

Marine Institute Seabird Monitoring

During the Celtic Sea Herring Acoustic Survey

9th – 29th October 2023

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Executive Summary

Irish waters represent one of the most important marine habitats for seabirds in Europe, 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 RV *Celtic Explorer* during the annual the Celtic Sea Herring Acoustic Survey (CSHAS), running from 9th - 29th October 2023.

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 79 hours and 8 minutes of survey effort were conducted over the course of CSHAS 2023. In total, 69 hours and 25 minutes of survey effort were conducted using a line transect methodology, while 25 minutes of effort were conducted using the point sampling methodology. A further 9 hours and 17 minutes of effort were conducted as a casual watch.

A total of 2459 seabird observations were recorded throughout the survey, totalling 13756 individuals. In total, 3318 seabirds were recorded as "in transect", while 10438 were recorded "off transect". The species encountered included 25 species from ten families. A further 48 observations of terrestrial migratory birds were also recorded, comprising of 152 individuals.

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 several large seabird colonies of significance at a European level (Mackey, *et al.*, 2004). At present, there are twenty-five species of seabirds known to breed on the British Isles, twenty-four of which breed in Ireland (Burnell, *et al.*, 2023; *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 2015-2021 as recorded during the Seabirds Count census and percentage change in numbers since the Seabird 2000 census 1998-2002 (Source: Burnell, et al., 2023). Note: All counts are of pairs unless otherwise stated.

Species	Latin name	Northern Ireland	Republic of Ireland	All- Ireland total	GB & Ireland Total	Percentage change since Seabird 2000 (1998-2002)
Northern Fulmar	<i>Fulmarus glacialis</i>	2,566	32,131	34,697	352,995	-35%
Manx Shearwater ¹	<i>Puffinus puffinus</i>	4,850	134,220	139,070	921,618	-
European Storm Petrel ¹	<i>Hydrobates pelagicus</i>	0	108,423	108,423	147,578	-
Leach's Storm Petrel ²	<i>Hydrobates leucorhous</i>	0	310	310	48,357	-
Northern Gannet	<i>Morus bassanus</i>	0	48,032	48,032	360,748	38%
Great Cormorant	<i>Phalacrocorax carbo</i>	561	4,124	4,685	13,330	-5%
European Shag	<i>Gulosus aristotelis</i>	278	4,748	5,026	25,961	-20%
Arctic Skua	<i>Stercorarius parasiticus</i>	0	0	0	727	-66%
Great Skua	<i>Stercorarius skua</i>	2	34	36	10,971	14%
Mediterranean Gull ²	<i>Ichthyaeus melanocephalus</i>	2	3	5	113	-
Black-headed Gull	<i>Chroicocephalus ridibundus</i>	12,465	7,146	19,611	105,102	-26%
Common Gull	<i>Larus canus</i>	758	1,983	2,741	25,525	-49%
Lesser Black-backed Gull ¹	<i>Larus fuscus</i>	3,954	7,471	11,425	64,267	-
Herring Gull ¹	<i>Larus argentatus</i>	2,177	9,702	11,879	74,926	-
Great Black-backed Gull	<i>Larus marinus</i>	449	2,825	3,274	11,265	-43%
Black-legged Kittiwake	<i>Rissa tridactyla</i>	17,152	24,723	41,875	241,321	-42%
Sandwich Tern	<i>Thalasseus sandvicensis</i>	1,944	2,464	4,408	15,484	9%
Roseate Tern ²	<i>Sterna dougallii</i>	4	734	738	790	-
Common Tern	<i>Sterna hirundo</i>	1,820	4,728	6,548	17,089	7%
Arctic Tern	<i>Sterna paradisaea</i>	800	2,708	3,508	33,215	-35%
Little Tern ²	<i>Sternula albifrons</i>	0	206	206	2,153	-
Common Guillemot ³	<i>Uria aalge</i>	155,890	178,090	333,980	1,449,589	-8%
Razorbill ³	<i>Alca torda</i>	24,730	32,904	57,634	258,629	18%
Black Guillemot ³	<i>Cephus grylle</i>	1,166	4,119	5,285	39,523	-9%
Atlantic Puffin	<i>Fratercula arctica</i>	461	1,557	2,018	254,162	-24%

¹ low confidence in population trends since due to changes in methodology and/or improved survey coverage

² confidential species; data presented is from Seabird 2000 (1998-2002) only

³ counts of individuals

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; Burnell, *et al.*, 2023). 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*, RV *Tom Crean* and RV *Celtic Voyager*, during oceanographic and fisheries surveys (Power & Keogh, 2022). 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.

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.*, 2022).

The survey has been undertaken annually since 1989 and since 2004 has been fixed in October and carried out on the RV *Celtic Explorer* or RV *Tom Crean*. 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.*, 2022).

The CSHAS provides a unique opportunity for surveillance of the autumn distribution of seabirds 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 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).

In order to contribute to its current monitoring regime, the Department of Housing, Local Government and Heritage (DHLGH), through the Marine Institute, commissioned the undertaking of a seabird survey from the RV *Celtic Explorer* during the annual Celtic Sea Herring Acoustic Survey (CSHAS), running from the 9th to the 29th of October 2023.

Methodology

The seabird survey was conducted across the two survey legs of CSHAS23 running from the 9th - 19th October and the 20th - 29th October 2023, using a single seabird observer for the duration of the survey. The seabird observer conducted visual survey effort while also recording all survey data. Given the presented survey transects for the 2023 survey (*Figure 1*), a standard line transect survey methodology was determined to be most suitable and was employed by the seabird surveyor. Survey transects were undertaken at speeds of 5-10 knots, with fishing activity being conducted at speeds of 2-3 knots.

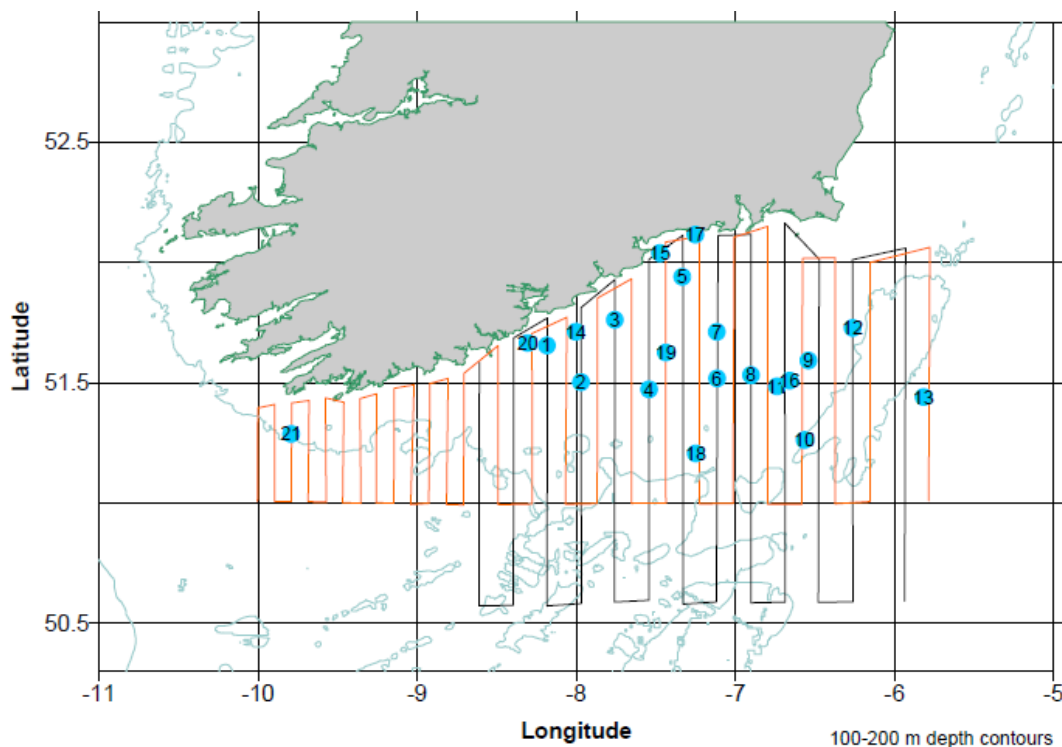


Figure 1: Representative cruise track of the Celtic Sea Herring Acoustic Survey (Source: Marine Institute, 2022).

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. 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.

Observations for seabirds were conducted from the monkey island (deck height 13 m above sea level), however, as in previous surveys aboard the *RV Celtic Explorer*; access to the monkey island was dependent on weather conditions.

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 track-line (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 were conducted within a survey quadrant of 300m x 300m. 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, Swarovski *EL 8.5x42* 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 I* DSLR camera with a Sigma *EF 100-400mm F5-6.3 DG DN OS* telephoto lens was used to visually document other information of scientific interest. Data were also collected on all migratory/ transient waterfowl and terrestrial birds encountered.

Data collection and recording

The Cybertracker (Cybertracker, 2023) data collection software package (Version 3.518) was configured for optimum use on the survey. Cybertracker was used to record positional, environmental and seabird observation data on a Samsung *Galaxy Tab A* Android tablet. Using the internal GPS, 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

Seabird survey effort was conducted across 18 days from the 10th - 27th October. Due to a number of port calls and poor weather during the survey it was not possible to conduct seabird survey for the full duration of the cruise. Vessel mobilisation took place on the 9th October, while demobilisation took place on the 29th October. No seabird survey effort was conducted on mobilisation or demobilisation days.

Adverse weather conditions due to Storm Babet (Met Eireann, 2024) on the 16th, 17th and 18th of October limited seabird survey effort. As weather conditions exceeded the specified weather limits for observations all effort was conducted as casual survey effort from the bridge. Seabird survey effort was again reduced on the 23rd of October due to poor weather.

Seabird survey effort was reduced on the 25th, 26th and 27th of October as the vessel was conducting low speed searches for herring within bays along the west coast. The slow speed and variable heading were not conducive to effective seabird surveying.

No survey effort was undertaken on the 28th of October as the vessel was stationary in Killybegs for calibration of the vessel's acoustic equipment.

A total of 79 hours and 8 minutes of survey effort were conducted over the course of CSHAS 2023. In total, 69 hours and 25 minutes of survey effort were conducted using a line transect methodology, while 25 minutes of effort were conducted using the point sampling methodology. A further 9 hours and 17 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 daily survey effort recorded over the course of the survey was 7 hours and 22 minutes while the average daily survey effort was 3 hours and 2 minutes. A graph of daily effort is provided in *Figure 2* below.

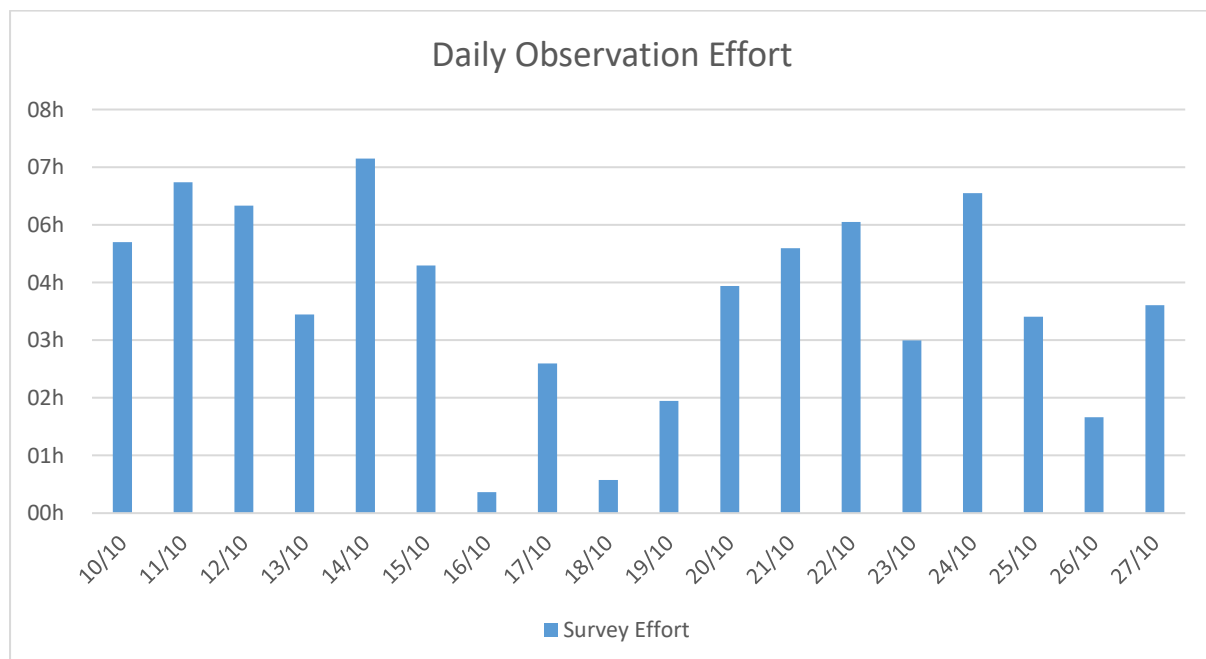


Figure 2: Daily visual effort undertaken during the survey.

Environmental Conditions

Weather conditions throughout the survey were generally moderate to poor across the survey, with high wind speeds, high swell and poor visibility recorded. On several occasions, seabird survey effort was restricted due to poor environmental conditions. 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. Several casual watches were undertaken during periods where the environmental conditions exceeded these parameters. A breakdown of key environmental factors recorded during the survey is provided hereunder.

Sea State

Sea state was recorded both in terms of the World Meteorological Organisation (WMO) sea state scale and the Beaufort scale. The WMO sea state was judged based on the total state of agitation of the sea, taking into account the effect of wind, swell and currents (WMO, 2011) on the sea conditions, 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 and 4 were the most common sea states recorded. The most frequently recorded WMO sea state was 4, accounting for approximately 54 hours (68%) of observation effort while WMO sea state 3 accounted for over 15 hours (19%). WMO sea state 5 and 6 each accounted for approximately 3.5 hours (5%) of observation effort (*Fig. 3a*).

The most frequently recorded Beaufort wind force/ sea state was a Beaufort 4, accounting for over 33 hours (42%) of survey effort. Beaufort 5 was recorded for almost 25 hours (31%) of observation effort, while Beaufort 3 accounted for over 12 hours (16%) of observation effort. Beaufort 6 and 7 were each recorded over approximately 3 hours of survey effort, while 1 hour of survey effort was recorded during Beaufort 8 conditions (*Fig. 3b*).

Swell

A swell height of 0.1-1 meter was most frequently recorded throughout the survey, being recorded in over 37 hours (47%) of survey effort. A swell height of 1.1-2 meters was recorded in over 34 survey hours (44%), while swell of over 2 meters was recorded during approximately 6 hours (7%) of survey effort (*Fig. 3c*).

Visibility

Visibility was generally very good during seabird survey effort; however, several periods of reduced visibility were also recorded. The most frequently recorded visibility was 11-15km, being recorded for over 51 hours (65%) of survey effort. Visibility of 6-10km was recorded during 17 hours (22%) of survey effort. Visibility of 1-5km was recorded during just 6.5 hours (8%) of survey effort while visibility of less than 1km was recorded during almost 4 hours (5%) of survey effort (*Fig. 3d*).

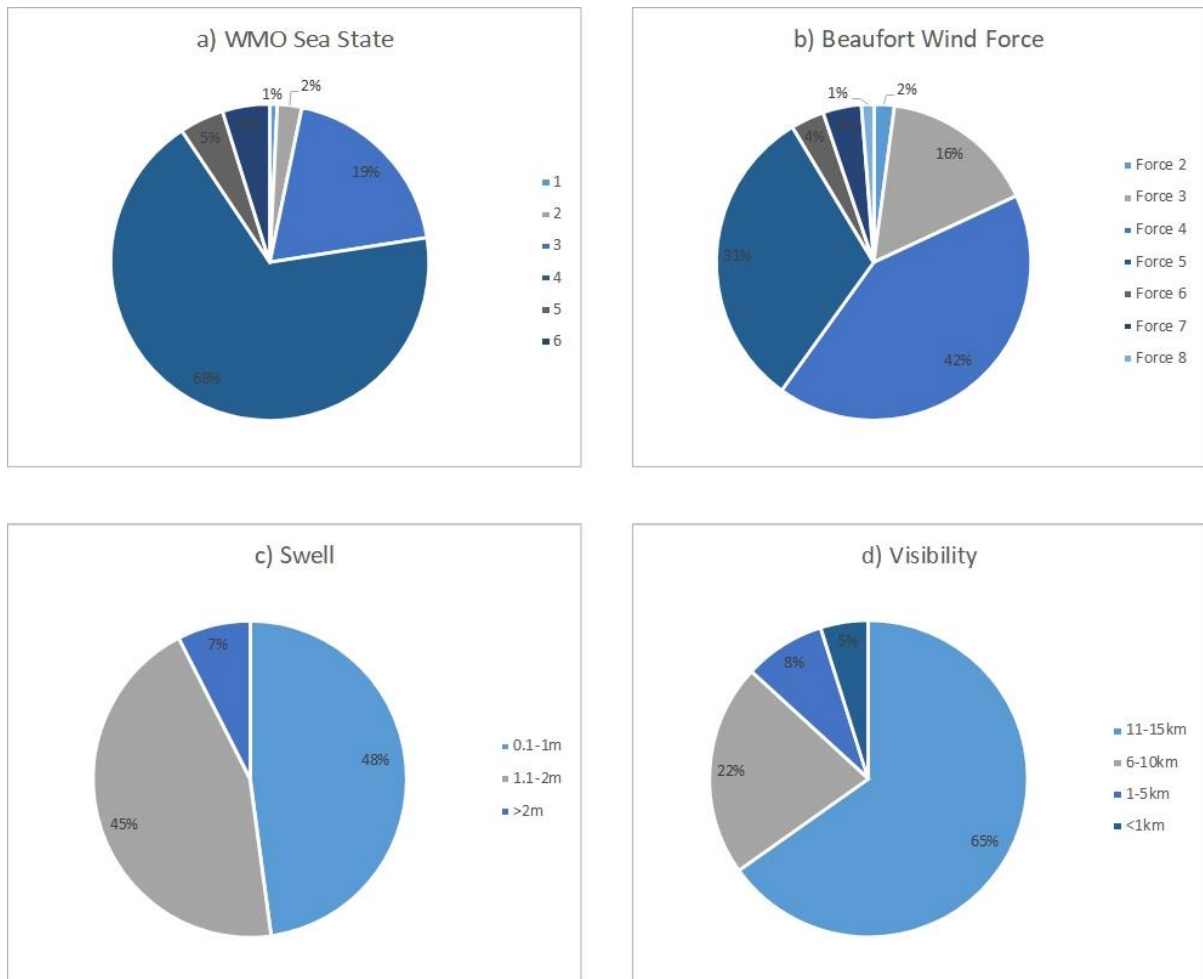


Figure 3: Summary of environmental conditions recorded on the CSHAS 2023; a) WMO sea state, b) Beaufort wind force, c) Swell (meters), d) Visibility (kilometres).

Seabird records

A total of 25 species from ten families were encountered during the survey, while several records were obtained of birds which could not be identified to species, these were recorded as either large gull sp., Guillemot/Razorbill or Pomarine/Arctic Skua. All 25 seabird species recorded during the survey were recorded during line transect survey effort, while 11 species were recorded during point counts.

In total, 2459 seabird observations were recorded throughout the survey, totalling 13756 individuals, with flock size ranging from one up to 500 for some species (Table 2). A summary of all seabirds recorded on the survey is presented in Table 2 and includes birds recorded during line transect, point sampling and casual watches.

Of the 2459 seabird observations recorded during the survey, 2278 were recorded during line transect effort. In total, 11597 seabirds were recorded during line transect effort, with 3299 of these recorded as 'in-transect'. The remaining 8298 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 is presented in *Figures 4- 11*. 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, point sampling and casual watches.

<i>Common Name</i>	<i>Species name</i>	<i>No. of records</i>	<i>No. of Seabirds</i>	<i>Flock size</i>
Northern Fulmar	<i>Fulmarus glacialis</i>	164	365	1-30
Cory's Shearwater	<i>Calonectris borealis</i>	91	325	1-65
Great Shearwater	<i>Ardenna gravis</i>	61	259	1-75
Sooty Shearwater	<i>Ardenna grisea</i>	121	818	1-200
Manx Shearwater	<i>Puffinus puffinus</i>	55	62	1-3
European Storm Petrel	<i>Hydrobates pelagicus</i>	9	11	1-3
Northern Gannet	<i>Morus bassanus</i>	616	2781	1-150
Pomarine Skua	<i>Stercorarius pomarinus</i>	3	3	1
Arctic Skua	<i>Stercorarius parasiticus</i>	18	20	1-3
Pomarine/Arctic Skua	<i>Stercorarius pomarinus/Stercorarius parasiticus</i>	1	1	1
Long-tailed Skua	<i>Stercorarius longicaudus</i>	1	1	1
Great Skua	<i>Stercorarius skua</i>	14	15	1-2
Mediterranean Gull	<i>Ichthyaetus melanocephalus</i>	2	2	1
Common Gull	<i>Larus canus</i>	24	316	1-200
Black-headed Gull	<i>Chroicocephalus ridibundus</i>	6	15	1-10
Lesser Black-backed Gull	<i>Larus fuscus</i>	93	1000	1-100
European Herring Gull	<i>Larus argentatus</i>	59	756	1-300
Yellow-legged Gull	<i>Larus michahellis</i>	4	4	1
Great Black-backed Gull	<i>Larus marinus</i>	65	341	1-50
Black-legged Kittiwake	<i>Rissa tridactyla</i>	344	2778	1-500
Gull sp.	<i>Laridae</i>	4	170	20-50
Common Tern	<i>Sterna hirundo</i>	3	3	1
Common Guillemot	<i>Uria aalge</i>	409	1434	1-100
Razorbill	<i>Alca torda</i>	227	1519	1-200
Razorbill/Guillemot	<i>Alcidae</i>	34	717	1-100
Atlantic Puffin	<i>Fratercula arctica</i>	13	19	1-3
European Shag	<i>Gulosus aristotelis</i>	16	18	1-3
Great Northern Diver	<i>Gavia immer</i>	2	3	1-2
	Total	2459	13756	

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>
Northern Fulmar	<i>Fulmarus glacialis</i>	153	299	72	227
Cory's Shearwater	<i>Calonectris borealis</i>	91	325	180	145
Great Shearwater	<i>Ardenna gravis</i>	57	154	66	88
Sooty Shearwater	<i>Ardenna grisea</i>	112	784	341	443
Manx Shearwater	<i>Puffinus puffinus</i>	47	54	6	48
European Storm Petrel	<i>Hydrobates pelagicus</i>	9	11	5	6
Northern Gannet	<i>Morus bassanus</i>	586	2158	533	1625
Pomarine Skua	<i>Stercorarius pomarinus</i>	2	2	0	2
Arctic Skua	<i>Stercorarius parasiticus</i>	12	12	2	10
Pomarine/Arctic Skua	<i>Stercorarius pomarinus/Stercorarius parasiticus</i>	1	1	0	1
Long-tailed Skua	<i>Stercorarius longicaudus</i>	1	1	0	1
Great Skua	<i>Stercorarius skua</i>	9	9	0	9
Mediterranean Gull	<i>Ichthyaeetus melanocephalus</i>	1	1	0	1
Common Gull	<i>Larus canus</i>	19	288	37	251
Black-headed Gull	<i>Chroicocephalus ridibundus</i>	5	14	1	13
Lesser Black-backed Gull	<i>Larus fuscus</i>	77	738	51	687
European Herring Gull	<i>Larus argentatus</i>	48	637	75	562
Yellow-legged Gull	<i>Larus michahellis</i>	3	3	0	3
Great Black-backed Gull	<i>Larus marinus</i>	51	250	16	234
Black-legged Kittiwake	<i>Rissa tridactyla</i>	322	2527	490	2037
Gull sp.	<i>Laridae</i>	4	170	0	170
Common Tern	<i>Sterna hirundo</i>	1	1	0	1
Common Guillemot	<i>Uria aalge</i>	390	1302	921	381
Razorbill	<i>Alca torda</i>	214	1101	469	632
Razorbill/Guillemot	<i>Alcidae</i>	32	715	10	705
Atlantic Puffin	<i>Fratercula arctica</i>	13	19	14	5
European Shag	<i>Gulosus aristotelis</i>	16	18	9	9
Great Northern Diver	<i>Gavia immer</i>	2	3	1	2
Total		2278	11597	3299	8298

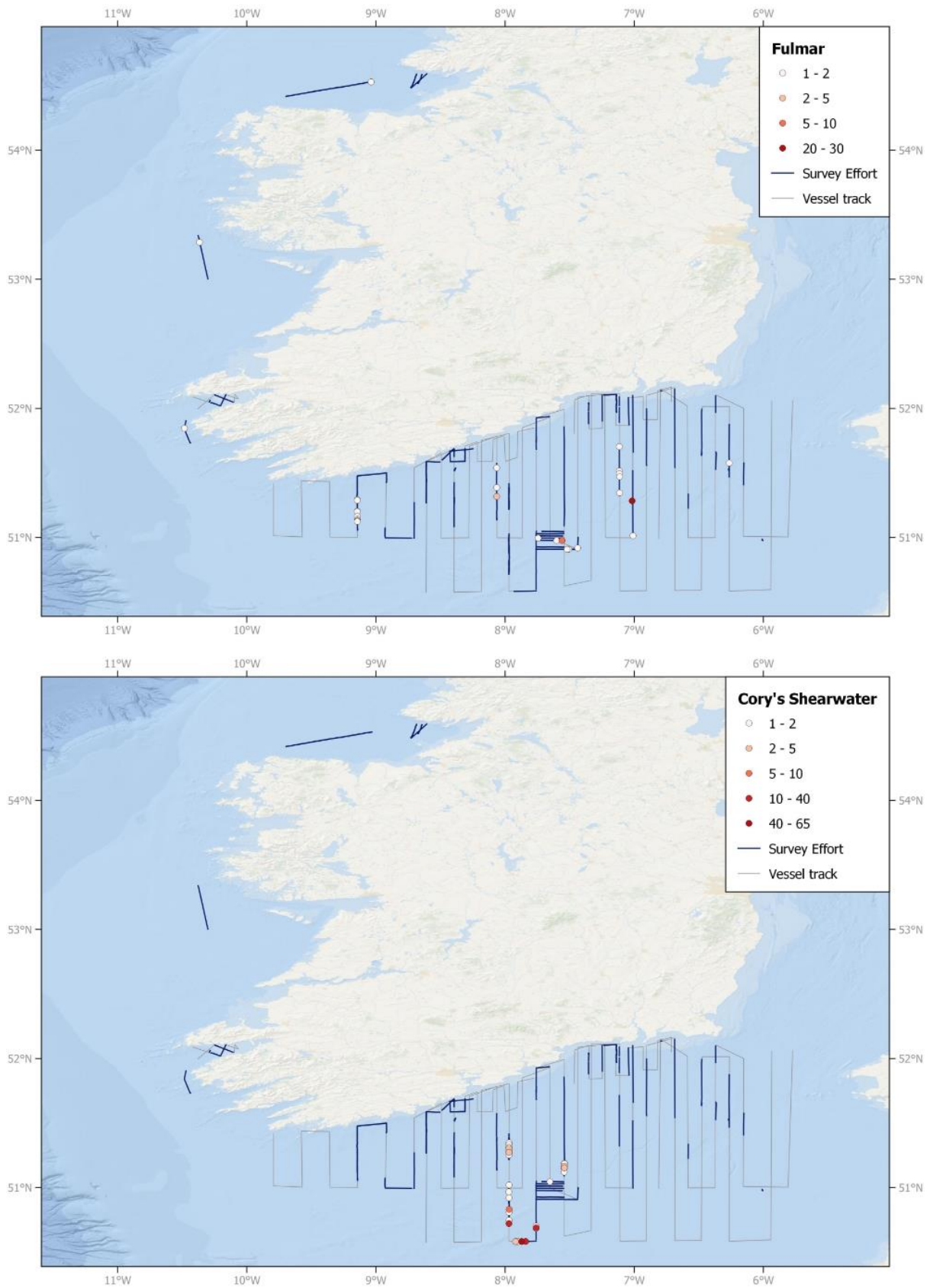


Figure 4: Distribution of a) Northern Fulmar and b) Cory's Shearwater recorded as 'in-transect' during line transect survey effort.

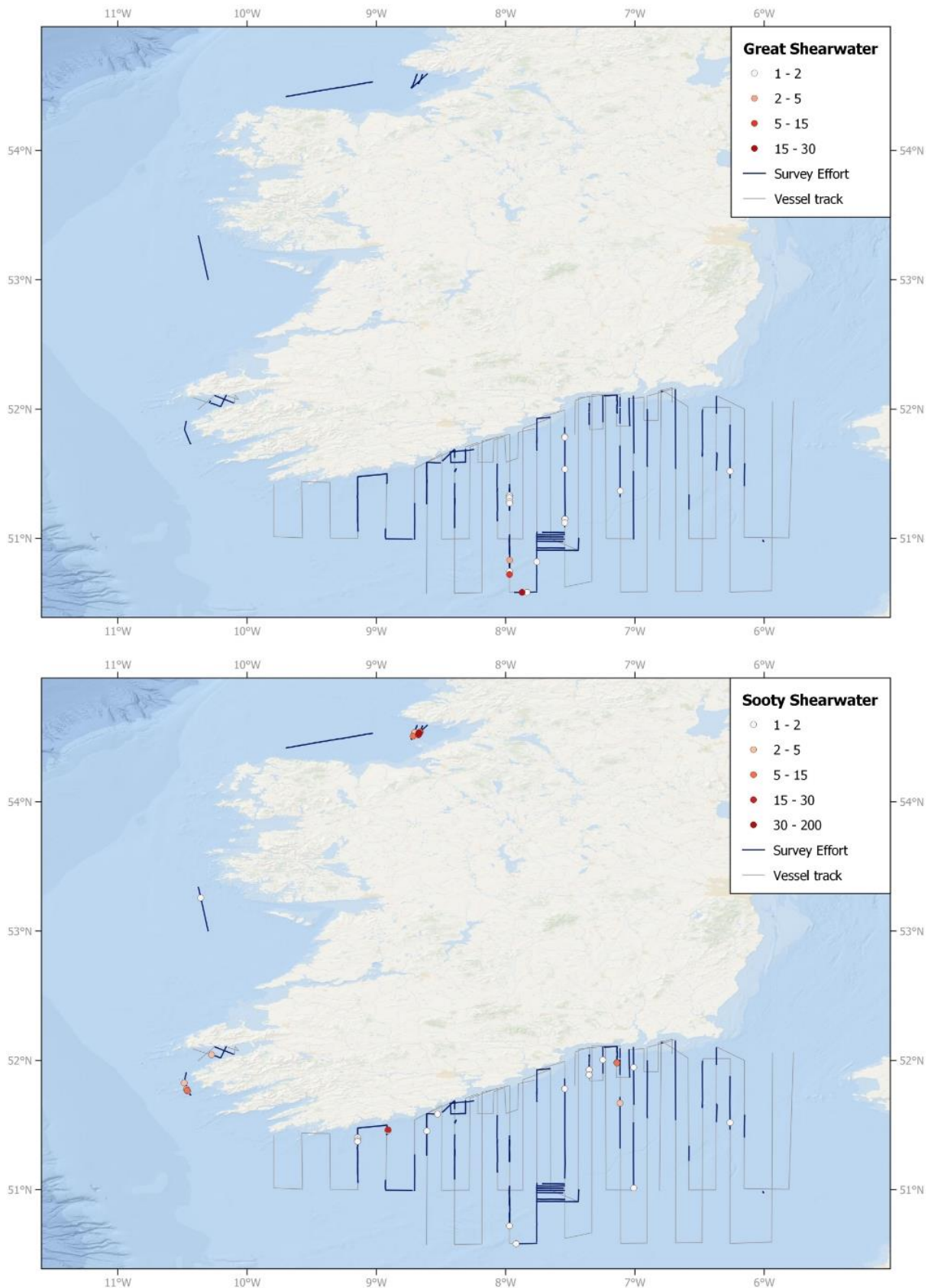


Figure 5: Distribution of a) Great Shearwater and b) Sooty Shearwater recorded as 'in-transect' during line transect survey effort.

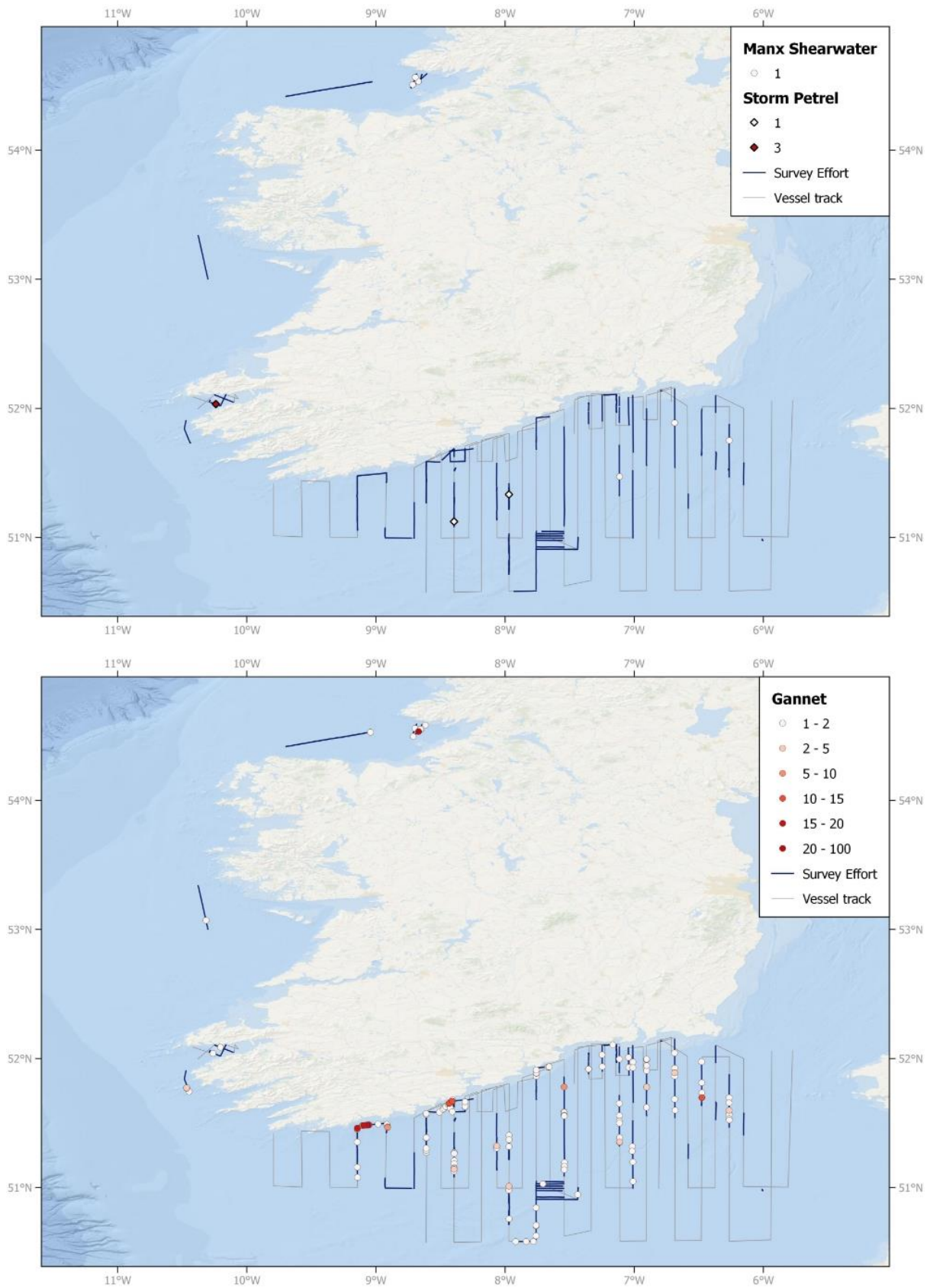


Figure 6: Distribution of a) Manx Shearwater and European Storm Petrel, and b) Northern Gannet recorded as 'in-transect' during line transect survey effort.

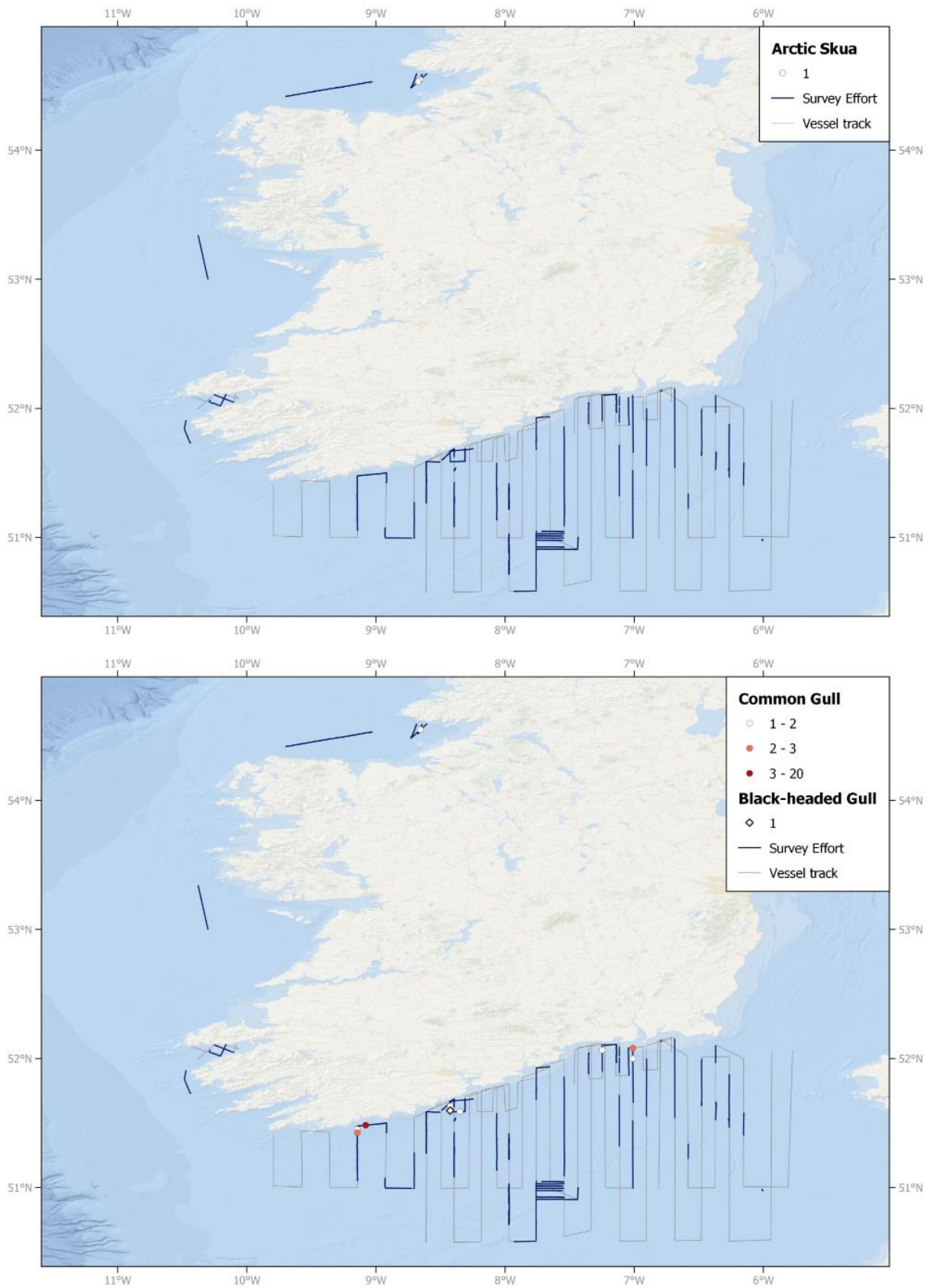


Figure 7: Distribution of a) Arctic Skua, and b) Common Gull and Black-headed Gull recorded as 'in-transect' during line transect survey effort.

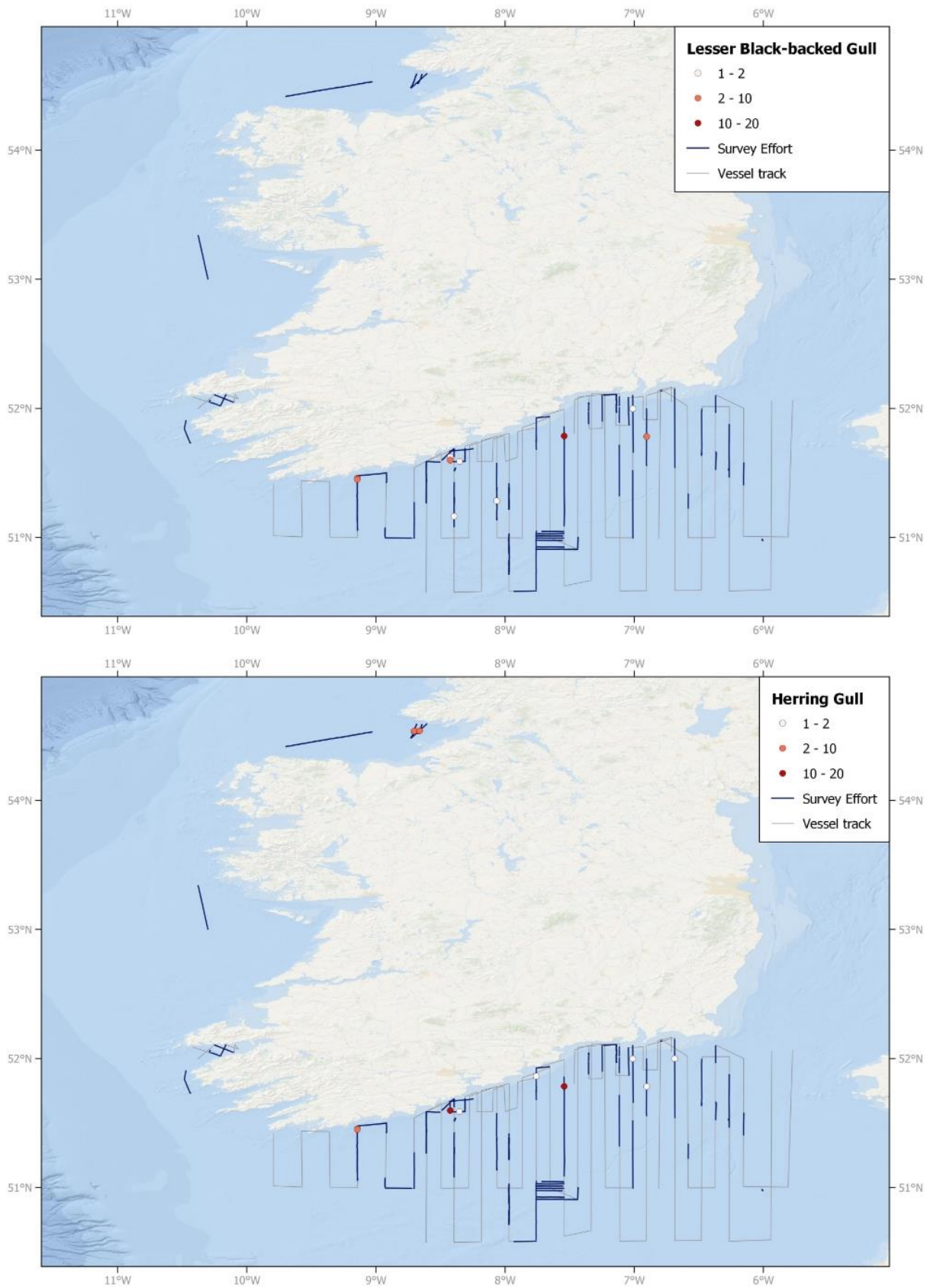


Figure 8: Distribution of a) Lesser Black-backed Gull and b) Herring Gull recorded as 'in-transect' during line transect survey effort.

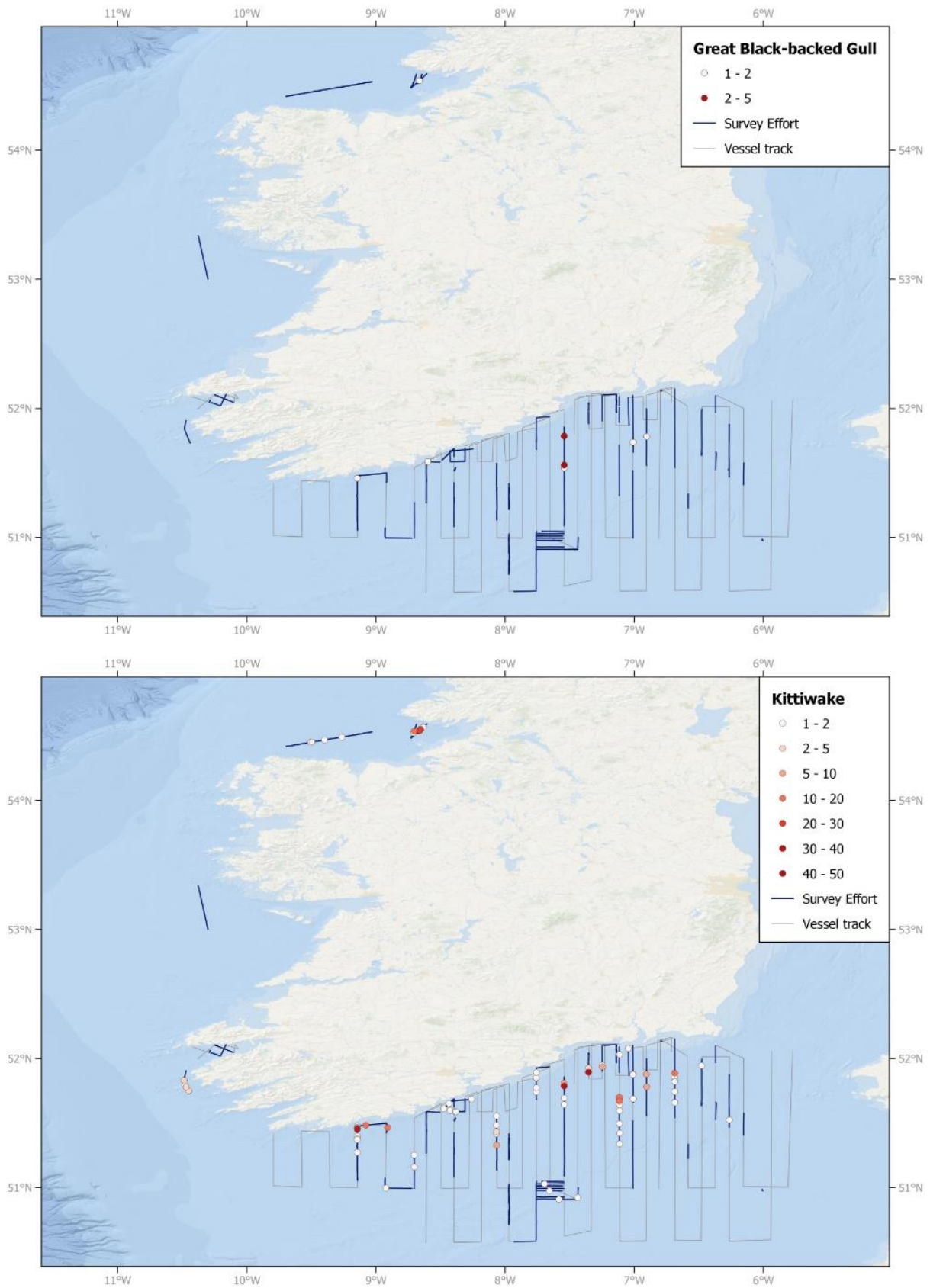


Figure 9: Distribution of a) Great Black-backed Gull and b) Kittiwake recorded as 'in-transect' during line transect survey effort.

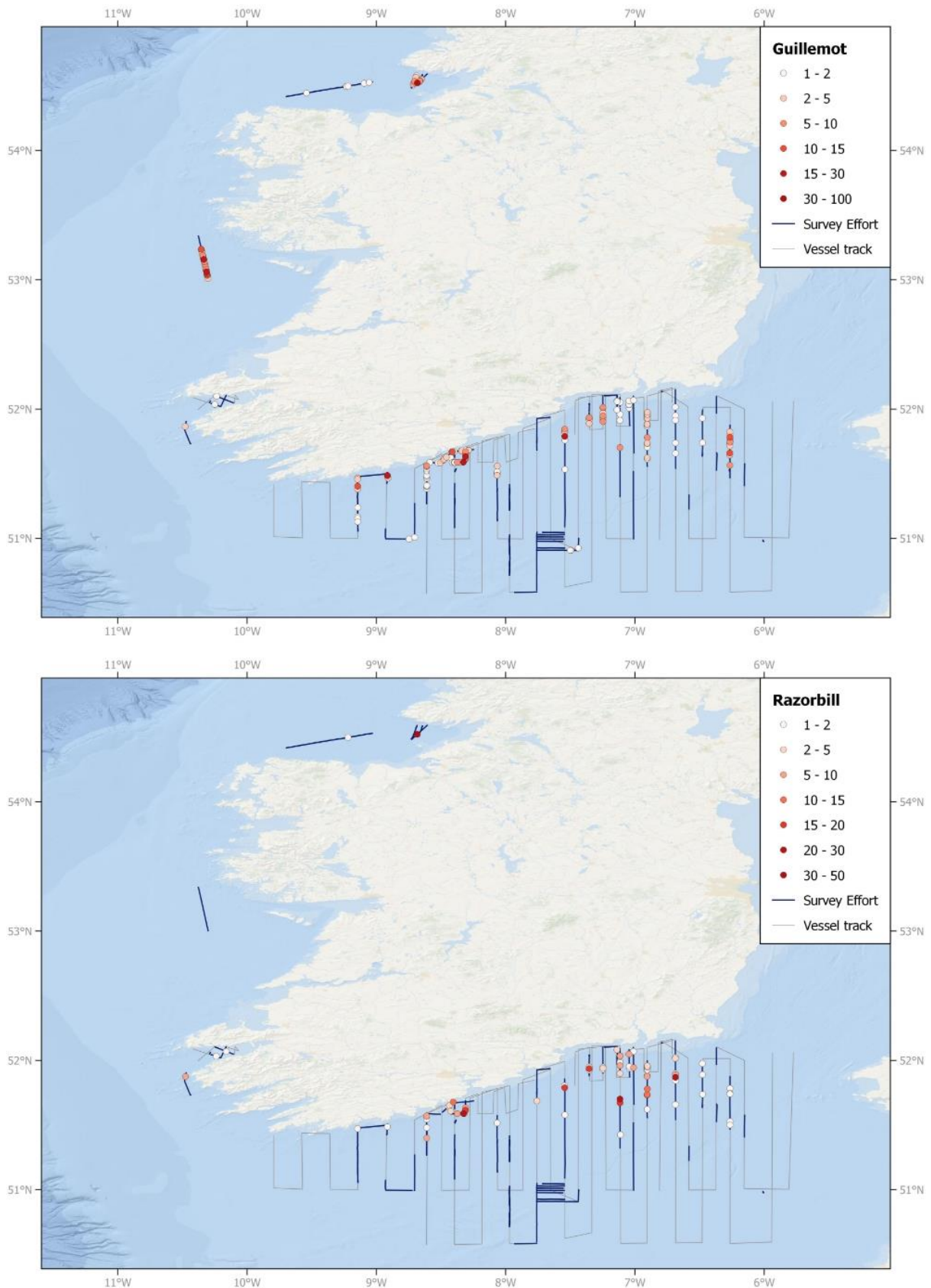


Figure 10: Distribution of a) Guillemot and b) Razorbill recorded as 'in-transect' during line transect survey effort.

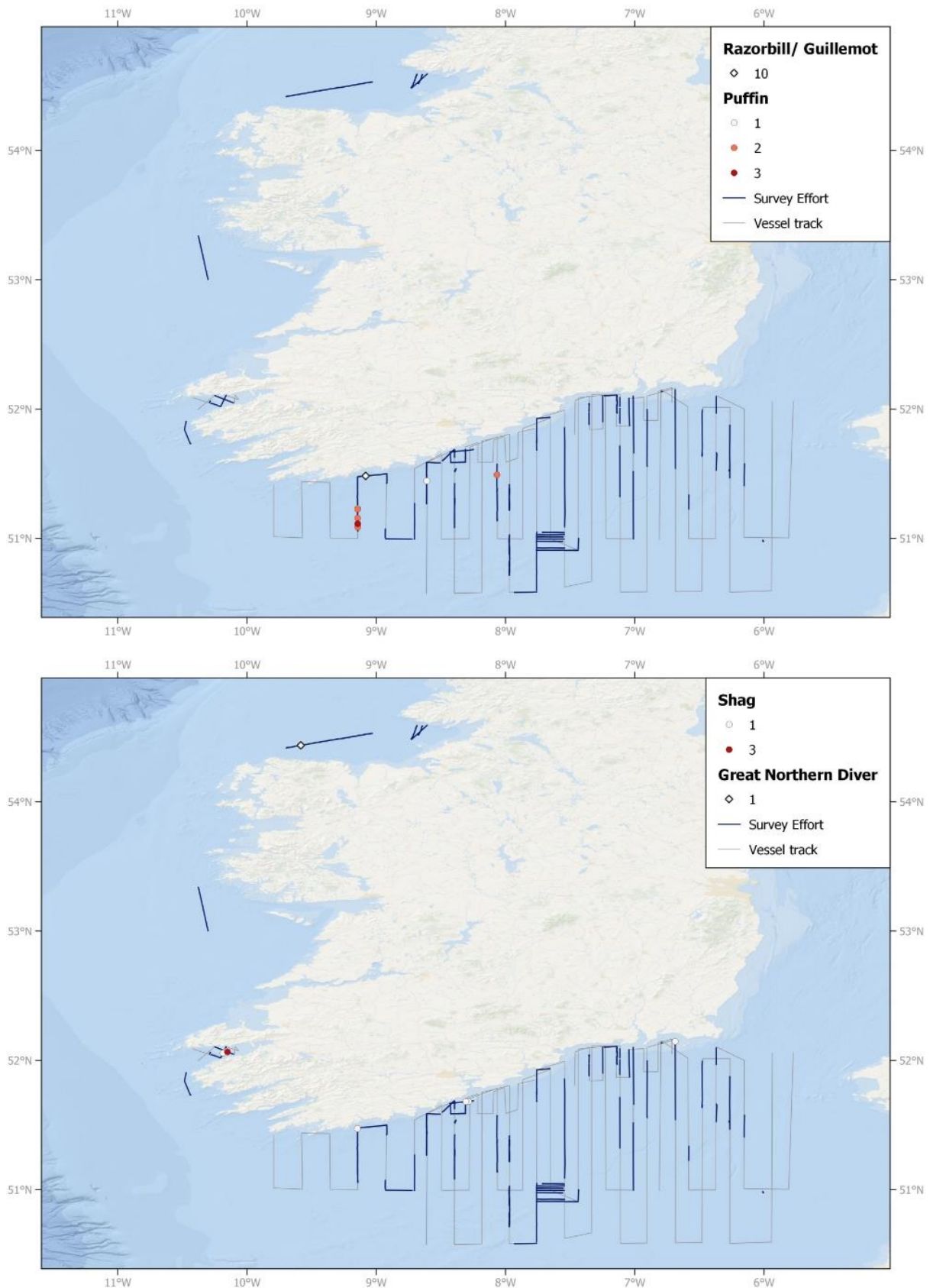


Figure 11: Distribution of a) Razorbill/Guillemot and Puffin and, b) European Shag and Great Northern Diver recorded as 'in-transect' during line transect survey effort.

Four separate point counts were conducted at oceanographic stations. A total of 18 seabird observations were recorded during point sampling effort, comprising 286 individuals from 11 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>
Northern Fulmar	<i>Fulmarus glacialis</i>	2	32
Great Shearwater	<i>Ardenna gravis</i>	1	75
Sooty Shearwater	<i>Ardenna grisea</i>	2	4
Manx Shearwater	<i>Puffinus puffinus</i>	1	1
Northern Gannet	<i>Morus bassanus</i>	4	58
Great Skua	<i>Stercorarius skua</i>	1	1
Lesser Black-backed Gull	<i>Larus fuscus</i>	2	53
Great Black-backed Gull	<i>Larus marinus</i>	1	5
Black-legged Kittiwake	<i>Rissa tridactyla</i>	2	32
Common Guillemot	<i>Uria aalge</i>	1	5
Razorbill	<i>Alca torda</i>	1	20
	Total	18	286

Northern Fulmar

Northern Fulmar (*Fulmarus glacialis*) were frequently encountered on the survey, being recorded on 164 occasions and totalling 365 individuals. In total, 153 observations of 299 individuals were recorded during line transect watches, with 72 individual birds recorded as 'in-transect'. All Northern Fulmar seen were of the double light morph (LL) plumage type. Fulmar were found to be patchily distributed in low numbers within the survey area (Fig. 4a). During survey effort, Fulmar were more frequently encountered in offshore waters and on the westerly lying transects, with higher abundances recorded on transects south of Galley Head, Reen Point and Toe Head. A large proportion of Fulmar observations were also recorded as 'off-transect', including numerous sightings off the Blasket Islands and some large aggregations in Dingle Bay. However, as these birds were recorded 'off-transect' they are not presented graphically here.

Shearwaters

Four species of shearwater were encountered during the survey: Cory's Shearwater (*Calonectris borealis*), Great Shearwater (*Ardenna gravis*), Sooty Shearwater (*Ardenna grisea*) and Manx Shearwater (*Puffinus puffinus*). All four species were recorded during line transect effort. Great Shearwater, Sooty Shearwater and Manx Shearwater were also recorded during point sampling watches.

Cory's Shearwater were recorded on 91 occasions, totalling 325 individuals. All records of Cory Shearwater were obtained during line transect effort with 180 individuals recorded as 'in-transect'. Cory's Shearwater showed a clustered distribution and were encountered exclusively in offshore

waters and highly localised over the Labadie Bank and around the former site of the Kinsale gas rigs (Fig. 4b).

Great Shearwater were recorded less frequently than Cory's Shearwater, and were observed on 61 occasions, totalling 259 individuals. Great Shearwater were recorded on 57 occasions (154 individuals) during line transect effort with 66 birds recorded as 'in-transect'. Great Shearwater were more patchily distributed than Cory's Shearwater and were encountered across the Celtic Sea survey area, although in lower numbers. Some of the larger congregations of Great Shearwater did coincide with higher abundances of Cory's Shearwater in areas such as the Labadie Bank and the former site of the Kinsale gas rigs (Fig. 5a). A large aggregation of 20 Great Shearwater were recorded during survey effort south of Reen Point, however these birds were recorded as 'off-transect' and are not presented graphically here.

Sooty Shearwater were recorded on 121 occasions, totalling 818 individuals, making it the most frequently recorded species of shearwater. Sooty Shearwater were recorded on 112 occasions (784 individuals) during line transect effort with 341 individuals recorded as 'in-transect'. Sooty Shearwater were found to be broadly distributed across much of survey area, with a more inshore tendency than the Great Shearwater or Cory's Shearwater (Fig. 5b). Sooty Shearwater were also found to display a somewhat patchy distribution with higher abundances recorded in areas such as, West of the Basket Islands, outer Dingle Bay, south of Galley Head, south of Reen Point and in the inshore waters from Hook Head to Helvick Head. Several large aggregations were also recorded in outer Donegal Bay however many of these larger aggregations were recorded as 'off-transect'.

Manx Shearwater were recorded on 55 occasions with 62 individual birds recorded. Manx Shearwater were recorded on 47 occasions (54 individuals) during line transect effort, however, only 6 birds were recorded as 'in-transect'. Manx Shearwater were broadly distributed across the entire survey area however they were recorded in lower numbers, generally just 1 to 3 birds, with the majority being recorded 'off-transect' (Fig. 6a).

Storm petrels

Storm petrels were infrequently recorded during the survey, with European Storm petrel (*Hydrobates pelagicus*) being the only species of storm petrel recorded.

European Storm petrel were recorded on 9 occasions, numbering 11 birds in total. All European Storm Petrel were recorded during line transect effort, with 5 birds recorded as 'in-transect'. European Storm Petrel were recorded on western transects in the Celtic Sea and in Dingle Bay. Most records were of single birds and the majority were recorded 'off-transect', however a group of 3 European Storm Petrel were recorded 'in-transect' in Dingle Bay.

Northern Gannet

Overall, Northern Gannet (*Morus bassanus*) were the most frequently observed seabird species on the survey, being recorded on 616 occasions and totalling 2781 individuals. In total, 586 observations of 2158 birds were recorded during line transect watches, with 533 Gannets 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 the entire survey area, although, as with many other species, several larger aggregations were also recorded. Large aggregations of Gannet were recorded 'in-transect' during inshore survey effort from Toe Head to Galley Head, and from the Old Head of Kinsale to Roberts' Head, with good numbers again recorded from Helvick Head to Hook Head (Fig. 6b). Several large feeding aggregations of 50-100 Gannet were recorded south of Bunmahon,

south of Helvick and over the Trench and the Smalls fishing grounds, however, these aggregations were recorded as 'off-transect' and are not presented graphically here.

Skuas

Four species of skua were encountered on the survey including, Pomarine Skua (*Stercorarius pomarinus*), Arctic Skua (*Stercorarius parasiticus*), Long-tailed Skua (*Stercorarius longicaudus*) and Great Skua (*Stercorarius skua*). All skua species were recorded during line transect survey effort, while Great Skua were the only species recorded during point counts. A further record of a single skua which could only be identified as Arctic/Pomarine Skua was recorded 'off-transect' during line transect effort. Arctic Skua were the only species recorded as 'in-transect' during line transect survey effort.

Three records of solitary Pomarine Skua were noted during the survey; two records were obtained during line transect effort, while the other was recorded during a casual watch. All sightings were recorded as 'off-transect'.

Arctic Skua were the most abundant skua species and were recorded on 18 occasions with 20 individual birds observed. Twelve records of solitary Arctic Skua were noted during line transect effort on the survey; with 2 birds recorded as 'in-transect' during survey effort in outer Donegal Bay. The distribution of Arctic Skua recorded as 'in-transect' during line transect effort are presented in *Figure 7a*.

A single record of a solitary Long-tailed Skua was noted during the survey and was recorded 'off-transect' during line transect effort.

Great Skua were encountered in low numbers throughout the survey (14 records of 15 individual birds). During line transect survey effort, Great Skua were encountered on 9 occasions, totalling 9 individual birds.

In general, Skua species were patchily distributed across much of the survey area in low numbers, however they were predominantly recorded 'off-transect'. There was an increased occurrence and diversity noted during inshore survey effort between Helvick Head and Brownstown Head, where nine Arctic Skua, three Pomarine Skua, one Long-tailed Skua and one Great Skua were recorded.

Gulls

Eight species of gull were encountered on the survey including; Mediterranean Gull (*Ichthyaetus melanocephalus*), Common Gull (*Larus canus*), Black-headed Gull (*Larus ridibundus*), Lesser Black-backed Gull (*Larus fuscus*), Herring Gull (*Larus argentatus*), Yellow-legged Gull (*Larus michahellis*), Great Black-backed Gull (*Larus marinus*) and Black-legged Kittiwake (*Rissa tridactyla*). Of these eight species, all but Mediterranean Gull and Yellow-legged Gull were recorded as 'in-transect' during line transect survey effort. Several flocks of large gulls which could not be identified to species level were recorded 'off-transect' during line transect survey effort, these gulls were recorded as "large gull species (*Larus spp.*)".

Although less common than some of the other gull species recorded, Common Gull (37 birds 'in-transect') and Black-headed Gull (1 bird 'in-transect') were recorded on a number of occasions during line transect effort. Both Common Gull and Black-headed Gull showed a strongly coastal distribution (*Fig. 7b*). Aggregations of Common Gull were observed in areas such as off Hook Head, south of Bunmahon, off Toe Head, Dingle Bay and Donegal Bay however the majority of these were recorded as 'off-transect'. The single 'in-transect' Black-headed Gull record was obtained off Kinsale, the largest

record of Black-headed Gull was 10 birds recorded as 'off-transect' during line transect effort in Donegal Bay.

Lesser Black-backed Gull were one of the most frequently encountered gull species on the survey with a total of 1000 individuals recorded during 93 observations. Lesser Black-backed Gull were the second most abundant species of gull recorded, being recorded on 77 occasions, amounting to 738 birds, during line transect effort. Of these, 51 birds were recorded as 'in-transect'.

Herring Gull were also regularly encountered during the survey, with 59 observations of 756 birds reported. During line transect effort, Herring Gull were recorded 48 times, amounting to 637 individual birds, 85 of which were recorded as 'in-transect'.

Three records of solitary Yellow-legged Gull were also recorded during line transect effort. One record of a 3rd winter bird following the survey vessel in bad weather was obtained in Dingle Bay. This bird showed plumage characteristics of the *atlantis* subspecies found on the Azores, Madeira and the Canaries. This distinctive subspecies is considered a rarity in Ireland with just 15 accepted records by the Irish Rare Birds Committee up to 2015 and several reports since then which have yet to be formally assessed (Hobbs, 2015). The other two Yellow-legged Gull records were obtained around the former site of the Kinsale gas rigs.

Great Black-backed gull were regularly encountered during the survey being encountered on 65 occasions and with a total of 341 individuals recorded. Great Black-backed Gull were recorded on 51 occasions, amounting to 250 birds, during line transect effort. Of these, 16 birds were recorded as 'in-transect'.

Lesser Black-backed Gull, Herring Gull and Great Black-backed Gull were each broadly distributed in low numbers across the survey area, however as with many other species, some patchiness was also evident in these three species. Large aggregations of each of these species were recorded on the Trench fishing ground and in Donegal Bay, however the majority of the birds were recorded as 'off-transect'. 'In-transect' records for all three species were more concentrated along inshore waters of the south coast off Kinsale and Toe Head (*Fig. 8a, 8b & 9a*).

Black-legged Kittiwake were the most frequently encountered and most abundant gull species on the survey with a total of 2778 birds recorded during 344 observations. During line transect survey effort, Black-legged Kittiwake were encountered on 322 occasions, totalling 2527 individual birds. Of these, 490 birds were recorded as 'in-transect'. Black-legged Kittiwake were found to be broadly distributed in low numbers across the entire survey area, however, a somewhat patchy distribution was also noted with higher numbers of 'in-transect' birds noted in areas such as inshore waters from Toe Head to Galley Head, Helvick Head to Brownstown Head, and outer Donegal Bay (*Fig. 9b*).

Terns

One species of tern were encountered over the course of the survey: Common Tern (*Sterna hirundo*). A solitary Common Tern was recorded as 'off-transect' during line transect effort in offshore waters on the Labadie Bank.

Auks

Three of the five species of auk known to occur in Irish waters were encountered on the survey. These were Guillemot (*Uria aalge*), Razorbill (*Alca torda*) and Atlantic Puffin (*Fratercula arctica*). All auk species were recorded during line transect, however Atlantic Puffin were not recorded during point

sampling survey effort. Several observations of auks identified only as Razorbill/Guillemot were also recorded during line transect survey effort.

Guillemot were the most frequently encountered of the auk species and the second most frequently encountered species overall. In total, 409 observations of 1434 individual Guillemot were recorded during the survey. During line transect watches 390 observations of 1302 individuals were noted, with 921 birds recorded as 'in-transect', making the Guillemot the most abundant species recorded on the survey. Guillemot were found to be broadly distributed across the entire survey area but were observed in highest densities in coastal regions from Kinsale to Roberts' Head, off Galley Head and Toe Head, west of Slyne Head and outer Donegal Bay (*Fig. 10a*).

Razorbill were the second most frequently encountered auk species during the survey. In total, 227 observations of 1519 individuals were recorded during the survey. During line transect watches, 214 observations of 1101 individuals were recorded, with 469 individuals recorded as 'in-transect'. Although less abundant, Razorbill showed a very similar distribution pattern to that of Guillemot with highest numbers recorded in coastal regions from Kinsale to Roberts' Head and outer Donegal Bay (*Fig. 10b*). Razorbill were also recorded in large numbers in inshore water from Hook Head west to Bunmahon, however the majority of these sightings were recorded as 'off-transect'. A single record on 10 auk recorded as Guillemot/ Razorbill were noted south of Reen Point (*Fig. 11a*).

Atlantic Puffin were infrequently encountered during the survey and were recorded exclusively during line transect effort. During line transect watches, 13 records of 19 Puffin were noted with 14 birds recorded as 'in-transect'. Puffin were restricted to western transects in the Celtic Sea survey area, with a single transect south of the Stags accounting for the majority of 'in-transect' Atlantic Puffin sightings (*Fig. 11a*).

Shags and Divers

European Shag and Great Northern Diver were recorded during the survey, both were recorded during line transect survey effort only.

Sixteen records of European Shag, totalling 18 individuals, were observed during survey effort, of these 9 European Shag were recorded as 'in-transect'.

Great Northern Diver were recorded on two occasions during the survey, totalling 3 individuals, a pair of which were recorded as 'in-transect'.

European Shag were reported 'in-transect' sporadically along the south and south west coasts, while the recorded pair of 'in-transect' Great Northern Diver was observed north of Belderg Harbour (*Fig. 11b*).

Terrestrial/migratory birds

A number of terrestrial/migratory birds were encountered during the survey. A total of 48 observations of terrestrial/migratory bird species were recorded during the survey (Table 5). These records comprised of 152 individuals from 20 species'. Species recorded included a Merlin (*Falco columbarius*), a Short-eared Owl (*Asio flammeus*), a Yellow Wagtail (*Motacilla flava*) and fifty Siskin (*Spinus spinus*).

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

Common Name	Species name	No. of records	No. of individuals
Eurasian Blackcap	<i>Sylvia atricapilla</i>	1	1
Common Chiffchaff	<i>Phylloscopus collybita</i>	2	3
Eurasian Collared Dove	<i>Streptopelia decaocto</i>	1	1
Goldcrest	<i>Regulus regulus</i>	2	2
European Golden Plover	<i>Pluvialis apricaria</i>	4	36
European Goldfinch	<i>Carduelis carduelis</i>	1	2
Northern Lapwing	<i>Vanellus vanellus</i>	1	2
Meadow Pipit	<i>Anthus pratensis</i>	15	22
Merlin	<i>Falco columbarius</i>	1	1
Pied/White wagtail	<i>Motacilla alba</i>	2	2
Redwing	<i>Turdus iliacus</i>	3	3
Short-eared Owl	<i>Asio flammeus</i>	1	1
Eurasian Siskin	<i>Spinus spinus</i>	1	50
Eurasian Skylark	<i>Alauda arvensis</i>	2	3
Common Snipe	<i>Gallinago gallinago</i>	2	2
Common Starling	<i>Sturnus vulgaris</i>	2	3
Barn Swallow	<i>Hirundo rustica</i>	4	12
Ruddy Turnstone	<i>Arenaria interpres</i>	1	1
Whooper Swan	<i>Cygnus cygnus</i>	1	4
Western Yellow Wagtail	<i>Motacilla flava</i>	1	1
Total		48	152

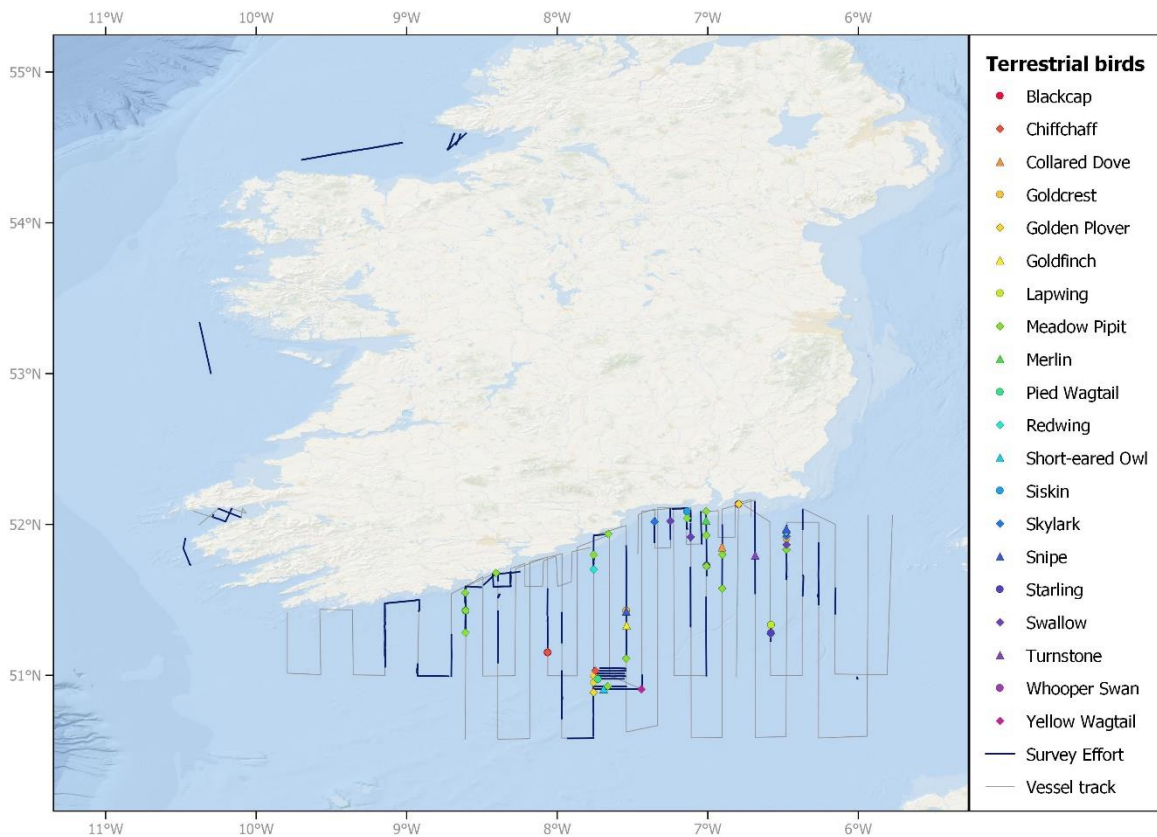


Figure 12: Distribution of terrestrial species recorded during survey effort.

Discussion

Since 2016 the Celtic Sea Herring Acoustic 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 (O’Donnell, et al., 2020), or in local bays as was the case in the present survey. A seabird survey has been conducted each year since the updated survey design was implemented. Seabird survey effort has varied across the time series of surveys since 2016. During the present survey a total of 79 hours and 8 minutes of survey effort conducted which was similar to the total of 72 hours and 41 minutes survey effort during CSHAS 2022 and 71 hours and 26 minutes of survey effort during CSHAS 2021. In both 2019 and 2020, approximately 117.5 hours of survey effort was undertaken per survey. In the preceding years from 2016-2018 survey effort varied between approximately 62.5 and 73.5 survey hours (Power and Keogh, 2022). The variation in the survey effort undertaken across years can largely be attributed to variable weather conditions at this time of year.

The seabird survey during this year’s CSHAS survey, and all CSHAS surveys since 2019, differed from CSHAS seabird surveys pre-2019 in that a single seabird surveyor was deployed for the duration of the survey. The use of a single observer surveys has meant that it was not always possible to collect all relevant seabird data in areas of high activity. This resulted in survey effort being curtailed on several occasions or restricted to focus on the correct identification, enumeration, distance estimation and

recording of species encountered while ancillary data such as age, moult stage and behaviour were de-prioritised.

As in previous surveys, a large number of records, from a broad range of taxa and species groups were observed over the course of the survey. In total, 25 species of seabird and 20 species of terrestrial bird were recorded during the present survey. This is broadly consistent with the species totals from recent seabird surveys during CSHAS. For example, on CSHAS 2022 27 species of seabird and 24 species of terrestrial bird were recorded, while on the 2021 survey, 26 species of seabird and 20 species of terrestrial bird were recorded. Over the surveys from 2016-2019 the number of seabird species recorded has varied from 23 to 30, while the number of terrestrial species encountered has varied between 12 and 26 (Power & Keogh, 2022).

Despite some inter-annual variation, the overall assemblage of seabird species recorded has remained relatively consistent over the years since 2016 (O'Donnell, et al., 2016; 2017; 2018; 2019, 2020), however this year's survey had the notable addition of Cory's Shearwater to the list of recorded species. Cory's Shearwater have not been previously encountered on the Celtic Sea Herring survey since the 2016 survey design update (O'Donnell, et al., 2016; 2017; 2018; 2019; 2020; 2021; 2022) but were recorded in significant numbers during the present survey.

Some variance in the reported occurrence of species has been noted across the survey time series (Power & Keogh, 2022), however, it is not possible to directly compare species abundance without further analysis. However, some large variations were evident for a number of species, this was particularly evident for shearwater species. As mentioned, Cory's Shearwater were recorded for the first time during the modern survey series, with 325 Cory's Shearwater recorded, of which 180 birds were recorded as 'in-transect'. Cory's Shearwater sightings in Irish waters peak in July-August, with some records in late June and numbers dwindling in September, and are generally rare outside these months. Great Shearwater were also reported in relatively large numbers, 259 Great Shearwater were recorded with 66 birds recorded as 'in-transect'. This was a sizeable increase on numbers reported during last year's survey (82 Great Shearwater, 32 'in-transect'), this despite the fact that the 2022 survey itself saw a noted increase over figures reported in 2021 (Power & Keogh, 2022), and Great Shearwater have been generally scarce across the time series (Power & Keogh, 2022). Sooty Shearwater too saw a dramatic increase in number this year, with 818 birds observed across the survey (341 'in-transect'), a substantial increase on the 120 birds recorded (17 'in-transect') in last year's survey. However, the 2022 survey reported a large decrease in Sooty Shearwater when compared to the 2021 survey.

In contrast, the number of Guillemot, and Razorbill recorded this year were substantially higher than recorded in 2022. In the present survey 1434 Guillemot were recorded (921 'in-transect'), while 1216 Guillemot were recorded last year (580 'in-transect'), however, this represents a substantial decrease on the figures reported in 2021 (2257 Guillemot, 1904 'in-transect'). Razorbill records increased this year for the second year running with 1519 Razorbill (469 'in-transect'), up from 770 Razorbill recorded in 2022 (286 'in-transect'), and 392 Razorbill recorded in 2021 (268 'in-transect').

This level of variation between years is not uncommon on the Celtic Sea Herring Acoustic Survey, for example, 2017 also showed reduced numbers of records for several species when compared to the preceding or following years (O'Donnell, et al., 2016; 2017; 2018). This variation may be down to any number of factors including; environmental conditions, survey design, observer effects or prey distribution. The increased prevalence of avian flu during the 2022 and 2023 breeding seasons may

also have had a significant effect, particularly on heavily impacted species such as Gannet (DAFM, 2023).

As has been the case in previous surveys (Power & Keogh, 2022; 2021; Connaughton & Power, 2020) Northern Gannet, Guillemot and Black-legged Kittiwake were the most abundant and widespread species' in the present survey, with Guillemot and Northern Gannet being the most widely distributed. Northern Gannet and Black-legged Kittiwake numbers were broadly similar to figures reported last year, however, last year represented a low point in the data series for both species (Power & Keogh, 2022).

A number of areas of high seabird density and diversity were observed over the course of the survey, often in the vicinity of commercial fishing grounds. These included areas such as; inshore waters from Toe Head to Galley Head, Kinsale to Roberts' Head, Helvick Head to Hook Head, the Labadie Bank, and the Trench fishing grounds. A number of these areas were also noted as 'hotspots' during previous surveys (Power & Keogh, 2022; 2021; Connaughton & Power, 2020). 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. Many of the areas noted as holding a high diversity and abundance of seabirds are within foraging range of important seabird colonies. For instance, Little Skellig has the largest population of Gannets in Ireland, and the Saltee Islands are also home to some of Ireland's largest Black-legged Kittiwake, Guillemot and Razorbill colonies (Cummins, *et al.*, 2019; Mitchell, *et al.*, 2004).

Given the outstanding international importance of the multi-species seabird colonies found in the British Isles (Kober, *et al.*, 2010), 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 CSHAS provides an excellent opportunity for the collection of data on the autumn distribution, abundance and behaviour of seabirds in the Celtic Sea. However, the amount and quality of data collected is confounded by factors such as environmental conditions and seabird survey design. 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 inconspicuous 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 autumn abundance and distribution of seabirds in Ireland's Celtic Sea 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 employed as both observer and scribe which is not recommended. Recent surveys have used a single ESAS trained seabird observer with a second, non-ESAS observer employed as scribe/secondary observer which was preferable than the present structure. However, the ESAS survey methodology recommends the use of a minimum of two ESAS trained observers, this would be preferable as it would allow some degree of observer rotation and rest. The use of three ESAS seabird observers would allow for a full 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 approaches 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 times without suffering the ill effects of fatigue.

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