affecting total survey effort. During this years' survey a total of 89 hours and 44 minutes of observer effort were recorded, with a number of survey days being lost or sharply restricted due to poor weather. This is broadly consistent with recorded effort from previous surveys (O'Donnell, *et al.*, 2018; 2017; 2015; 2014), and to be expected considering the time of year and survey location.

As in previous surveys, large numbers of seabirds, from a broad range of species were observed over the course of the survey. In total, 18 species of seabird and 10 species of terrestrial bird were recorded during the present survey. This is, again, broadly consistent with the species totals from previous seabird surveys during BWAS (O'Donnell, *et al.*, 2018; 2017; 2015; 2014).

Fulmar, gannet and kittiwake were the most abundant and widespread species' recorded during the present survey. In fact, the survey was overwhelmingly dominated by gannet and fulmar, together these species accounted for 66% of all records and 93% of individual seabirds recorded. Kittiwake accounted for a further 14% of all records and 4% of individual seabirds recorded. The dominance of these species in the records would have been emphasised by the absence or relative scarcity of certain migratory species (e.g. shearwaters, terns), many of which had yet to return to Irish waters from their winter grounds.

Despite the generally broad distribution of fulmar, gannet and kittiwake, a number of areas with a very high density of seabird activity were observed over the course of the survey. These areas had both high abundances of the commonly encountered species and an increased diversity of other species present also. Such areas included; the shelf slopes west of the Blaskets, Donegal and the Outer Hebrides, the Faroe-Shetland Channel and the Porcupine Bank. The high levels of seabird activity and feeding behaviour observed in these 'hotspots' suggests abundant feeding opportunities and high prey availability for seabirds in these locations.

Given the outstanding international importance of the multi-species seabird colonies found in the British Isles (Kober, *et al.*, 2010; Cummins, *et al.*, 2019), it is important to recognise the important role played by the winter foraging areas utilised by the seabirds that reside there. The availability and distribution of prey are known to be vital for the breeding success, and thus long term stability, of many seabird populations (Mackey, *et al.*, 2004). As such, the identification and management of key hotspots for foraging seabirds, both during the breeding and non-breeding seasons, are important steps in guarding the long term health and stability of seabird colonies (Kober, *et al.*, 2010). Protecting

seabirds in their offshore foraging habitats through the designation of SPAs would also further assist Ireland in meeting its obligation under the EU Birds Directive.

The BWAS provides an excellent opportunity for the collection of data on the spring time distribution, abundance and behaviour of seabirds along Ireland's deep-water Atlantic margins. However, the amount and quality of data collected is confounded by factors such as environmental conditions and seabird survey design. Weather conditions throughout the survey were generally moderate to poor, with high wind speeds and sea states recorded persistently. The total number of seabird survey hours was reduced on a number of occasions due to conditions exceeding the environmental parameters for surveying. Environmental conditions, particularly elevated sea states, also likely affected the detection probability of certain less conspicuous species. The use of a larger ESAS qualified seabird 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 the at-sea spring abundance and distribution of seabirds in Ireland's Atlantic deep water habitats.

Recommendations

An increase to the number of ESAS trained seabird observers on-board would be recommended for this survey. The present survey used a single ESAS trained seabird observer due to COVID 19 restrictions, however recent surveys have also used a single ESAS trained seabird observer with a second, non-ESAS observer employed as scribe/ secondary observer. The ESAS survey methodology recommends the use of a minimum of two ESAS trained observers. The use of three ESAS seabird observers would allow a rotational system of two seabird observers on-effort (one observing, the other scribing) while the third observer takes a break. This approach would increase effort coverage of the survey area, minimise observer fatigue and allow full coverage of all daylight hours. However, the authors appreciate the constraints on using such a large seabird survey team.

The approach outlined above would facilitate more sufficient coverage, which should increase the chances of detecting seabirds, particularly rare or scarce species, while also ensuring that all seabird observers get sufficient breaks/periods of rest. Sufficient breaks/periods of rest are highly important for seabird observers for maintaining full concentration during all effort watches without suffering the ill effects of fatigue.

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Finally, the seabird observer wishes 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 seabird observer looks forward to future collaborations.

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