EMFF Operational Programme 2014-2020

Marine Biodiversity Scheme

Marine Institute Seabird Monitoring

During the Celtic Sea Herring Acoustic Survey

9th – 29th October 2022

Lead Agency: Marine Institute

Lead Partners: National Parks and Wildlife Service,

Authors: Emerald Marine

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Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
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An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

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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 *Tom Crean* during the annual the Celtic Sea Herring Acoustic Survey (CSHAS), running from 9th - 29th October 2022.

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 72 hours and 41 minutes of survey effort were conducted over the course of CSHAS 2022. In total, 60 hours and 17 minutes of survey effort were conducted using a line transect methodology, while 9 hours and 6 minutes of effort were conducted using the point sampling methodology. A further 3 hours and 17 minutes of effort were conducted as a casual watch.

A total of 2291 seabird observations were recorded throughout the survey, totalling 9854 individuals. In total, 2410 seabirds were recorded as "in transect", while 7444 were recorded "off transect". The species encountered included 27 species, from ten families. A further 49 observations of terrestrial migratory birds were also recorded, comprising of 100 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 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). 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 SCR Census (1985-88)*[1]
Northern Fulmar	*Fulmarus glacialis*	5,992	32,918	38,910	537,991	0%
Manx Shearwater[2]	*Puffinus puffinus*	4,633	32,545	37,178	332,267	
European Storm Petrel[2]	*Hydrobates pelagicus*	0	99,065	99,065	124,775	
Leach's Storm Petrel[2]	*Hydrobates leucorhous*	0	310	310	48,357	
Northern Gannet	*Morus bassanus*	0	32,758	32,758	259,311	39%
Great Cormorant	*Phalacrocorax carbo*	663	4,548	5,211	13,681	7%
European Shag	*Gulosus aristotelis*	301	3,426	3,727	32,306	-25%
Arctic Skua	*Stercorarius parasiticus*	0	0	0	2,136	-37%
Great Skua	*Stercorarius skua*	0	1	1	9,635	26%
Mediterranean Gull	*Ichthyaetus melanocephalus*	2	3	5	113	
Black-headed Gull	*Chroicocephalus ridibundus*	10,107	3,876	13,983	141,890	2%
Common Gull	*Larus canus*	557	1,060	1,617	49,780	39%
Lesser Black-backed Gull	*Larus fuscus*	1,973	2,876	4,849	116,684	42%
Herring Gull	*Larus argentatus*	714	5,521	6,235	149,177	-17%
Great Black-backed Gull	*Larus marinus*	76	2,243	2,319	19,713	-6%
Black-legged Kittiwake	*Rissa tridactyla*	13,060	36,100	49,160	415,995	-23%
Sandwich Tern	*Thalasseus sandvicensis*	1,954	1,762	3,716	14,252	-11%
Roseate Tern	*Sterna dougallii*	4	734	738	790	44%
Common Tern	*Sterna hirundo*	1,704	2,485	4,189	14,497	-2%
Arctic Tern	*Sterna paradisaea*	767	2,735	3,502	56,123	-29%
Little Tern	*Sternula albifrons*	0	206	206	2,153	-25%
Common Guillemot	*Uria aalge*	98,546	138,108	236,654	1,559,484	32%
Razorbill[3]	*Alca torda*	24,084	27,446	51,530	216,087	23%
Black Guillemot[4]	*Cepphus grylle*	1,174	3,367	4,541	42,683	
Atlantic Puffin	*Fratercula arctica*	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., 2016; 2017; 2018; 2019, 2020, 2021). 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., 2021).

The survey has been undertaken annually since 1989 and since 2004 has been fixed in October and carried out on the RV *Celtic Explorer*. This years' survey was the first in which the RV *Tom Crean* was used. 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., 2016; 2017; 2018; 2019, 2020, 2021).

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 *Tom Crean* during the annual Celtic Sea Herring Acoustic Survey (CSHAS), running from the 9th to the 29th of October 2022.

Methodology

The seabird survey was conducted across the two survey legs of CSHAS22 running from the 9th - 19th October and the 20th - 29th October 2022, 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 2022 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.

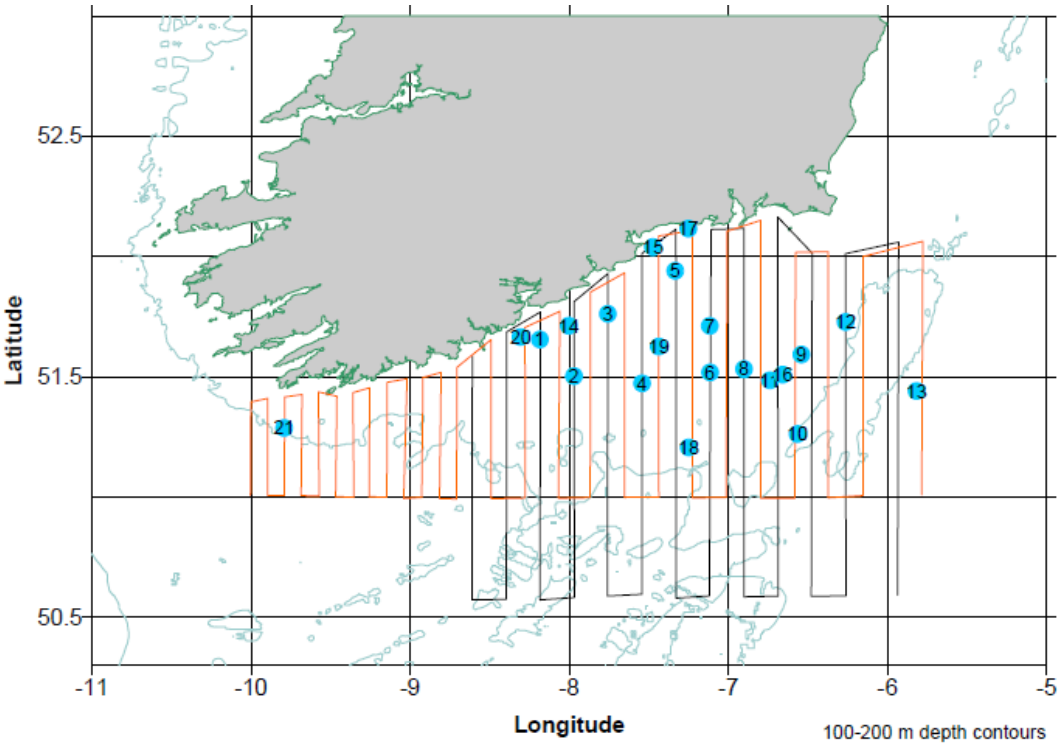

Figure 1: Representative cruise track of the Celtic Sea Herring Acoustic Survey (Source: Marine Institute, 2022).

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 observation deck (deck height 12.9 m above sea level) or bridge (deck height 10m above sea level), however, access to the observation deck 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^{o} 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 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 NL 10x32 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, 2022) 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. 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 ^{o} arc around the vessel. Data recording methodology remained similar for both point sampling and line transect methods.

Results

Effort

Vessel mobilisation took place on the 9th October, while demobilisation took place on the 29th October, it was not possible to conduct seabird survey effort on either of these days. Seabird survey effort was conducted across 16 days from the 10th - 28th 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.

Survey effort was limited on the 10th of October as the vessel was stationary in Dunmanus Bay for calibration of the vessels acoustic equipment. Survey effort was again limited on 28th of October as the vessel was stationary in Galway for calibration of the vessels acoustic equipment.

No seabird survey effort was conducted on the 15th or 21st of October due to weather conditions exceeding the specified weather limits for observations. Seabird survey effort was also greatly reduced on the 19th, 26th and 27th October due to adverse weather conditions.

Seabird survey effort was greatly reduced on the 17th of October due to a port call for crew change. No seabird survey effort was conducted on the 20th of October due to a port call for crew change and presidential visit.

A total of 72 hours and 41 minutes of survey effort were conducted over the course of CSHAS 2022. In total, 60 hours and 17 minutes of survey effort were conducted using a line transect methodology, while 9 hours and 6 minutes of effort were conducted using the point sampling methodology. A further 3 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 8 hours and 20 minutes while the average daily survey effort was 3 hours and 49 minutes. A graph of daily effort is provided in *Figure 2 b*elow.

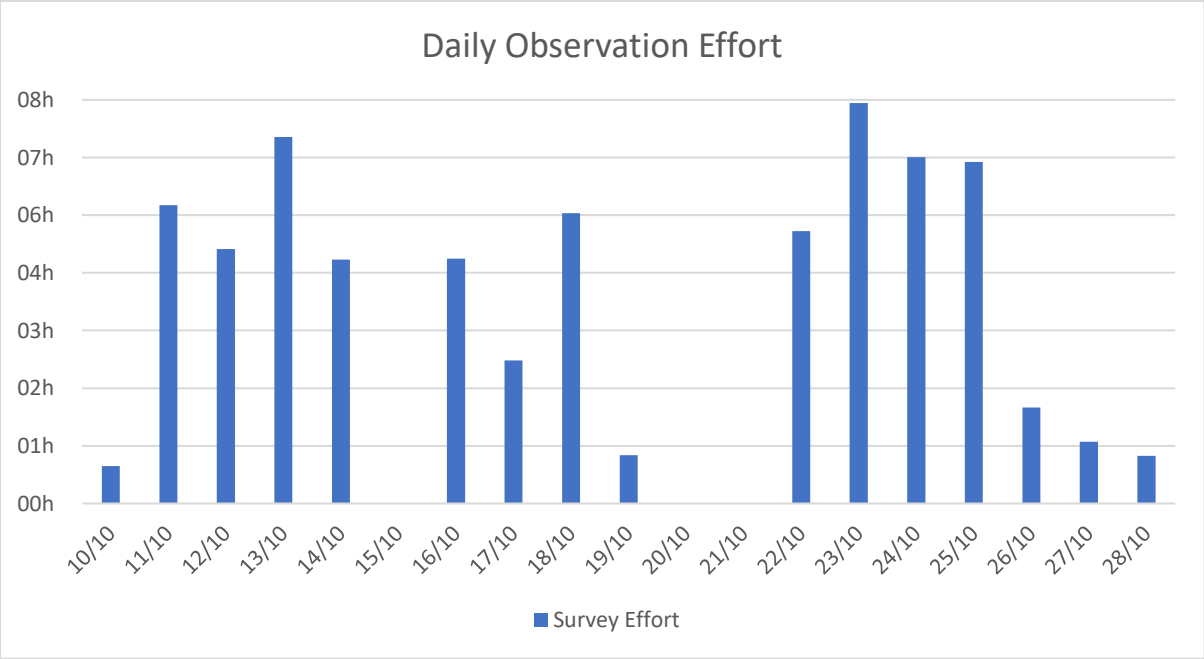

Figure 2: Daily visual effort undertaken during the survey.

Environmental Conditions

Weather conditions throughout the survey were generally favourable during leg 1, however leg 2 saw a significant deterioration, with high wind speeds recorded. On a number of 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. A number of 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, 4 and 5 were the most common sea states recorded. The most frequently recorded WMO sea state was 4, accounting for just over 26.5 hours (37%) of observation effort. WMO sea state 3 accounted for over 21 hours (29%) while WMO sea state 5 accounted for over 19.5 hours (27%). WMO sea state 2 and 6 each accounted for approximately 2-3 hours (3-4%) of observation effort (*Fig. 3a*).

The most frequently recorded Beaufort wind force/ sea state was a sea state 5, accounting for over 24 hours (33%) of survey effort. Beaufort wind force/ sea state 3 was recorded for 22 hours (30%) of observation effort, while Beaufort wind force/ sea state 4 accounted for over 12 hours (17%) of observation effort (*Fig. 3b*).

Swell

A swell height of 0.1-1 meter was most frequently recorded throughout the survey, being recorded in over 35 hours (48%) of survey effort. A swell height of 1.1-2 meters was recorded in over 31 survey hours (43%), while swell of over 2 meters was recorded during approximately 6 hours (9%) of survey effort (*Fig. 3c*).

Visibility

Visibility was generally very good during seabird survey effort; however, a number of periods of reduced visibility were also recorded. The most frequently recorded visibility was 11-15km, being recorded for almost 40 hours (55%) of survey effort. Visibility of 16-20km was recorded during 18 hours (25%) of survey effort, while visibility of 6-10km was recorded for over 14 hours (20%) of survey effort. Visibility of 1-5km was recorded during just 37mins (1%) of survey effort. Visibility of less than 1km was not recorded during survey effort (*Fig. 3d*).

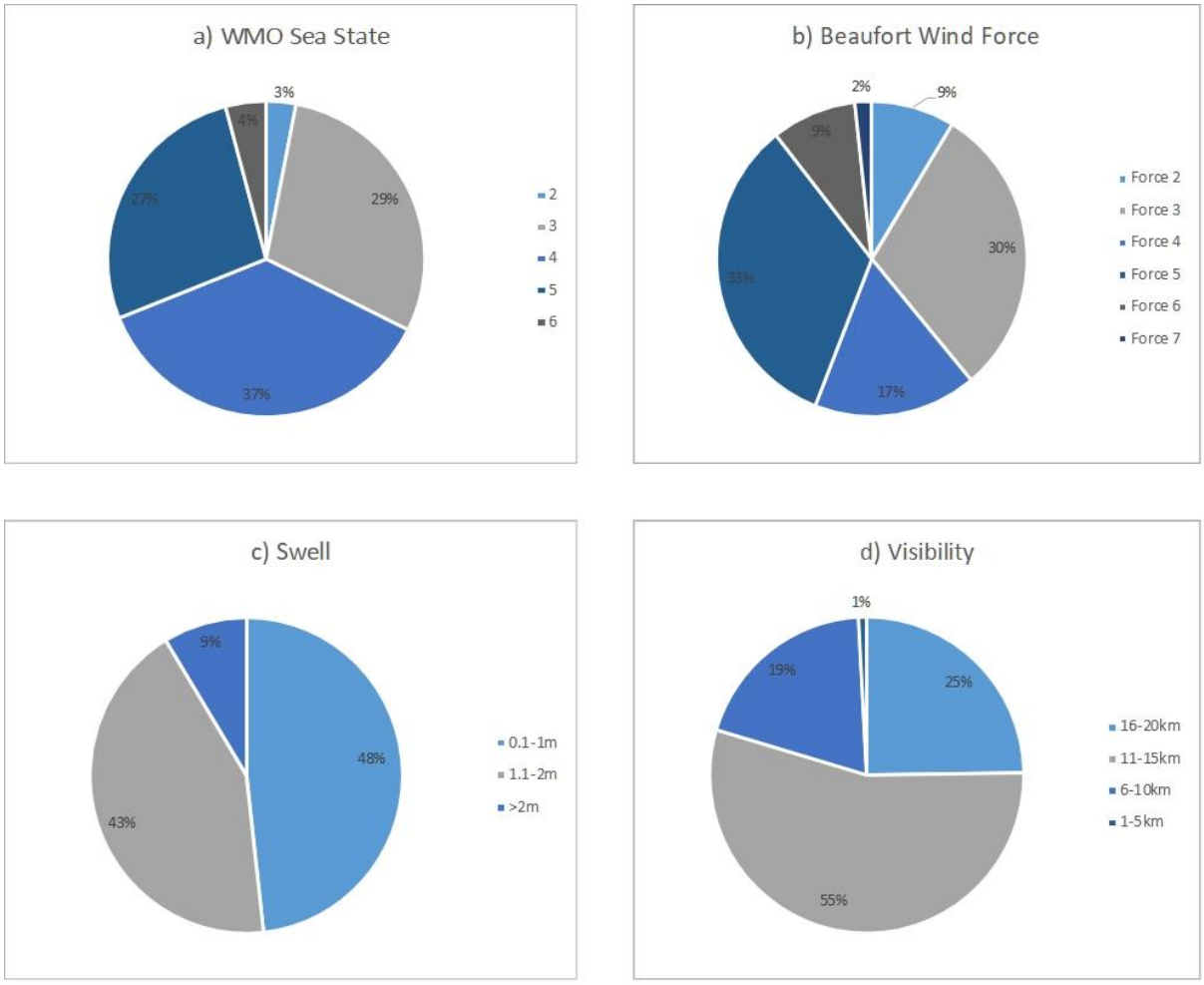

Figure 3: Summary of environmental conditions recorded on the WESPAS 2021; a) WMO sea state, b) Beaufort sea state/ wind force, c) Swell height (meters), d) Visibility (kilometres).

Seabird records

A total of 27 species from ten families were encountered during the survey, while a number of records were obtained of birds which could not be identified to species, these were recorded as either large gull sp. or guillemot/ razorbill. Of the 27 seabird species recorded during the survey, 23 were recorded during line transect survey effort, while 21 species were recorded during point counts.

In total, 2291 seabird observations were recorded throughout the survey, totalling 9854 individuals, with flock size ranging from one up to 200 for some species (*Table 2*). A summary of all seabirds recorded on the survey is presented in *Table 2* and includes birds recorded during both line transect and point sampling watches.

Of the 2291 seabird observations recorded during the survey, 2155 were recorded during line transect effort. In total, 7090 seabirds were recorded during line transect effort, with 2410 of these recorded as 'in-transect'. The remaining 4680 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- 10*. 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.

Common Name	***Species name***	***No. of records***	***No. of Seabirds***	***Flock size***
Northern Fulmar	*Fulmarus glacialis*	64	272	1-75
Great Shearwater	*Ardenna gravis*	14	82	1-31
Sooty Shearwater	*Ardenna grisea*	29	120	1-65
Manx Shearwater	*Puffinus puffinus*	21	30	1-3
European Storm Petrel	*Hydrobates pelagicus*	2	3	1-2
Northern Gannet	*Morus bassanus*	649	2826	1-200
Pomarine Skua	*Stercorarius pomarinus*	2	2	1
Arctic Skua	*Stercorarius parasiticus*	9	11	1-2
Long-tailed Skua	*Stercorarius longicaudus*	1	1	1
Great Skua	*Stercorarius skua*	13	14	1-2
Mediterranean Gull	*Ichthyaetus melanocephalus*	3	3	1
Common Gull	*Larus canus*	13	25	1-7
Sabine's Gull	*Xema sabini*	2	2	1
Black-headed Gull	*Chroicocephalus ridibundus*	8	14	1-4
Lesser Black-backed Gull	*Larus fuscus*	88	601	1-100
Herring Gull	*Larus argentatus*	51	345	1-200
Yellow-legged Gull	*Larus michahellis*	1	1	1
Great Black-backed Gull	*Larus marinus*	121	234	1-20
Black-legged Kittiwake	*Rissa tridactyla*	429	2564	1-175
Large Gull sp.	*Laridae*	1	200	200
Arctic Tern	*Sterna paradisaea*	1	1	1
Common Guillemot	*Uria aalge*	455	1216	1-40
Razorbill	*Alca torda*	215	770	1-60
Razorbill/Guillemot	*Alcidae*	20	312	1-50
Black Guillemot	*Cepphus grylle*	2	3	1-2
Atlantic Puffin	*Fratercula arctica*	58	142	1-16
European Shag	*Gulosus aristotelis*	17	54	1-15
Great Cormorant	*Phalacrocorax carbo*	1	5	5
Great Northern Diver	*Gavia immer*	1	1	1
	Total	**2291**	**9854**	

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

Common Name	***Species name***	***No. of records***	***No. of Seabirds***	***In Transect***	***Off Transect***
Northern Fulmar	*Fulmarus glacialis*	56	87	31	56
Great Shearwater	*Ardenna gravis*	11	49	32	17
Sooty Shearwater	*Ardenna grisea*	21	38	17	21
Manx Shearwater	*Puffinus puffinus*	19	26	8	18
Northern Gannet	*Morus bassanus*	633	2001	471	1530
Pomarine Skua	*Stercorarius pomarinus*	1	1	0	1
Arctic Skua	*Stercorarius parasiticus*	9	11	5	6
Great Skua	*Stercorarius skua*	10	10	2	8
Mediterranean Gull	*Ichthyaetus melanocephalus*	1	1	1	0
Common Gull	*Larus canus*	10	15	2	13
Sabine's Gull	*Xema sabini*	2	2	1	1
Black-headed Gull	*Chroicocephalus ridibundus*	6	12	1	11
Lesser Black-backed Gull	*Larus fuscus*	76	327	60	267
Herring Gull	*Larus argentatus*	42	80	17	63
Yellow-legged Gull	*Larus michahellis*	1	1	0	1
Great Black-backed Gull	*Larus marinus*	109	174	67	107
Black-legged Kittiwake	*Rissa tridactyla*	413	1931	785	1146
Large Gull sp.	*Laridae*	1	200	0	200
Arctic Tern	*Sterna paradisaea*	1	1	0	1
Common Guillemot	*Uria aalge*	443	1093	580	513
Razorbill	*Alca torda*	202	674	286	388
Razorbill/Guillemot	*Alcidae*	18	212	3	209
Black Guillemot	*Cepphus grylle*	1	1	0	1
Atlantic Puffin	*Fratercula arctica*	54	107	25	82
European Shag	*Gulosus aristotelis*	15	36	16	20
	Total	**2155**	**7090**	**2410**	**4680**

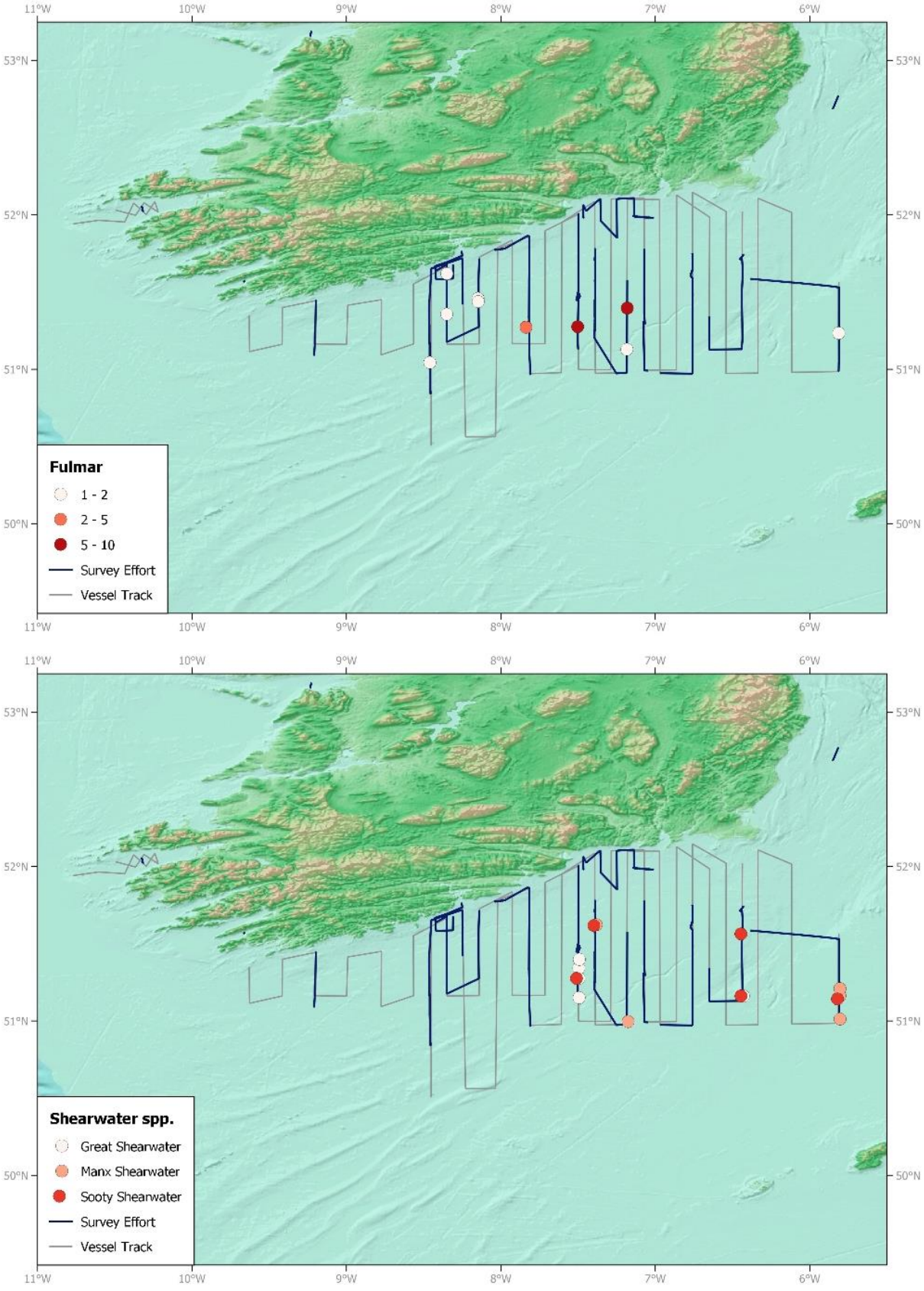

Figure 4: Distribution of a) Northern Fulmar and b) Shearwater spp. recorded as 'in-transect' during line transect survey effort.

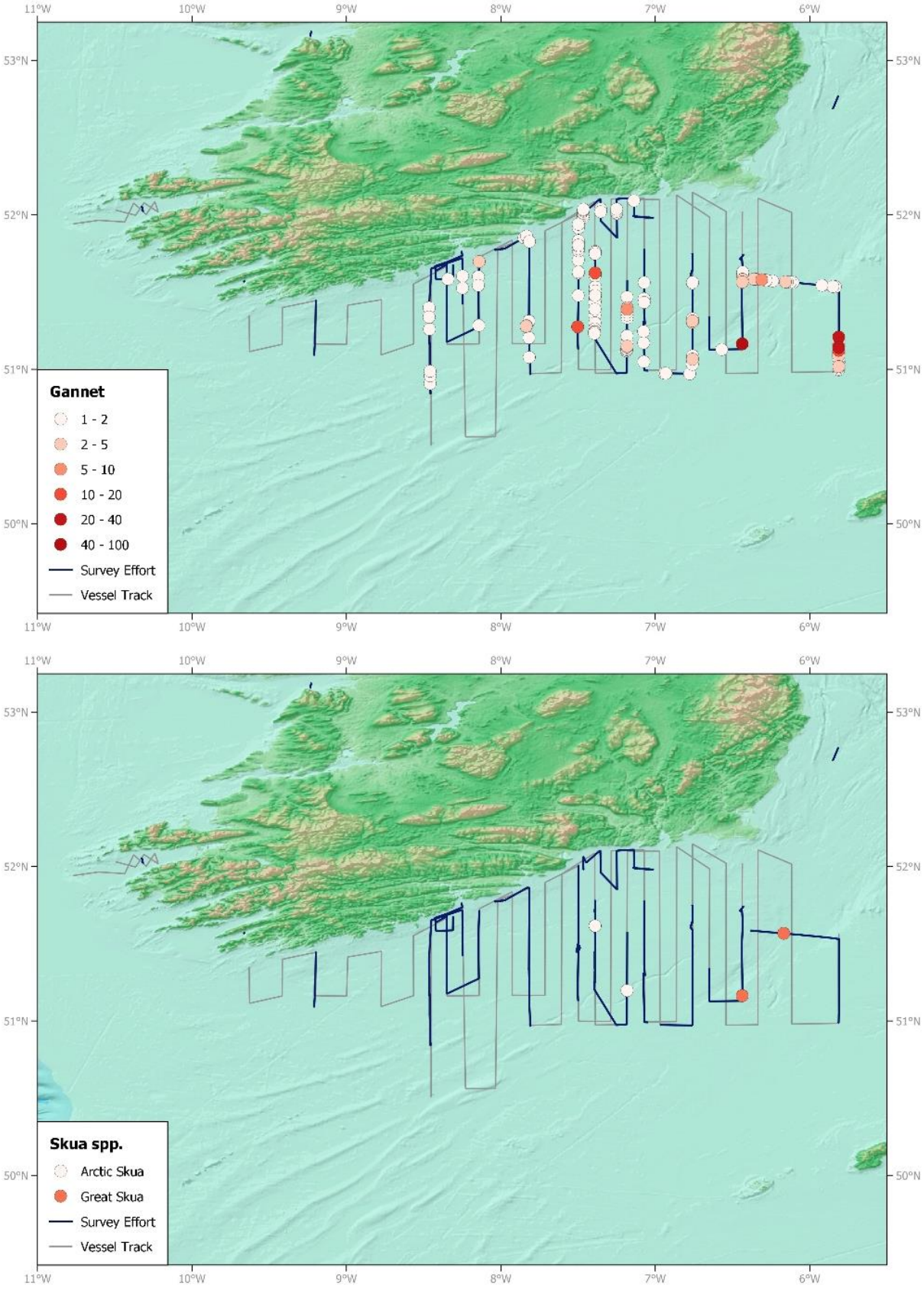

Figure 5: Distribution of a) Northern Gannet and b) Skua spp. recorded as 'in-transect' during line transect survey effort.

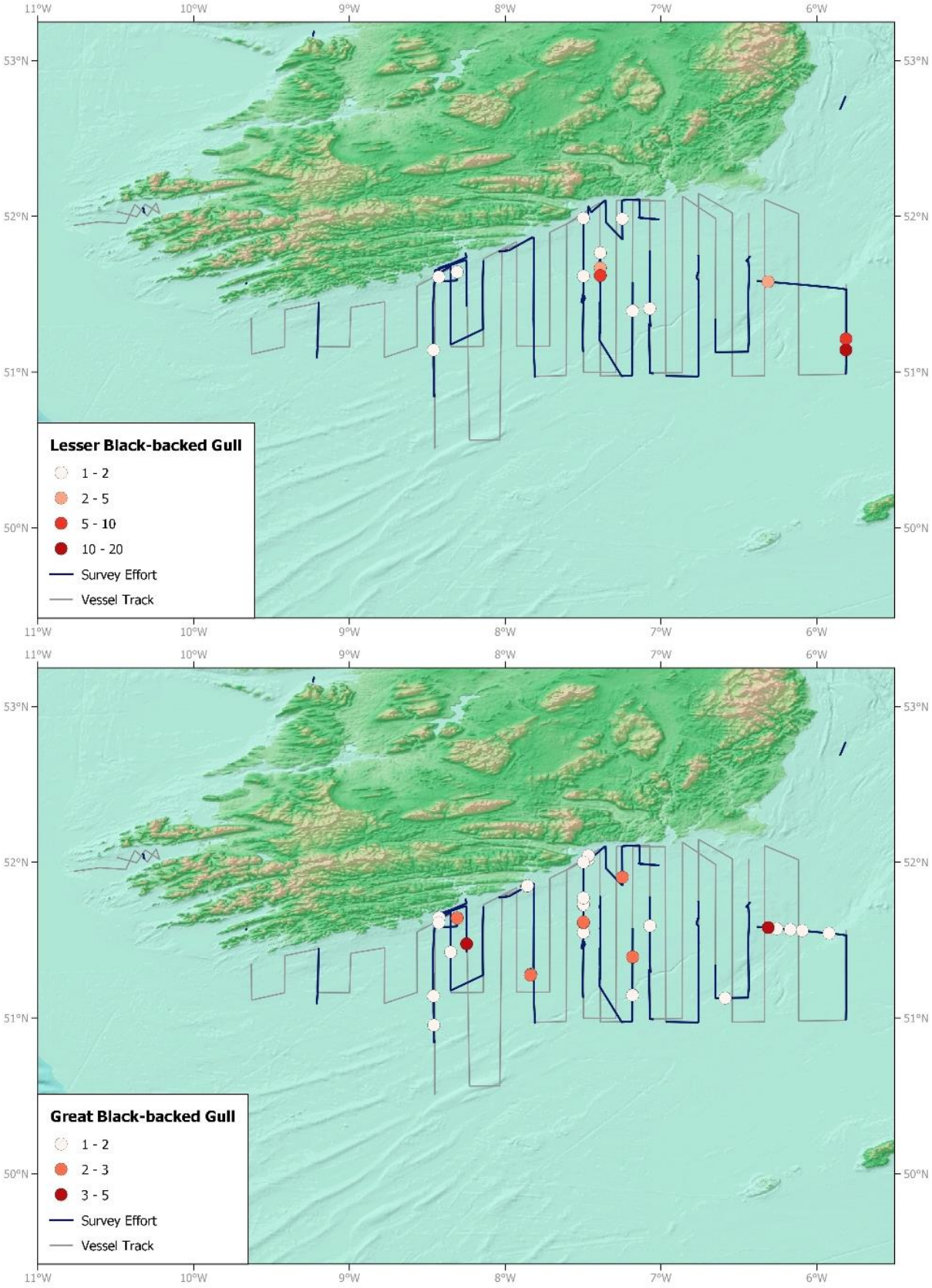

Figure 6: Distribution of a) Lesser Black-backed Gull and b) Great Black-backed Gull recorded as 'in-transect' during line transect survey effort.

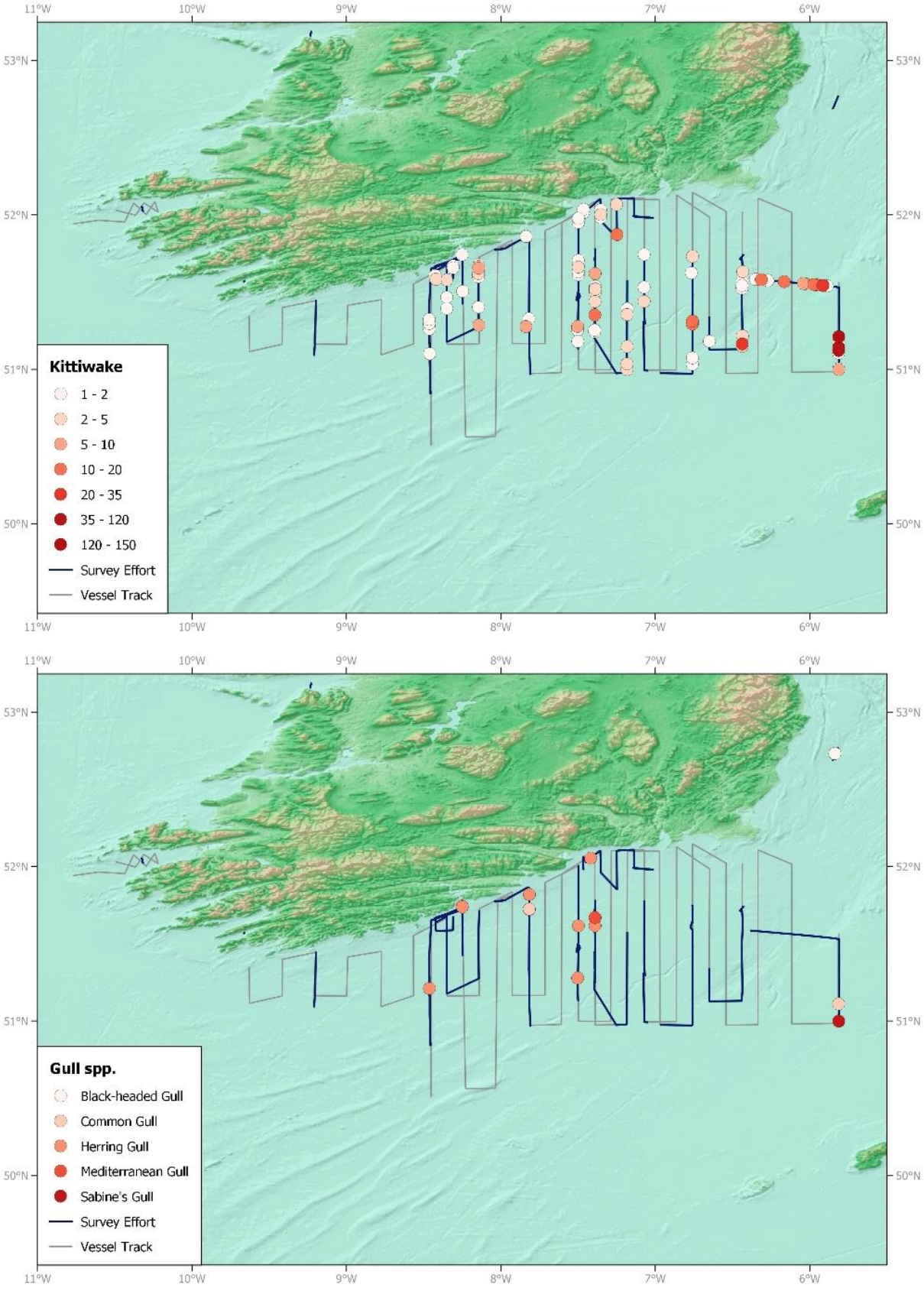

Figure 7: Distribution of a) Black-legged Kittiwake and b) Gull spp. recorded as 'in-transect' during line transect survey effort.

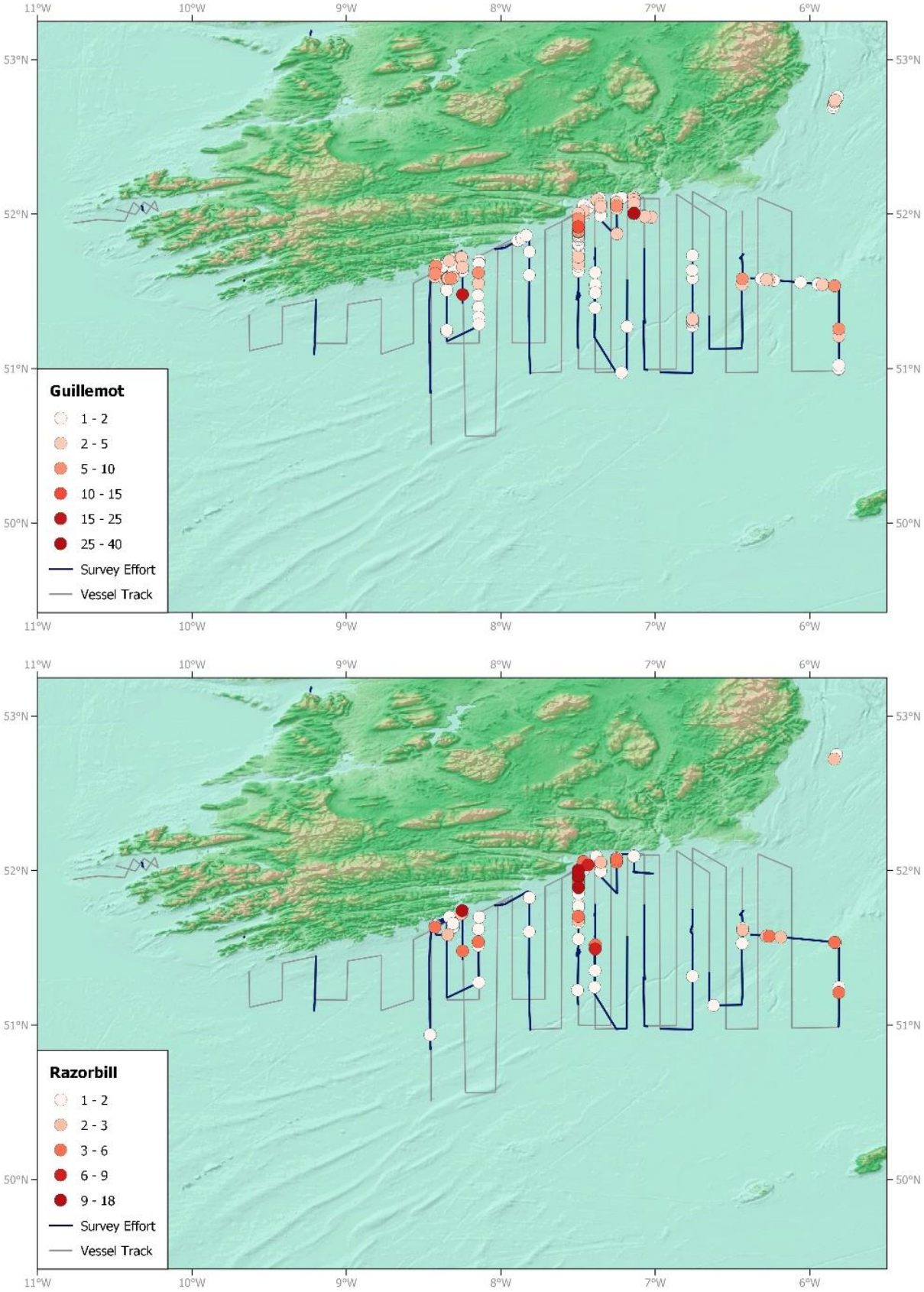

Figure 8: Distribution of a) Common Guillemot and b) Razorbill recorded as 'in-transect' during line transect survey effort.

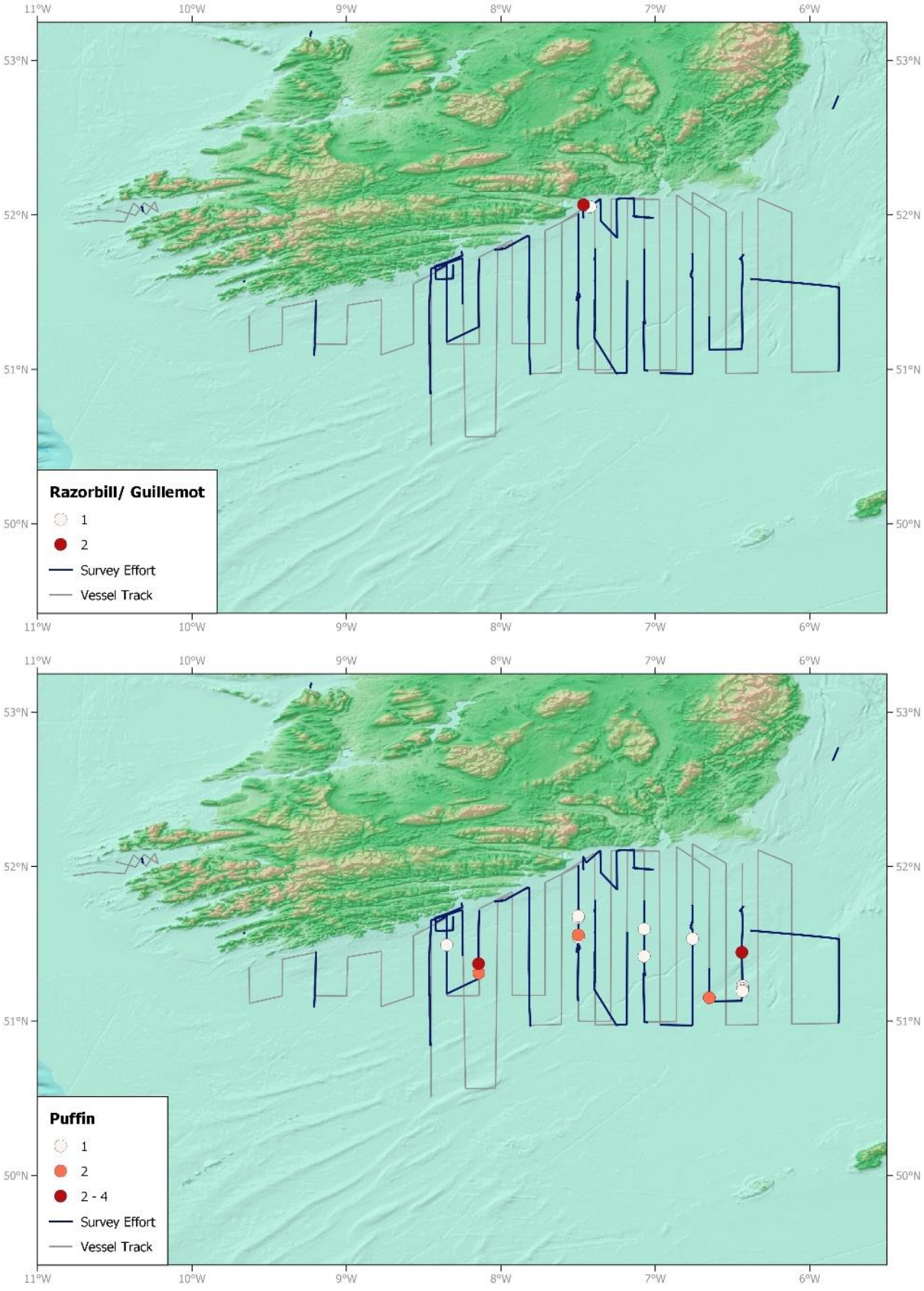

Figure 9: Distribution of a) Razorbill/ Common Guillemot and b) Atlantic Puffin recorded as 'in-transect' during line transect survey effort.

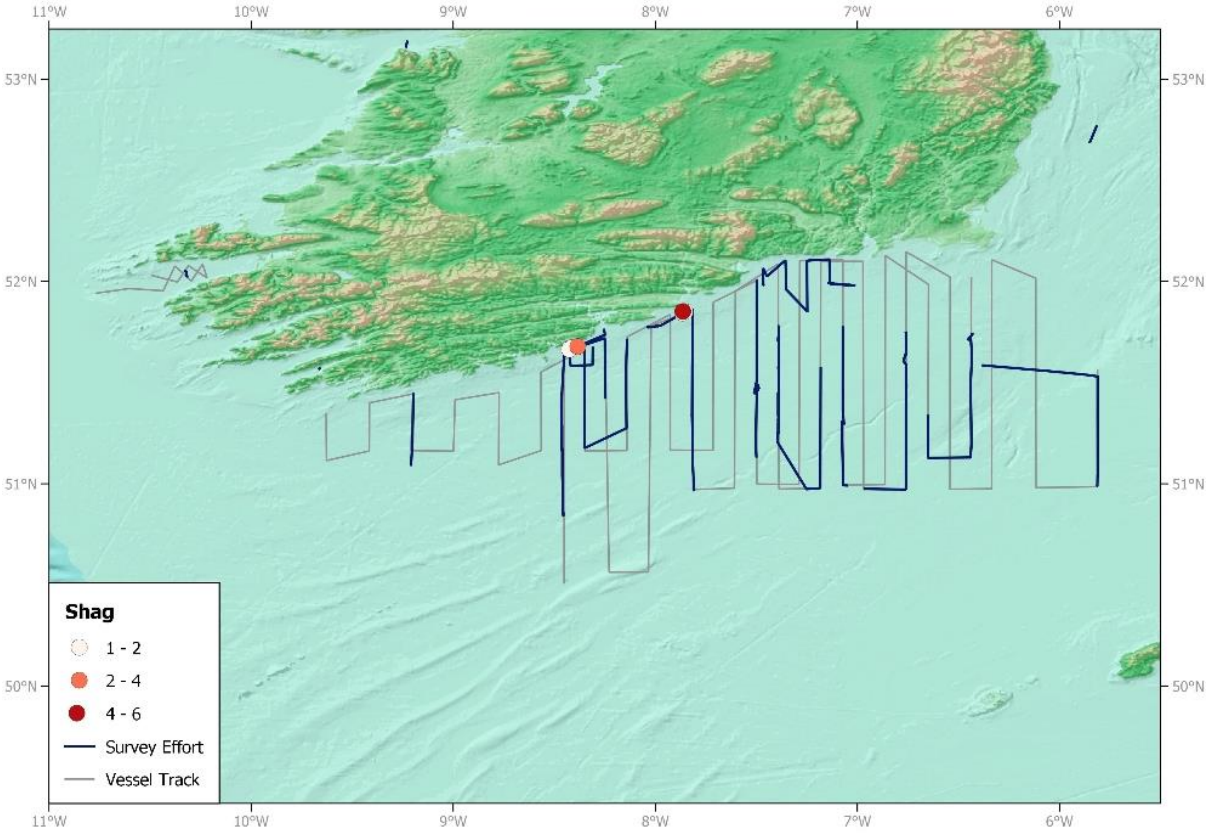

Figure 10: Distribution of European Shag recorded as 'in-transect' during line transect survey effort

Thirteen point counts were conducted at oceanographic or fishing stations. A total of 97 seabird observations were recorded during point sampling effort, comprising 1613 individuals from 20 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.

Common Name	***Species name***	***No. of records***	***Off transect***
Northern Fulmar	*Fulmarus glacialis*	4	10
Great Shearwater	*Ardenna gravis*	1	1
Sooty Shearwater	*Ardenna grisea*	5	6
European Storm Petrel	*Hydrobates pelagicus*	1	2
Northern Gannet	*Morus bassanus*	13	540
Great Skua	*Stercorarius skua*	1	1
Mediterranean Gull	*Ichthyaetus melanocephalus*	2	2
Common Gull	*Larus canus*	2	9
Black-headed Gull	*Chroicocephalus ridibundus*	1	1
Lesser Black-backed Gull	*Larus fuscus*	9	239
Herring Gull	*Larus argentatus*	8	255
Great Black-backed Gull	*Larus marinus*	10	52
Black-legged Kittiwake	*Rissa tridactyla*	13	308
Common Guillemot	*Uria aalge*	9	46
Razorbill	*Alca torda*	10	62
Razorbill / Guillemot	*Alcidae*	1	50
Black Guillemot	*Cepphus grylle*	1	2
Atlantic Puffin	*Fratercula arctica*	2	3
European Shag	*Gulosus aristotelis*	2	18
Great Cormorant	*Phalacrocorax carbo*	1	5
Great Northern Diver	*Gavia immer*	1	1
	Total	**97**	**1613**

Northern Fulmar

Northern Fulmar (*Fulmarus glacialis*) were frequently encountered on the survey, being recorded on 64 occasions and totalling 272 individuals. In total, 56 observations of 87 individuals were recorded during line transect watches, with 31 individual birds recorded as 'in-transect'. The majority of birds seen were of the double light morph (LL) plumage type, however two High Arctic 'Blue' Fulmars were also recorded. Fulmar were found to be patchily distributed in low numbers within the survey area (*Fig. 4a*). During survey effort, Fulmar were more frequently encountered on the westerly lying transects, with higher abundances recorded on transects south of Cork Harbour and south of Helvick Head. A number of Fulmar observations were also recorded as 'off-transect', including a flock of 75 birds south of The Stags. However as these birds were recorded 'off-transect' they are not presented graphically here.

Shearwaters

Three species of shearwater were encountered on the survey: Great Shearwater (*Ardenna gravis*), Sooty Shearwater (*Ardenna grisea*) and Manx Shearwater (*Puffinus puffinus*). All three species were recorded during line transect effort. Both Great Shearwater and Sooty Shearwater were also recorded during point sampling watches.

Sooty Shearwater were recorded on 29 occasions, totalling 120 individuals. Sooty Shearwater were recorded on 12 occasions (38 individuals) during line transect effort with 17 individuals recorded as 'in-transect'. Sooty Shearwater were found to be broadly distributed in low numbers across the entire survey area, however the majority of 'in-transect' records were obtained on more easterly transects (*Fig. 4b*). Sooty Shearwater were also found to display a somewhat patchy distribution with higher abundances recorded in areas such as outer Dingle Bay, south of The Stags and the Smalls, however many of these larger aggregations were recorded as 'off-transect'.

Great Shearwater were recorded less frequently, and were observed on 14 occasions, totalling 82 individuals. Great Shearwater were recorded on 11 occasions (49 individuals) during line transect effort with 32 individuals recorded as 'in-transect'. Great Shearwater were also found to be broadly distributed in low numbers across the entire survey area, displaying a similar distribution pattern to Sooty Shearwater (*Fig. 4b*). Great Shearwater were also found to display a somewhat patchy distribution with higher abundances recorded in areas such as The Trench fishing grounds, south of The Stags and the Smalls, however many of these larger aggregations were recorded as 'off-transect'.

Manx Shearwater were recorded on 21 occasions with 30 individual birds recorded. All Manx Shearwater were recorded during line transect effort, with 8 birds recorded as 'in-transect'. Manx Shearwaters were equally widespread however they were recorded in lower numbers, generally just 1 to 2 birds, with the majority being recorded 'off-transect' (*Fig. 4b*).

Storm petrels

Storm petrels were absent for the majority of the survey. European Storm petrel (*Hydrobates pelagicus*) was the only species of storm petrel recorded during the survey and was only recorded in the last few days of survey effort.

European Storm petrel were recorded on 2 occasions, numbering 3 birds in total. One record of two European Storm Petrel was recorded during a point watch in Galway Bay, the remaining record of a solitary bird was recorded during a casual watch, also in Galway Bay.

Northern Gannet

Overall, Northern Gannet (*Morus bassanus*) were the most frequently observed seabird species on the survey, being recorded on 649 occasions and totalling 2826 individuals. In total, 633 observations of 2001 birds were recorded during line transect watches, with 471 Gannets recorded as 'in-transect', making Gannet the 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, a number of larger aggregations were also recorded. These larger aggregations were observed in areas such as outer Dingle Bay and south of the Stags, as well as in the vicinity of fishing grounds such as (*Fig. 5a*). Particularly large feeding aggregations of 100-200 Gannet were recorded over the The Trench, Celtic Deep, and the Smalls fishing grounds and in outer Dingle Bay, 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, Great Skua (*Stercorarius skua*), Pomarine Skua (*Stercorarius pomarinus*), Long-tailed Skua (*Stercorarius longicaudus*) and Arctic Skua (*Stercorarius parasiticus*). Great Skua, Pomarine Skua and Arctic Skua were each recorded during line transect survey effort. Of the four species, Great Skua were the only species recorded during point counts. Long-tailed Skua were recorded during a casual watch only. The distribution of skua species recorded as 'in-transect' during line transect effort are presented in *Figure 6a.*

Great Skua were regularly encountered in low numbers throughout the survey (13 records of 14 individual birds). During line transect survey effort, Great Skua were encountered on 10 occasions, totalling 10 individual birds. Of these, only 2 Great Skua were recorded as 'in-transect'.

Nine records of Arctic Skua, totalling 11 individuals, were noted during line transect effort on the survey; with 5 Arctic Skua recorded as 'in-transect'.

Two records of solitary Pomarine Skua were noted during the survey; one record was obtained during line transect effort, while the other was recorded during a casual watch, both were recorded as 'off-transect'.

In general, Skua spp. were patchily distributed across much of the survey area in low numbers, however they were predominantly recorded 'off-transect'. The distribution of Great and Arctic Skua recorded as 'in-transect' during line transect effort are presented in *Figure 5b.*

Gulls

Nine species of gull were encountered on the survey including; Mediterranean Gull (*Ichthyaetus melanocephalus*), Common Gull (*Larus canus*), Sabine's gull (*Xema sabini*), 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 nine species, all but Yellow-legged Gull were recorded as 'in-transect' during line transect survey effort. A large flock of 200 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, Mediterranean Gull (14 birds 'in-transect), Sabine's Gull (1 bird 'in-transect'), Common Gull (26 birds 'in-transect) and Black-headed Gull (19 birds 'in-transect') were recorded on a number of occasions during line transect effort. Common Gull were distributed broadly in low number across the survey area, while Black-headed Gull

showed a more coastal distribution. Isolated records of individual Mediterranean Gull and Sabine's gull were recorded (*Fig. 7b*).

Lesser Black-backed Gull were one of the most frequently encountered gull species on the survey with a total of 601 individuals recorded during 88 observations. Lesser Black-backed Gull were the second most abundant species of gull recorded, being recorded on 76 occasions, amounting to 327 birds, during line transect effort. Of these, 60 birds were recorded as 'in-transect'.

Great black-backed gull were the second most frequently encountered gull species on the survey being encountered on 121 occasions and with a total of 234 individuals recorded. Great Black-backed Gull were one of the most abundant species of gull recorded, being recorded on 109 occasions, amounting to 174 birds, during line transect effort. Of these, 67 birds were recorded as 'in-transect'.

Herring Gull were also regularly encountered during the survey, with 51 observations of 345 birds reported. During line transect effort, Herring Gull were recorded 42 times, amounting to 80 individual birds, 17 of which were recorded as 'in-transect'.

Lesser Black-backed Gull, Great Black-backed Gull and Herring 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 and the Smalls fishing grounds, however the majority of the birds were recorded as 'off-transect' (*Fig. 6a, 6b & 7b*).

A solitary Yellow-legged Gull (1 bird 'off-transect') was also encountered on one occasion during line transect effort in the vicinity of the Kinsale gas rigs.

Kittiwake were the most frequently encountered and most abundant gull species on the survey with a total of 2564 birds recorded during 429 observations. During line transect survey effort, Kittiwake were encountered on 413 occasions, totalling 1931 individual birds. Of these, 785 birds were recorded as 'in-transect'. 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 The Smalls and south of The Stags (*Fig. 7a*).

Terns

One species of tern were encountered over the course of the survey: Arctic Tern (*Sterna paradisaea*). A solitary Arctic Tern was recorded as 'off-transect' during line transect effort in offshore waters south of Helvick Head.

Auks

Four of the five species of auk known to occur in Irish waters were encountered on the survey. These were Guillemot (*Uria aalge*), Black Guillemot (*Cepphus grylle*), Razorbill (*Alca torda*) and Atlantic Puffin (*Fratercula arctica*). All auk species' were recorded during both line transect and point sampling survey effort. A number of observations of auks identified only as Razorbill/ Guillemot were also recorded during both line transect and point sampling survey effort.

Guillemot were the most frequently encountered of the auk species and the second most frequently encountered species overall. In total, 455 observations of 1216 individual Guillemot were recorded during the survey. During line transect watches 443 observations of 1093 individuals were noted, with 580 birds recorded as 'in-transect'. Guillemot were found to be broadly distributed across the entire

survey area but were observed in highest densities in coastal regions off Kinsale, Helvick Head and the Gold Coast (*Fig. 8a*).

Razorbill were the second most frequently encountered auk species during the survey. In total, 215 observations of 770 individuals were recorded during the survey. During line transect watches, 202 observations of 674 individuals were recorded, with 286 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 off Kinsale, Helvick Head and the Gold Coast (*Fig. 8b*). The distribution of auks identified as Guillemot/Razorbill is also consistent with the distribution of Guillemot and Razorbill (*Fig. 9a*).

Puffin were also frequently encountered during the survey, though not as common as Guillemot or Razorbill. In total, 58 records of 142 Puffin were recorded over the course of the survey. During line transect watches, 54 records of 107 Puffin were noted with 25 birds recorded as 'in-transect'. Puffin were broadly distributed across much of the survey area, predominantly in offshore waters, and showed a more even distribution than many other species (*Fig. 9b*).

Two records of Black Guillemot were reported during the survey. A solitary Black Guillemot was recorded 'off-transect' during line transect effort at the mouth of Cork Harbour. One record of a pair of Black Guillemot was observed while conducting a point sampling watch in Dunmanus Bay while the vessel was calibrating acoustic equipment.

Cormorants, Shags and Divers

Both Great Cormorant and European Shag were recorded during this years' CSHAS. Shag were recorded during both line transect and point sampling survey effort, however, Cormorant were recorded solely during point sampling survey effort.

Shag were recorded on 17 occasions totalling 54 birds. During line transect survey effort 15 records totalling 36 Shag were observed, of these 16 Shag were recorded as 'in-transect'. Shag were reported 'in-transect' off Helvick Head and Kinsale (*Fig. 10*), with some larger flocks recorded 'off-transect' in Dunmanus Bay and Galway Bay.

The single record of Cormorant on the survey was a flock of 5 Cormorant encountered in Dunmanus Bay during a point watch.

A solitary Great Northern Diver was also recorded in Dunmanus Bay during a point watch.

Terrestrial/migratory birds

A number of terrestrial/migratory birds were encountered during the survey. A total of 49 observations of terrestrial/ migratory bird species were recorded during the survey (*Table 5*). These records comprised of 100 individuals from 24 species'. Species recorded included a little egret (*Egretta garzetta*), a common redstart (*Phoenicurus phoenicurus*), a goldcrest (*Regulus regulus*) and a spotted flycatcher (*Muscicapa striata*). A flock of Greater White-fronted Geese (*Anser albifrons*) were detected flying overhead during the survey, the birds were not seen but were identified by the flight call. The reported number of 5 Greater White-fronted Geese is hence a best estimate of numbers present.

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

Common Name	***Species name***	***No. of records***	***No. of individuals***
Greater White-fronted Goose	*Anser albifrons*	1	5
Common Scoter	*Melanitta nigra*	1	1
Feral pigeon	*Columba livia*	1	1
European Golden Plover	*Pluvialis apricaria*	2	4
Eurasian Curlew	*Numenius arquata*	2	4
Ruddy Turnstone	*Arenaria interpres*	1	1
Grey Heron	*Ardea cinerea*	1	1
Little Egret	*Egretta garzetta*	1	1
Common Kestrel	*Falco tinnunculus*	1	1
Hooded Crow	*Corvus cornix*	2	4
Eurasian Skylark	*Alauda arvensis*	2	2
Barn Swallow	*Hirundo rustica*	3	7
Eurasian Blackcap	*Sylvia atricapilla*	4	4
Goldcrest	*Regulus regulus*	1	1
Eurasian Wren	*Troglodytes troglodytes*	1	1
Common Starling	*Sturnus vulgaris*	3	17
Redwing	*Turdus iliacus*	2	2
Song Thrush	*Turdus philomelos*	1	1
Spotted Flycatcher	*Muscicapa striata*	1	1
Common Redstart	*Phoenicurus phoenicurus*	1	1
Grey Wagtail	*Motacilla cinerea*	2	2
Pied/ White wagtail	*Motacilla alba*	1	1
Meadow Pipit	*Anthus pratensis*	12	33
European Rock Pipit	*Anthus petrosus*	2	4
	Total	**49**	**100**

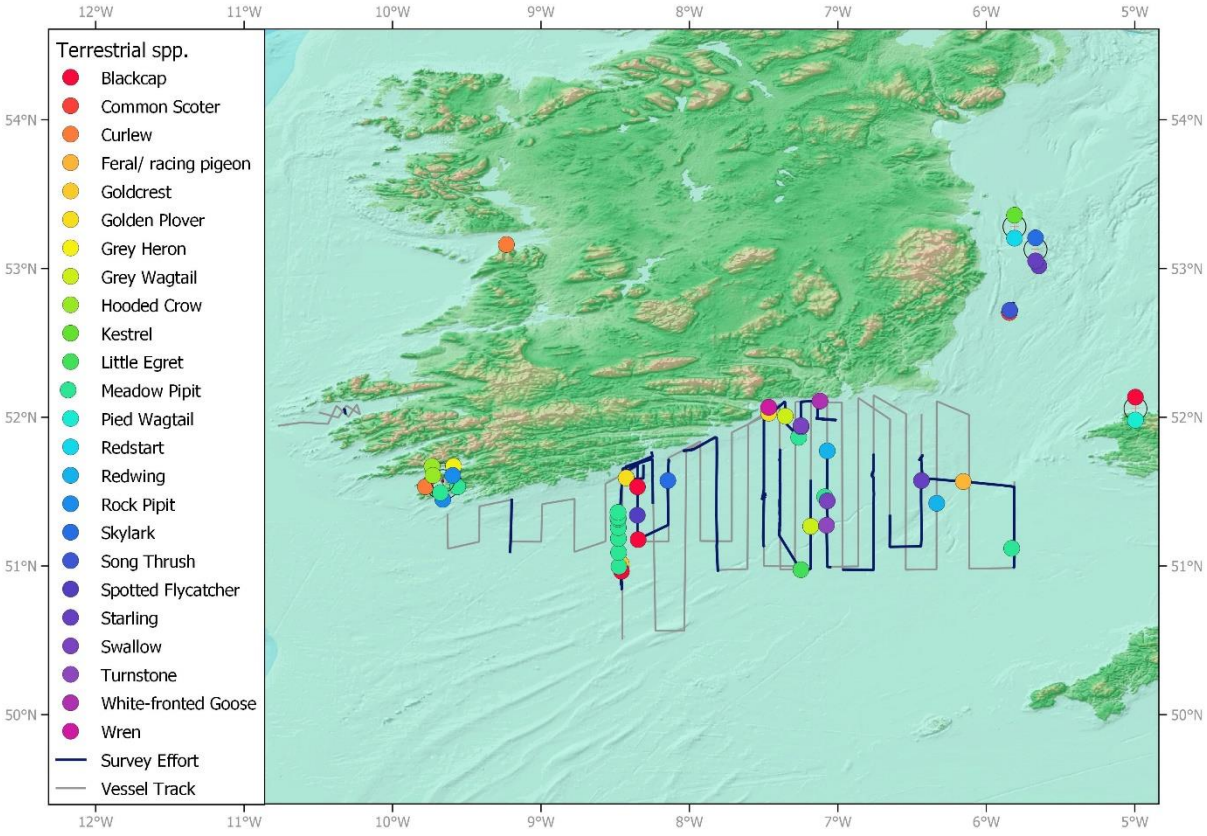

Figure 11: Distribution of terrestrial species recorded during survey effort.

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 72 hours and 41 minutes of survey effort was conducted which was similar to the total of 71 hours and 26 minutes of survey effort conducted during CSHAS 2021. In both 2019 and 2020, approximately 117.5 hours of survey effort was conducted per survey. In the preceding years from 2016-2018 survey effort varied between approximately 62.5 and 73.5 survey hours (O'Donnell, et al., 2016; 2017; 2018; 2019, 2020, 2021). 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 survey and CSHAS 2020 and 2021 differed from previous CSHAS seabird surveys in that only a single seabird surveyor was deployed for the duration of the survey. In the present survey this was due to crewing restrictions on the RV *Tom Crean*, while in 2020 and 2021 crewing restrictions were put in place as a mitigation measure against the impacts of the COVID 19pandemic. The use of a single observer on these 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 a number of 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, 27 species of seabird and 24 species of terrestrial bird were recorded during the present survey. This is broadly consistent with the species totals from previous seabird surveys during CSHAS. For example, on CSHAS'21 26 species of seabird and 20 species of terrestrial bird were recorded during the present survey, while on the 2020 survey, 27 species of seabird and 19 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 (O'Donnell, et al., 2016; 2017; 2018; 2019, 2020, 2021).

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), with no seabird species recorded in the present survey which had not been previously encountered.

Some variance in the reported occurrence of species has been noted across the survey time series (O'Donnell, et al., 2016; 2017; 2018; 2019, 2020, 2021), however, it is not possible to directly compare species abundance without further analysis. A reduction in the numbers of birds recorded on the present survey was evident for a number of species when compared to last year's survey. This was particularly evident for species such as Gannet, Guillemot, Sooty Shearwater and European Storm Petrel. A steep decline is apparent in the numbers of Gannet recorded on the 2021 survey (5667 Gannets, 758 'in-transect') compared to the present survey (2826 Gannets, 471 'in-transect'), a reduction of 50% in terms of Gannet numbers and 38% in terms of Gannets 'in-transect' (Power & Keogh, 2021). Similarly, a large decrease in Guillemot numbers was apparent compared to last years'

data. In the present survey 1216 Guillemot were recorded (580 'in-transect'), while 2257 Guillemot were recorded last year (1904 'in-transect'), constituting a 46% decrease in the number of Guillemot recorded and a 70% decrease in the number recorded 'in-transect' (Power & Keogh, 2021). Sooty Shearwater also showed a marked decrease in numbers with 120 birds recorded (17 'in-transect'), this constitutes a drop of 76% (and 80% 'in-transect') on last years' figures of 499 birds (137 'in-transect') (Power & Keogh, 2021). Notably, European Storm Petrel were completely absent from the Celtic Sea during this years' survey, the only records were obtained in Galway Bay. This is in contrast to the 53 European Storm Petrel (40 'in-transect') recorded during CSHAS 2021 (Power & Keogh, 2021).

In contrast, the number of Great Shearwater, Kittiwake and Razorbill recorded this year were substantially higher than recorded in 2021. This years' survey recorded 82 Great Shearwater, 32 of which were 'in-transect', which is a 645% and 1500% respective increase on the 11 Great Shearwater recorded during last year's survey, of which 2 were 'in-transect' (Power & Keogh, 2021). Interestingly, no Great Shearwater were recorded on the survey in 2020 (Connaughton & Power, 2020), and Great Shearwater have been generally scarce across the time series (O'Donnell, et al., 2016; 2017; 2018; 2019, 2020). Kittiwake too showed a marked increase in numbers with 2654 birds recorded (785 'in-transect'), this constitutes a rise of 83% (and 60% 'in-transect') on last years' figures (Power & Keogh, 2021). Substantial increases in Razorbill numbers are also evident compared to last years' data. In the present survey 770 Razorbill were seen (286 'in-transect'), while 392 Razorbill were seen last year (268 'in-transect'), constituting a 96% increase in the number of Razorbill seen and a 7% increase in the number recorded 'in-transect' (Power & Keogh, 2021).

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 a number of 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 breeding season may also have had a significant effect, particularly on heavily impacted species such as Gannet (DAFM, 2022).

Gannet, Guillemot and Kittiwake were the most abundant and widespread species' in the present survey, with Guillemot and Gannet being the most widely distributed. Despite their abundance and generally broad distribution, these species, along with many other species' recorded, displayed a somewhat patchy distribution. 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; south of The Stags, south of Helvick Head, and the Smalls and the Trench fishing grounds. A number of these areas were also noted as 'hotspots' during the 2020 and 2021 surveys (Power & Keogh, 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 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 due to crewing restrictions on the RV *Tom Crean*, 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 times without suffering the ill effects of fatigue.

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