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Volume 7B Proposed Development (Offshore) Appendices

Appendix 6-1 Offshore Ornithology Baseline Characterisation Report

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OCEAN WINDS

Volume 7B Appendix 6-1 Offshore Ornithology Baseline Characterisation Report

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Acronyms and Abbreviations

AOB	Apparently Occupied Burrows
AON	Apparently Occupied Nests
AOT	Apparently Occupied Territories
BDMPS	Biologically Defined Minimum Population Scales
BST	British Summer Time
BTO	British Trust for Ornithology
CRM	Collision Risk Modelling
CV	Coefficient of Variation
DAS	Digital Aerial Survey
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
ESAS	European Seabirds At Sea
GMT	Greenwich Mean Time
GPS	Global Positioning System
HPAI	Highly Pathogenic Avian Influenza
HRA	Habitats Regulations Appraisal
ID	Identification
IND	Individuals
INTERREG VA	Northern Ireland- Ireland and West Scotland
JNCC	Joint Nature Conservation Committee
MarPAMM	Marine Protected Area Management and Monitoring
MMF	Mean Maximum Foraging Range

OWF	Offshore Wind Farm
QA	Quality Assurance
RSPB	Royal Society for the Protection of Birds
SA	Site Attendance
SD	Standard Deviation
SMP	Seabird Monitoring Plan
SPA	Special Protection Area
SST	Sea Surface Temperature
WTG	Wind Turbine Generator

1 Introduction

1.1.1.1 This appendix outlines the offshore ornithology baseline characterisation for the Proposed Development (Offshore), located in the Moray Firth, Scotland. This includes the Caledonia Offshore Wind Farm (OWF) (i.e., Array Area) and the Caledonia Offshore Export Cable Corridor (OECC) seaward of Mean High-Water Springs (MHWS). The information included is a comprehensive account of the species that have been recorded in the site-specific data, as well as their abundances/densities, and spatiotemporal distribution.

1.1.1.2 The Proposed Development (Offshore) will be developed in two phases (see Volume 1, Chapter 5: Proposed Development Phasing), referred to as Caledonia North and Caledonia South. The Array Areas of the two phases are referred to as the Caledonia North Site and the Caledonia South Site. It is assumed that construction of the two application areas could be progressed in either order (e.g., Caledonia North constructed in the first phase, then Caledonia South in the second phase, or vice-versa) or at the same time. This has been assessed within a single Environmental Impact Assessment Report (EIAR) covering the Proposed Development (Offshore) as well as Caledonia North and Caledonia South alone.

1.1.1.3 The abundance and density estimates of all species recorded have been calculated by behaviour for the Caledonia OWF (which includes the Caledonia North Site and Caledonia South Site), as well as the Caledonia North Site and Caledonia South Site separately, in each case for the respective array area, the array area plus a 2km buffer and the array area plus a 4km buffer. All outputs are presented in full in the following annexes:

- Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South);
- Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South); and

- Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South).

1.1.1.4 This Technical Report presents the findings from a desk-based data review and site-based surveys, providing the information requested as part of the NatureScot (2023[1]) guidance. It provides baseline information on the seasonal distribution, density and abundance of seabirds based on:

- Existing reports, data and literature (Section 2); and
- Site-specific Digital Aerial Survey (DAS) data (Section 3).

1.1.1.5 The ornithological species, scientific names and corresponding taxonomic groupings used throughout this Technical Report, as well as the wider ornithological assessment of the Proposed Development (Offshore), are provided in Volume 7B, Appendix 6-1, Annex 10: Scientific Names and Taxonomic Groupings.

1.1.1.6 The species density and abundance estimates presented in this Technical Report underpin the assessment of any potential impacts from the Proposed Development (Offshore). The relevant density and abundance estimates used within the assessment are identified within Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates used as inputs into quantitative impact assessments.

1.1.1.7 Spatial distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

1.1.1.8 For MRSea data, methods for calculating abundance estimates are detailed within Volume 7B, Appendix 6-1, Annex 15: MRSea Method Statement. Distribution maps generated using MRSea are presented within Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report.

2 Desktop Study

2.1 Key Data Sources

2.1.1.1 Table 2–1 provides a summary of the available literature and data sources considered as part of an initial desk-based review. To note, the NatureScot Guidance Note 2 (NatureScot, 2023[1]) has been followed in the production of this Technical Report.

Table 2–1: Summary of key data sources.

Title	Author	Year
Existing OWF Data		
Moray East OWF Pre-construction Aerial Survey Report 2018	Moray Offshore Windfarm (East) Limited[2]	2018
Beatrice OWF Beatrice OWF Pre-Construction Aerial Survey Report	Beatrice Offshore Windfarm Ltd (BOWL)[3]	2015
Moray East OWF Environmental Statement	Moray Offshore Renewables Limited[4]	2011
Moray West OWF EIAR	Moray Offshore Windfarm (West) Limited[5]	2018
Beatrice OWF Environmental Statement	BOWL[6]	2012
Beatrice OWF Post-construction Monitoring Reports (Year 1 and Year 2)	MacArthur Green[7,8]	2021; 2023
Publicly Available Datasets		
Designated Sites (NatureScot SiteLink)	NatureScot[9]	Multiple
Seabird Monitoring Programme: Seabirds Count national colony census data	British Trust for Ornithology (BTO)[10]	Multiple
Seabird Tracking Data	BirdLife International[11]; plus other published tracking data	Multiple
Beatrice O&G Field Decommissioning EIA	Repsol Sinopec Resources UK Limited[12]	2018
Literature		
Potential impacts of offshore windfarms on birds	Peer reviewed scientific literature regarding the potential impacts from	Multiple

Title	Author	Year
	OWFs: e.g., Garthe and Hüppop (2004[13]); Drewitt and Langston (2006[14]); Stienen *et al.* (2007[15]); Speakman *et al.* (2009[16]); Langston (2010[17]); Band (2012[18]); Cook *et al.* (2012[19]); Furness and Wade (2012[20]); Wright *et al.* (2012[21]); Furness *et al.* (2013[22]); Johnston *et al.* (2014a[23]; 2014b[24]); Cook *et al.* (2014[25]; 2018[26]); Dierschke *et al.* (2017[27]); Jarrett *et al.* (2018[28]); Leopold and Verdaat (2018[29]); Mendel *et al.* (2019[30]); Goodale and Milman (2020[31]).	
Bird distribution at sea	Publicly available reports of seabird distribution: e.g., Stone *et al.* (1995[32]); Brown and Grice (2005[33]); Kober *et al.* (2010[34]); Bradbury *et al.* (2014[35]); HiDef Ltd. (2015[36]); Waggitt *et al.* (2019[37]); Cleasby *et al.* (2020[38]); Davies *et al.* (2021[39])	Multiple
Bird breeding ecology	Publicly available information on the breeding ecology of various bird species: e.g., Cramp and Simmons (1977-94[40]); Del Hoyo *et al.* (1992-2011[41]); Robinson (2005[42]).	Multiple
Bird population estimates and demographic rates	Publicly available reports/data on seabird populations and demographic rates for use in assessments: e.g., Horswill *et al.* (2017[43]); Mitchell *et al.* (2004[44]); BirdLife International (2004[45]); Holling *et al.* (2011[46]); Musgrove *et al.* (2013[47]); Furness (2015[48]); Frost *et al.* (2019[49]); JNCC (2020[50]).	Multiple
Bird migration and foraging movements	Publicly available reports of bird movements during breeding season foraging trips and migration: e.g., Wernham *et al.* (2002[51]); Thaxter *et al.* (2012[52]); Wright *et al.* (2012[21]); Wakefield *et al.* (2013[53]; 2017[54]); Furness *et al.* (2018[55]); Woodward *et al.* (2019[56]); Woodward *et al.* (2023[57]).	Multiple

2.2 Review of Additional Bird Data Relevant to the Baseline

2.2.1 Overview

2.2.1.1 In addition to the digital aerial surveys of the Caledonia OWF undertaken between April 2021 and March 2023, this section provides a review of additional bird data of relevance to the baseline characterisation. As the majority of additional data is now over five years old and the abundance of seabirds has likely changed since the data were collected, the following sections provide contextual information on the wider Moray Firth Zone to support the primary baseline data source.

2.2.2 Moray East OWF Boat-Based Surveys (2010 - 2012)

2.2.2.1 Site-specific boat-based surveys were undertaken as part of the baseline data collection for Moray East OWF between April 2010 and March 2012. The surveys were used to characterise the baseline ornithology to inform the Environmental Impact Assessment (EIA) (Moray Offshore Renewables Ltd, 2012[58]).

2.2.2.2 A total of 28 boat-based surveys were undertaken within the Moray Firth development zone (incorporating the Moray East OWF plus a buffer of approximately 4km). The data were collected using standard European Seabirds at Sea (ESAS) line transect methods (Tasker *et al*., 1984[59]). The transects were oriented from east to west, with strip widths of 300m. Snapshots for flying birds were undertaken at one minute time intervals.

2.2.2.3 A total of 77,713 birds in flight and 66,452 birds on sea were recorded in the survey area, with guillemot (17,379 in flight and 18,947 on sea), razorbill (3,687 in flight and 8,178 on sea; as well as 14,979 guillemot/razorbill in flight and 13,673 on sea), fulmar (15,913 in flight and 4,209 on sea), kittiwake (11,352 in flight and 8,146 on sea) and gannet (3,563 in flight and 1,105 on sea) the most abundant species recorded within the 24 months of surveys.

2.2.2.4 Additionally, GPS tagging of foraging birds was included in the Moray East OWF surveys, which produced distribution maps to determine potential overlap and hotspots within the proposed site. Of the species tagged (fulmar (17 retrieved); kittiwake (25 retrieved); guillemot (26 retrieved); razorbill (20 retrieved)) no species overlapped with the Caledonia OWF.

2.2.3 Moray East OWF Pre-Construction DAS (2018)

2.2.3.1 Pre-construction DAS were undertaken at Moray East OWF and a 10km buffer between May and July 2018 to update information on seabird distribution and abundance previously collected during the baseline surveys for the Moray East

OWF (see Section 2.2.2) and to provide a mid-breeding season DAS baseline dataset for comparison between construction and post-construction phase surveys (Moray Offshore Windfarm (East) Limited, 2018[2]).

2.2.3.2 Three surveys were carried out from May 2018 to July 2018. The transects were orientated perpendicular to the coastline in a south-east to north-west direction and were spaced 2.5km apart.

2.2.3.3 A total of 12,235 birds of >10 species were recorded across all surveys, with the most abundant species recorded similar to the baseline dataset (see Section 2.2.2). The most abundant species estimated (derived from design-based analysis) when combining the monthly estimates of birds on the water and in flight was guillemot (24,899). Thereafter guillemot/razorbill (20,092) was the second most abundant; followed by kittiwake (18,315), razorbill (5,790), herring gull (3,287), fulmar (3,172), gannet (2,880) and puffin (1,619).

2.2.3.4 Birds were largely distributed throughout the survey area during the 2018 surveys, with no persistent hotspots of records in the area to the east of the survey area, where the Caledonia OWF is located.

2.2.4 Moray West OWF DAS (2016 – 2017)

2.2.4.1 As part of the baseline data collection, 12 months of DAS data was collected for the Moray West OWF from April 2016 to March 2017. The transects were spaced 2.5km with a 4km buffer around the survey site, and were placed in a south-east to north-west direction (Moray Offshore Windfarm (West) Limited, 2018[5]).

2.2.4.2 Key species that were recorded in the Moray West survey areas were great black-backed gull, kittiwake, herring gull, auks and gannet.

2.2.5 Beatrice OWF Boat-Based Surveys (2009 - 2011)

2.2.5.1 Site-specific boat-based surveys were undertaken as part of the pre-application data collection for Beatrice OWF site between October 2009 and September 2011 (BOWL, 2012[6]).

2.2.5.2 The data was collected using standard ESAS methods (Tasker *et al.,* 1984[59]). A line-transect methodology was employed using transects placed in an east-west orientation spaced at 2km intervals, incorporating the proposed site plus a buffer of approximately 4km.

2.2.5.3 A total of 21,419 individuals were recorded across the 22 boat-based surveys, with >20 species recorded. Guillemot (total of 9,139) was the most abundant species, with kittiwake (total of 2,519), fulmar (total of 2,459), and 'unidentified auks' (total of 1,855) recorded as the key species in the surveys.

2.2.6 Beatrice OWF Pre-Construction DAS (2015)

2.2.6.1 Pre-construction DAS were conducted between May and August 2015 to update information on seabird distribution and abundance previously collected in the Moray Firth during the middle months of the breeding season (see Section 2.2.5) and to provide a baseline DAS dataset for comparison between construction and post-construction phase surveys (Beatrice Offshore Wind Farm Ltd, 2016[3]).

2.2.6.2 The surveys were carried out during the 2015 breeding season, with a total of six surveys undertaken. The transects were approximately perpendicular to the coast in a north-east to south-west direction, with 2.5km spacing between lines. The overall survey area was defined using a 10km buffer to the coast and 4km from the outer edge of the OWF.

2.2.6.3 The pre-construction DAS report outlines the results for seven main species recorded within the four-month survey period. Similar species to previous surveys (see Section 2.2.5) were recorded in the site.

2.2.6.4 According to design-based abundance estimates, guillemot (peak of 67,000 (July)) was the most abundant species recorded, with kittiwake (peak of 4,000 (June/July)), puffin (3,700 (August)), razorbill (peak of 4,000 (July)) and gannet (peak of 900 (July)) included in the most abundant species recorded within the surveys.

2.2.7 Beatrice OWF Post-Construction DAS (2019 - 2021)

2.2.7.1 The Beatrice OWF became fully operational in May 2019, since which two years of post-construction DAS have been undertaken to attempt to assess the potential impacts on seabirds (MacArthur Green, 2021[7]; 2023[8]). The surveys were undertaken in an identical manner to the 2015 DAS (see Section 2.2.6).

2.2.7.2 Following the construction/installation of all the turbines, the first six post-construction DAS were conducted in May to July 2019, with the second year of post-construction DAS run from May to August 2021.

2.2.7.3 Generally, the same key species were observed over the two years of post-construction surveys, and these were similar to the species recorded in the 2015 pre-construction DAS (see Section 2.2.6). The total raw counts from the six 2021 DAS surveys are presented below.

2.2.7.4 Guillemot (3,763 in flight and 47,402 on sea) and razorbill (461 in flight and 3,268 on sea) were the most abundant species with kittiwake (3,700 in flight and 2,960 on sea) also recorded in high abundance. Variation in abundance in the array area between years was recorded, with some seabirds increasing across the period and other peaking in the second post-construction survey. This report is important to highlight the potential impact, or lack of impact, of the presence of an operational OWF in the Moray Firth on seabirds.

2.2.8 BTO Tagging Study, Buchan Ness to Collieston Cliffs (2023)

2.2.8.1 The BTO carried out a tagging study at the Buchan Ness to Collieston Coast Special Protection Area (SPA) during the 2023 breeding season. A total of 50 guillemots and razorbills (25 of each species) were fitted with GPS tracking devices and time depth recorders, each collecting data for an average of four days. GPS tracking devices were also fitted to 12 kittiwakes, each collecting data for an average of six days. Full details of the study are presented in Johnston *et al.* (2024[60]).

2.2.8.2 The data collected were used to produce a range of outputs. These included utilisation distributions, split by behaviour, foraging trip metrics, and flight height distributions. The findings of this study are referred to in the species accounts in Section 5, and are also referred to in other areas of the assessment where they are considered to be relevant.

3 Caledonia OWF Digital Aerial Surveys

3.1 Overview of Survey Flights

3.1.1.1 A programme of 24 digital aerial surveys took place monthly between May 2021 and April 2023 inclusive (see Volume 7, Appendix 19: APEM 24 Monthly Digital Aerial Surveys). Surveys were conducted using APEM's bespoke camera system, termed "Shearwater IV", customised by in-house specialists for surveying the offshore environment.

3.1.1.2 The camera system is integrated with custom flight planning software that allows each survey transect to be accurately mapped out before the aircraft leaves the ground. Each image capture node is precisely defined, allowing the system to fire the camera exposures at exactly the right location. This ensures that each survey is flown with the same orientation and the camera is triggered at the same position within set tolerances. APEM's flight planning software enables tolerances along survey lines to be set, meaning the camera system would automatically abort data capture should the aircraft drift away from the planned flight line. APEM's on-board camera technician continually monitored the imagery as it was collected to ensure the data collected was fit for purpose. The camera technician would make the decision to cease data collection should the conditions become unsuitable for surveying and/or data collection. Subsequently, the survey would then be resumed at the next opportunity.

3.1.1.3 The digital aerial surveys captured images at 1.5cm ground sampling distance along 13 transect lines spaced approximately 2.6km apart within the Survey Area (Figure 3-1). The average flown altitude of the baseline surveys was between 441m and 453m, and no data was collected from below 400m. The Caledonia North Survey Area (including the Caledonia North Site) was covered by 11 transects, whilst the Caledonia South Survey Area (including the Caledonia South Site) was covered by 12 transects. The full details of the transects are presented in Table 3–1.

3.1.1.4 The transect lines orientation was planned based on a variety of factors, including the most efficient method to fly in terms of flying hours and the safest and most efficient method to fly based on the airspace and any obstacles in the area. Furthermore, orientation is determined through the environmental gradient which may affect the distribution and abundance of the surveyed species. The environmental gradient includes factors such as distance to coast and bathymetry. Finally, decisions were also made on other survey areas in the same location to avoid any conflict with other aircraft.

Table 3–1: Number of transects, survey line minimum/maximum lengths and total lengths of all survey lines in each reporting region within the Survey Area.

Region	Number of Transects	Minimum Transect Length (km)	Maximum Transect Length (km)	Total Length of Transects (km)
Caledonia OWF	9	4.52	30.68	163.39
Caledonia OWF plus 2km buffer	11	6.06	35.59	246.14
Caledonia OWF Survey Area	13	5.46	39.70	338.25
Caledonia North Site	7	3.07	18.13	83.48
Caledonia North Site plus 2km buffer	9	4.42	24.25	141.91
Caledonia North Survey Area	11	3.40	28.83	211.71
Caledonia South Site	8	4.61	12.55	80.39
Caledonia South Site plus 2km buffer	10	6.11	16.67	139.66
Caledonia South Survey Area	12	5.46	20.87	205.95

3.1.1.5 Imagery was captured in raw format and post-processed to ensure optimal quality for the subsequent stage of image analysis, to extract information on marine fauna or other notable occurrences. When a survey was completed, data were checked to ensure the number of lines and the number of images collected was correct, and that the quality of the imagery was acceptable. Once the image analysis was completed, further Quality Assurance (QA) processes took place (see Section 3.2.2).

3.1.1.6 The dates, number of flights needed to survey all transects (due to weather or technical issue), on task start and end times, are provided for each digital aerial survey in Table 3–2 with the corresponding weather conditions provided in Table 3–3.

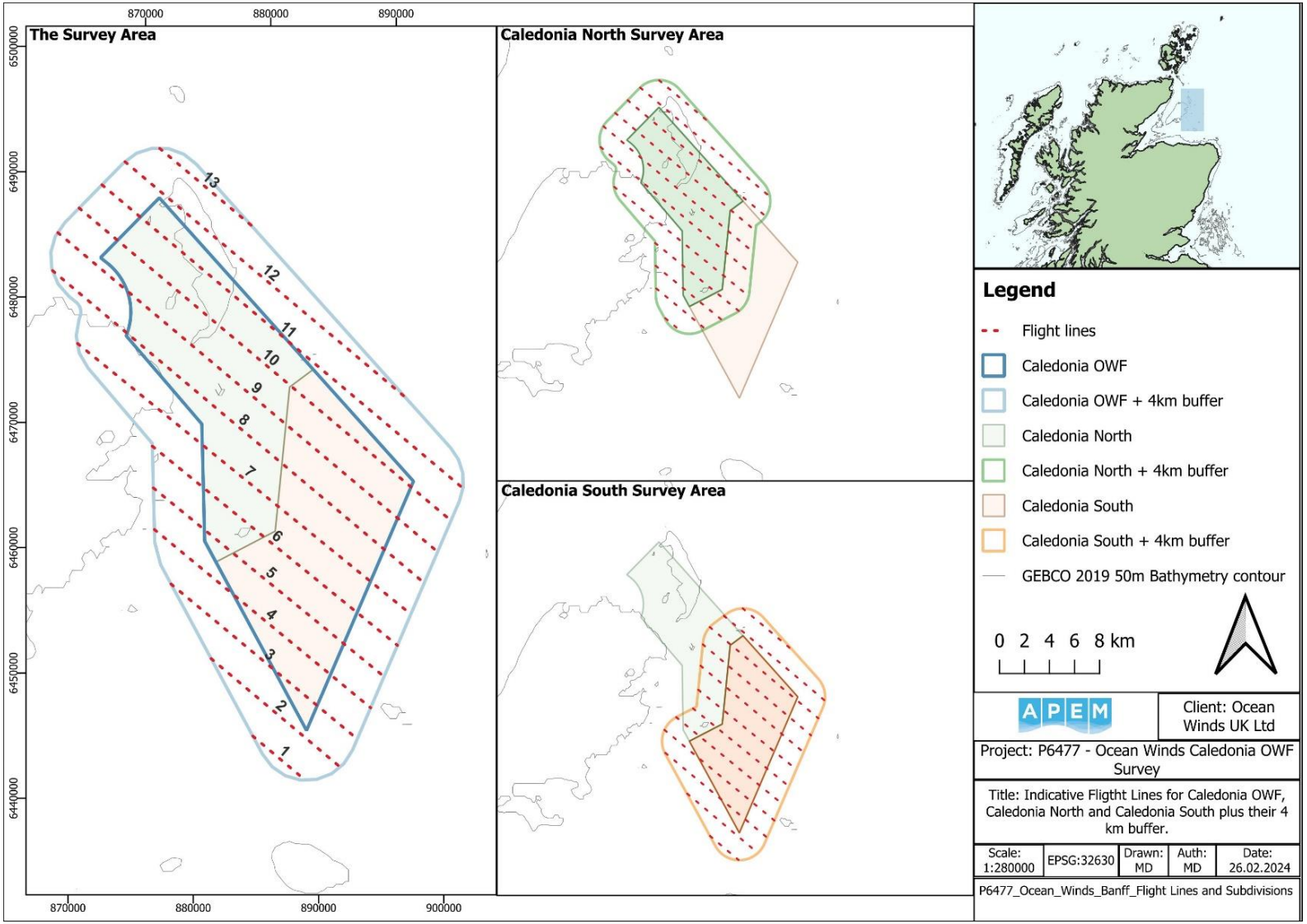


Figure 3-1: The Caledonia OWF, Caledonia North Site and Caledonia South Site plus 4km buffers with indicative flight lines (Source: see Volume 7, Appendix 19).

Table 3–2: Survey date, flight number and start/end time (Coordinated Universal Time) of each survey flight during May 2021 to April 2023 survey period.

Survey No.	Date	Flight Number	UTC Start Time (HH:MM)	UTC End Time (HH:MM)
1[1]	15-May-21	1	11:55	14:00
2[1]	10-Jun-21	1	15:56	18:11
3[1]	2-Jul-21	1	09:21	11:18
4[1]	1-Aug-21	1	17:41	19:48
5[1]	14-Sep-21[2]	1	09:43	11:50
6[1]	4-Oct-21	1	08:50	10:52
7	15-Nov-21	1	10:34	12:38
8	6-Dec-21	2[3]	13:04	14:21
9	9-Jan-22	1	10:22	12:19
10	13-Feb-22	1	11:16	13:18
11	2-Mar-22	1	09:34	11:36
12[1]	26-Apr-22	1	09:36	12:37
13[1]	14-May-22	1	10:41	12:40
14[1]	4-June-22	1	14:02	16:17
15[1]	5-July-22	1	15:57	18:05
16[1]	10-August-22	1	08:46	11:58
17[1]	11-Sep-22	1	09:01	11:02
18[1]	14-Oct-22	1	09:22	11:22
19	25-Nov-22	1	09:37	11:35
20	17-Dec-22	1	10:37	12:42
21	9-Jan-23[4]	2	09:40	11:54
22	13-Feb-23	1	11:49	14:30
23	10-Mar-23	1	14:41	16:50
24[1]	04-Apr-23	1	08:57	10:57

Survey No.	Date	Flight Number	UTC Start Time (HH:MM)	UTC End Time (HH:MM)

[1] UTC time is identical to GMT (for example, surveys 7 to 11), but for surveys undertaken during BST (for example, surveys 1 to 6, and 12), differs from UK time by -1 hour.

[2] Survey 13 September 2021 aborted due to aircraft issue and re-flown on the 14th of September.

[3] Survey 06 December 2021 was flown by two aircraft. The start time correspond to the time the first aircraft started recording and the end time correspond to the time the second aircraft finished recording.

[4] Survey 07 January 2023 aborted due to rain and re-flown on 09 January.

Table 3–3: Weather conditions recorded during each survey flight during the May 2021 to April 2023 survey period.

Survey No.	Date	Douglas Sea State[1]	Turbidity[2]	Wind Speed (knots) / direction	Cloud Cover (%)[3]	Visibility (km)	Air Temp (°C)
1	15-May-21	1	1	3-13 / N-NNE	100	10+	5
2	10-Jun-21	2	0	21-29 / W	100	10+	18
3	2-Jul-21	1	1	5 / N	90	10+	10
4	1-Aug-21	2	0	15-18 / NNW	99	20+	8
5	14-Sep-21	3	2	5-10 / SSE	30-45	10+	12
6	4-Oct-21	2-3	1	14-22 / SW	20-30	10+	9
7	15-Nov-21	1	1	8-15 / W	20	10+	7-8
8	6-Dec-21	2	1-2	12-20 / S	100	30+	3
9	9-Jan-22	0	0	3-9 / S-W	5	30+	4
10	13-Feb-22	2	1	6-8 / W-SW	60-90	10+	5
11	2-Mar-22	2-4	1	24-29 / SE	10-40	10+	2-3
12	26-Apr-22	1	2	9-20 / NE-NNE	75	10+	4
13	14-May-22	2	2	18 / W	100	10+	9
14	4-June-22	2	2	6-10 / N	0	10+	13

Survey No.	Date	Douglas Sea State[1]	Turbidity[2]	Wind Speed (knots) / direction	Cloud Cover (%)[3]	Visibility (km)	Air Temp (°C)
15	5-July-22	3	3	3-7 / W- SE	35	20+	11
16	10-Aug-22	0.5 – 1.5	0.5 - 1	17 – 31 / SW	0-100	40+	18
17	11-Sep-22	2 - 3	0	13 – 18 / S	20 - 60	10+	13
18	14-Oct-22	3	2	18 / W - SW	10	10+	8
19	25-Nov-22	3	2	23 – 34 / S	10 - 80	20 - 30	7 - 8
20	17-Dec-22	3	2	22 – 29 / SW - W	80 - 95	20	3
21	9-Jan-23	1	1	19 / W	20	10+	5
22	13-Feb-23	1	1	7 – 13 / S - W	10	10+	6 - 7
23	10-Mar-23	1 – 2	0	5 – 26 / SW -W	50 - 70	10+	0
24	4-Apr-23	1-2	0	15 - 17 / SW	80 - 100	10+	6-7

[1] 0 = Calm (Glassy), 1 = Calm (Rippled), 2 = Smooth, 3 = Slightly Moderate, 4 = Moderate

[2] 0 = Clear, 1 = Slightly Turbid, 2 = Moderately Turbid, 3 = Highly Turbid

[3] 0 = Clear, 1-10 = Few, 11-50 = Scattered, 51-95 = Broken, 96-100 = Overcast

3.1.1.7 Weather conditions during all surveys were conducive to collecting and analysing imagery for the purpose of providing data on the identification, distribution and abundance of bird species and marine fauna within the Survey Area. Favourable conditions for surveying are defined as a cloud base of at least 1,300ft, visibility of >5km, wind speed of <30 knots, and sea state of 4 (moderate) or less. For safety reasons, no surveying took place in icy conditions.

3.1.1.8 Measures were taken to minimise glint and glare, such as avoiding surveying when the sun angle has the greatest potential to impact image quality. Furthermore, additional imagery was collected through the survey, providing an alternative set of images for analysis to ensure that sufficient coverage is achieved in the case that imagery was affected strongly by glint or glare. The number of image nodes clipped to the Survey Area, coverage collected per survey, and the coverage analysed per site and site plus a 4km buffer are presented in Table 3–4. It should be noted the footprint areas covered during the May 2021 to April 2023 survey period and raw data can be provided upon request.

Table 3–4: Number of images and survey coverage collected for each monthly survey across the Survey Area and analysed coverage per region during the May 2021 to April 2023 survey period.

Survey No.	No. Image Nodes	Survey coverage (%)	Coverage Analysed (%)					
			Caledonia OWF	Caledonia OWF Survey Area	Caledonia North Site	Caledonia North Survey Area	Caledonia South Site	Caledonia South Survey Area
1	2385	25.49	17.14	17.39	17.15	17.07	17.16	17.22
2	2384	25.48	17.02	17.23	16.92	16.89	17.18	17.19
3	2323	24.85	16.94	17.25	16.89	16.50	17.04	16.64
4	2383	25.47	17.26	17.51	17.26	17.21	17.31	17.37
5	2384	25.48	17.22	17.40	17.26	17.11	17.23	17.21
6	2481	26.52	17.08	17.34	17.14	17.10	17.06	17.21
7	2383	25.47	17.20	17.47	17.11	17.11	17.35	17.38
8	2383	25.47	17.22	17.45	17.26	17.16	17.22	17.28
9	2385	25.49	17.27	17.49	17.29	17.26	17.29	17.34
10	2372	25.35	18.50	18.64	18.57	18.16	18.46	18.41
11	2384	25.48	18.67	18.82	18.78	18.50	18.62	18.60
12	2384	25.43	17.36	17.62	17.41	17.36	17.35	17.43
13	2387	25.51	17.25	17.47	17.23	17.19	17.30	17.39
14	2385	25.49	17.39	17.44	17.56	17.29	17.25	17.25

Survey No.	No. Image Nodes	Survey coverage (%)	Coverage Analysed (%)					
			Caledonia OWF	Caledonia OWF Survey Area	Caledonia North Site	Caledonia North Survey Area	Caledonia South Site	Caledonia South Survey Area
15	2387	25.51	17.08	17.35	17.08	17.07	17.13	17.26
16	2382	25.43	17.33	17.47	17.34	17.45	17.37	17.43
17	2383	25.44	17.27	17.31	17.43	17.16	17.14	17.12
18	2388	25.47	17.12	17.15	17.27	17.02	17.00	17.01
19	2385	25.52	16.99	17.24	16.96	16.94	17.06	17.08
20	2384	25.49	17.07	17.12	17.21	16.95	16.96	16.96
21	2382	25.48	17.16	17.19	17.28	16.95	17.08	17.08
22	2376	25.39	17.40	17.49	17.35	17.30	17.50	17.32
23	2386	25.50	17.13	17.26	17.06	17.01	17.24	17.15
24	2384	25.48	17.63	17.62	17.73	17.44	17.57	17.46

3.2 Methodology

3.2.1 Species Identification

3.2.1.1 There are occasions when it is not possible to identify an individual in the digital aerial survey image to the species level and the individual is identified as belonging to a higher-level group (for example, 'small gulls'). The possible groups and the individual species that are included in the groups are listed in Table 3–5.

Table 3–5: Individual and group level of bird species included in 'unidentified' groups during the May 2021 to April 2023 survey period.

Species Level 1	Group Level 2	Group Level 3	Group Level 4	Group Level 5
Great northern diver	Diver species			
Red-throated diver				
Kittiwake	Small gulls		Gull species	Fulmar/Gull species
Common Gull				
Great Black-backed Gull	Black-backed gulls	Large gulls		
Lesser Black-backed Gull				
Herring Gull				
Fulmar				
Common tern	'Commic' tern		Tern species	
Arctic tern				
Guillemot	Guillemot/ Razorbill	Auk species		Auk/Shearwater species
Razorbill				
Black guillemot				
Puffin				
Sooty shearwater		Large shearwater species	Shearwater species	
Manx shearwater				

3.2.1.2 The images were analysed to enumerate birds to species level, where possible. Targets identified from the images were 'snagged' (i.e., located within the images) and categorised. Yearly identification rates of species specific to Caledonia OWF surveys are presented in Table 3–6. Unidentified bird species have not been included in the ID rate calculations due to the low number observed during the survey period (n=32 in year 1; n=36 in year 2) and the broadness of the grouping. Identification rate of an individual to the species level, from May 2021 to April 2023, specific to the Caledonia OWF project, are presented hereafter (Table 3–6).

3.2.1.3 The ID rates were calculated (per month or per year) from the total raw counts of species and each related group level observation in the Caledonia OWF. The total sum of all species and related group levels were then calculated. Each total raw counts of the species and related groups is divided by the total sum of the whole species/group and multiplied by 100. For instance, for guillemot in Caledonia OWF year 2 the raw count was 12.132 and the group total was 13.478 with an ID% of (12.132/13.478) *100=90%.

3.2.1.4 In year 1, great skua, great northern diver, fulmar, gannet, positively identified to species level and do not form part of the higher-level groupings. In year 2, pink-footed goose, great skua, Arctic skua, red-throated diver and gannet were all positively identified to species level and do not form part of the higher-level groupings.

3.2.1.5 The species identification table represents a simple calculation of the proportion of each species recorded in the survey dataset. This approach provides a comparison of species frequencies without accounting for potential bias related to species rarity. It is important to acknowledge that less common species may appear to have lower identification percentages simply because they were less frequently captured in the imagery. This does not necessarily reflect a true identification rate but rather their relative abundance within the sampled population.

Table 3–6: Yearly average of identification rate of species recorded to species level from a higher taxonomic grouping, within the Survey Area during the May 2021 to April 2023 survey period.

Species Common Name	ID Species Level 1 (%) – Year 1: May 21 to April 22	ID Species Level 1 (%) – Year 2: May 22 to Apr 23
Pink-footed goose	-	100%
Mallard	100%	-
Kittiwake	99.8%	99.8%
Common gull	64.3%	36.4%
Great black-backed gull	92.1%	94.3%
Herring gull	61.9%	83.9%
Lesser black-backed gull	8.1%	50%
Common tern	37.5%	-
Arctic tern	64.3%	42.9%
Great skua	100%	100%
Arctic skua	-	100%
Guillemot	78.4%	90%
Razorbill	31.3%	53.8%
Black guillemot	0.1%	0.1%
Puffin	76.5%	81.1%
Great northern diver	100%	-
Red-throated diver	-	100%
Fulmar	100%	99.9%
Sooty shearwater	2.5%	-
Manx shearwater	32.8%	8.5%
Gannet	100%	100%

Summary of Quality Assurance

3.2.2 Overview

3.2.2.1 Internal QA was carried out on the data collected from each of the surveys. Each image containing birds was reviewed and checked by APEM's dedicated QA Manager, ensuring that 100% of birds and marine mammals found were subject to internal QA to ensure that species identification was correct. Images containing no birds were removed and kept separately for further internal QA. Of these 'blank' images, 10% were randomly selected for QA. If there was less than 90% agreement, the entire batch was re-analysed independently by a different staff member than who initially analysed the imagery.

3.2.2.2 The '90% agreement' relates to 'missed' targets in images deemed 'blank' during original analysis, and is not related to target (species) identification. All target identifications made by analysts are reviewed by the QA team and all judgement on identifications is evidenced-based with respect to survey conditions/quality variations. All identifications have been checked to ensure they a representative for a given bird/target meaning any agreement between original ID and reviewer ID could be at either species level or a higher grouping.

3.2.3 Bird Abundance and Density Estimation

3.2.3.1 For each monthly digital aerial survey of the Survey Area, geo-referenced locations of birds or marine mammals contained within each individual digital still image were used to generate raw counts. Individual locations contained within the Survey Area were then extracted using QGIS, providing raw count data. These data are presented for all species recorded in Volume 7, Appendix 19: APEM 24 Monthly Digital Aerial Surveys. It should be noted that the raw data can be provided upon request.

3.2.3.2 The raw counts were divided by the number of images collected to give the mean number of animals per image (i). Population estimates (N) for each survey month were then generated by multiplying the mean number of animals per image by the total number of images required to cover the entire study area (A), calculated by the total area of the survey area divided by the average size of the collected images:

$$N = i\,A$$

3.2.3.3 Non-parametric bootstrap methods were used for variance estimation. A variability statistic was generated by re-sampling 999 times with replacement from the raw count data. The statistic was evaluated from each of these 999 bootstrap samples and upper and lower 95% confidence intervals of these 999 values were taken as the variability of the statistic over the population (Efron and Tibshirani, 1993[61]).

3.2.3.4 Autocorrelation is accounted for in the design-based estimates by treating transects as the independent sampling unit. This allows for the presence of autocorrelation between observations within a transect, but assumes that transects are independent from one another. This is a common assumption when assessing survey data and is justified by the substantial distance between transects.

3.2.3.5 999 bootstrap samples was selected as it provides a balance between computational cost and accuracy, and was deemed conservative as it far exceeds sample numbers, which have been shown to result in good estimates for the coefficient of variation (p.53, Efron and Tibshirani, 1994[61]). To confirm that this was sufficient, histograms of bootstrap estimates were examined to ensure the re-sampled abundance estimates followed expected normal distributions (or log-normal for species with low counts). In all cases, histograms showed good agreement with the expected distributions and there was no evidence that additional bootstrap samples were needed.

3.2.3.6 Measures of precision were calculated using a Poisson precision for the abundance estimates. This produced a CV (Coefficient of Variation) based on the relationship of the standard error to the mean (Thomas *et al*., 2010[62]). A target precision of ≤0.16 allows the detection of a population change of a factor as small as two (Bohlin, 1990[63]).

3.2.3.7 In different settings CV can be defined as either the ratio of the standard deviation to the mean, which is an estimate of variability (e.g., Snedecor and Cochran, 1967[64]; Howell, 1992[65]), or as the ratio of the standard error to the mean, which is an estimate of precision in a given estimate (e.g., Elliott, 1977[66]). As the primary objective here is to determine whether the sampling regime was sufficient to estimate the population mean with a given level of precision, the later of the two CV definitions is most appropriate. CV has been defined here as CV = SE/mean, following the precedent set by Bohlin *et al*. (1989[67]; 1990[63]) and other visual survey methodologies (Buckland *et al*., 1993[68]).

3.2.3.8 All analysis and data manipulation carried out by APEM was conducted in the R programming language (R Development Core Team, 2021[69]) and non-parametric 95% confidence intervals were generated using the 'boot' library function (Canty and Ripley, 2022[70]). This results in species-specific monthly abundance estimates being calculated from the raw count data, with upper and lower 95% confidence limits (Lower and Upper Confidence Limits, [LCL; UCL]). Where appropriate, a level of precision is also presented for each monthly abundance estimate. Dividing the monthly abundance estimates by the size of the Survey Area (Table 3–7) calculates the density (birds/km^2) for any given species. Abundance and density estimates presented in this Technical Report were calculated from the total raw count of individuals per species, recorded on a given month, regardless of the recorded behaviour (with the exception of deceased individuals, which were removed from the analysis, though these records are reported in Section 4.2).

3.2.3.9 For MRSea data, methods for calculating abundance estimates are detailed within Volume 7B, Appendix 6-1, Annex 15: MRSea Method Statement.

Table 3–7: Survey area by site.

Site	Survey Area Plus 4km Buffer (km^2)
Caledonia North (includes buffer overlap with the Caledonia South Site)	557
Caledonia South (includes buffer overlap with Caledonia North Site)	534
Caledonia OWF	884

Apportioning of Unidentified Birds

3.2.3.10 Although the majority of individuals recorded from the surveys are identified to species level, a number remained identified to group level only. The abundance estimates with confidence limits within Volume 7, Appendix 19: APEM 24 Monthly Digital Aerial Surveys include attribution of unidentified individuals into the monthly abundance estimates and densities to account for these unidentified individuals. This is based on an apportionment of the group level identified individuals between those species within that group that were identified to species level within each individual monthly abundance estimate.

3.2.3.11 The number of unidentified individuals in a group is proportioned to the specific species that are contained within that group, based on the relative abundance of the positively identified species in that month's survey. Following the same methodology, confidence limits were also apportioned. For example, in the case of kittiwake, the count consists of:

Positively identified kittiwake + proportion of group level identified small gulls estimated to be kittiwake calculated from positively identified small gull species.

3.2.3.12 For instance, if 10 'small gull species' are recorded in June, and 20 kittiwake and 20 common gulls are also recorded in June, the apportioning calculation will estimate that birds identified in June as 'small gull species are likely to consist of five kittiwake and five common gulls.

3.2.3.13 In the 24 months surveys for the Caledonia OWF Survey Area, the individuals identified to group level contained within the dataset were:

- Wader species;
- Black-backed gull species;
- Large gull species;
- Gull species;
- 'Commic' tern;

- Tern species;
- Guillemot/razorbill;
- Auk species;
- Fulmar/gull species;
- Small shearwater species;
- Shearwater species;
- Auk/shearwater species;
- Thrush species;
- Passerine species; and
- Bird species.

3.2.3.14 Where no species-specific identification for common tern and Arctic tern is possible (size and plumage features are so similar that it is often difficult to separate them), they remain in the data as 'commic' tern. As a wide-ranging group, unidentified bird species counts (<0.01% of the total of birds recorded across the two years in the Survey Area, n = 54) do not undergo apportionment.

3.2.3.15 The apportioned abundance and density estimates of all species recorded (as well as raw counts of unidentified species) have been calculated for the Caledonia OWF, as well as Caledonia North and Caledonia South, in each case for the respective array area, the array area plus a 2km buffer and the array area plus a 4km buffer. All outputs are presented in full in the following annexes:

- Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South);
- Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South); and

- Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South).

3.2.3.16 The relevant density and abundance estimates used within the assessment are identified within Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates used as inputs into quantitative impact assessments.

3.2.3.17 In a given month, instances may have occurred when there were individuals only identified to group level rather than positively identified to species level. In such cases, apportionment of species abundance was undertaken, whereby individuals identified to group level were divided and assigned to month across the data, following a hierarchical approach using:

- Same month, same year, same area (site or buffer only);
- Same month, same year, same survey area (site and buffer);
- Same month, same year, same survey area, larger buffer (if available);
- Same bio-season/season, same year, same area (site or buffer only);
- Same bio-season, same year, same survey area (site and buffer);
- Same bio-season, same year, same survey area, larger buffer (If available);
- Same month, different year, same area (site or buffer only);
- Same month, different year, same survey area (site and buffer);
- Same month, different year, same survey area, larger buffer (if available);
- Same bio-season/season, different year, same area (site or buffer only);
- Same bio-season/season, different year, same survey area (site and buffer); and
- Same bio-season/season, different year, same survey area, larger buffer (if available).

3.2.3.18 Bar plot diagrams created for key species (kittiwake, great black-backed gull, herring gull, great skuas, guillemot, razorbill, puffin, gannet) were created using apportioned abundance estimates in the R programming language (R Development Core Team, 2021[69]). Breeding and non-breeding seasons were also highlighted on the diagrams as per NatureScot (2020[71]).

Availability Bias

3.2.3.19 Diving birds, such as guillemot and razorbill, spend time foraging beneath the water surface. As a result of this, an unknown number of birds may go undetected due to the snapshot nature of aerial survey techniques (i.e., they are underwater, and therefore unavailable to be counted by the survey aircraft as it passes overhead). To account for this 'availability bias', a correction factor must be applied. This factor is applied to birds recorded on

the sea only; birds in flight are assumed to be 100% available for detection and are therefore not included in these calculations.

3.2.3.20 The correction factors applied to guillemot and razorbill were based on that recommended by JNCC in a submission during the examination phase of the East Anglia ONE OWF, referred to by JNCC as Method C (JNCC, 2013[72]). This applies a correction factor, on the basis of aerial surveys recording 76% of sitting guillemot and 83% of sitting razorbill, which assumes 24% and 17% of these species, respectively, will be underwater when aerial imagery is captured. The correction factor for puffin assumes 14% to be underwater at any time (Spencer, 2012)[73]. Therefore, to correct for availability bias the 'unavailable' birds are added to the bird totals on a monthly basis to create revised population estimates. The 'corrected' abundance estimates for guillemot and razorbill are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South); and
- Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South).

3.2.4 Consideration of Biological Seasons

3.2.4.1 During the breeding season birds are strongly associated with their nesting sites, engaging in in nesting, egg-laying and provisioning young. Outside of the breeding season (i.e., during the non-breeding season), birds are more widely distributed and their association with their breeding colonies diminishes. The non-breeding season encompasses the brief "breeding site attendance" period defined for some species in the NatureScot (2020[1]) guidance.

3.2.4.2 The defined breeding and non-breeding seasons for all species were derived from the NatureScot (2020[1]) (see Table 3–8).

3.2.4.3 For kittiwake, razorbill and gannet, further subdivisions of the non-breeding season were undertaken in addition to the use of the NatureScot seasons. These were based on the biologically relevant seasons presented in Furness (2015[48]) (see Table 3-9). The subdivisions of the defined seasons, presented in Table 3–9, have been agreed with NatureScot in consultation.

Table 3–8: Defined seasons in the Scottish Marine Environment used in the assessment for key species (NatureScot, 2020[71]).

Species	Breeding Season	Post-breeding Migration Season	Non-breeding Season	Pre-breeding Migration Season
Kittiwake	**Mid-April to August**	-	**September to early April**	Early April
Guillemot	**April to mid-August**	Late-August to mid-October (flightless moult August to mid-October)	**Late August to March**	February to March
Razorbill	**April to mid-August**	Late-August to November (flightless moult August to November)	**Late August to March**	March
Puffin	**April to Mid-August**	Late August	**Late August to March**	Late March (flightless moult February to mid-March)
Gannet	**Mid-March to September**	-	**October to early March**	Mid-February to early-March
Herring gull	**April to August**	-	**September to March**	March
Great Skua	**Mid-April to Mid-September**	-	**Mid-September to Mid-April**	Early April
Great black-backed gull	**April to August**	-	**September to March**	March
Fulmar	**April to Mid-September**	-	**Mid-September to March**	-
Time periods in **bold** are those used by the assessment.				

Table 3–9: Non-breeding season BDMPS periods based on Furness (2015[48]) used in the apportionment of key species to specific populations.

Species	Autumn Migration	Winter Period	Spring Migration	Non-breeding
Kittiwake	**September to December** (August to December)	-	**January to mid-April** (January to April)	-
Guillemot	-	-	-	**Late-August to March** (August to February)
Razorbill	**Late-August to October** (August to October)	**November to December**	**January to March**	-
Puffin	-	-	-	**Late-August to March**
Gannet	**October to November** (September to October)	-	**December to mid-March** (December to March)	**-**
Great skua	**Mid-April to Mid-September**	**Mid-September to October**		**Mid-April to Mid-September**
Fulmar	**Mid-September to Octobe**r (September to October)	**November**	**December to March**	-

Species and seasonal definitions used for additional assessment are in **bold**. Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 3–8), with the original definitions as per Furness (2015[48]) provided in parentheses where different.

3.2.5 Calculation of Mean Seasonal Peaks

3.2.5.1 Mean seasonal peak population estimates, including both birds in flight and on the sea (corrected for availability bias), were calculated for each species in each defined season. This was calculated through averaging the Year 1 and Year 2 peak abundance for each defined season. It is noted that the collection of DAS data started in May 2021. As per the NatureScot (2020[71]) Seasonal Definition Guidance, the majority of species-specific breeding seasons begin in April (or end of March for gannet). When calculating the mean seasonal peaks for the distributional assessment, the survey in April 2023 has been combined with the Year 1 data in order to align with the defined breeding seasons. This approach provides two full years' worth of data covering the biologically relevant seasonal periods.

3.2.5.2 Surveys were generally assigned to a season based on the day of the month that the survey was flown. For seasons starting or ending halfway through the month, the 15th/16th was used as a mid-month cut off. This was necessary to avoid the same monthly estimate potentially being used in both the breeding and non - breeding season.

3.2.5.3 Mean seasonal peaks are required for relevant species for displacement modelling and assessment. The Caledonia OWF, Caledonia North and Caledonia South are reported separately in Volume 7B, Appendix 6-2: Offshore Ornithology Distributional Responses Technical Report (with full results provided in the associated annexes).

4 Results

4.1 Overview

4.1.1.1 The total number of birds observed (density and abundance estimates) across the 24 surveys in the Caledonia OWF, Caledonia North and Caledonia South, are provided in the following annexes:

- Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF);
- Volume 7B, Appendix 6-2, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North); and
- Volume 7B, Appendix 6-2, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South).

4.1.1.2 Additionally, the following annexes have been provided detailing the abundance and density estimates of birds in flight and birds on sea:

- Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South); and
- Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South).

4.1.1.3 The relevant density and abundance estimates used within the assessment are identified within Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates used as inputs into quantitative impact assessments.

4.1.1.4 The following species have been discussed in further detail in the species account sections below:

- Kittiwake;
- Great black-backed gull;
- Herring gull;
- Lesser black-backed gull;
- Great skua;
- Guillemot;

- Razorbill;
- Puffin;
- Red-throated diver;
- Fulmar; and
- Gannet

4.1.1.5 An additional eight species were observed across the 24 surveys in the Caledonia OWF, Caledonia North and Caledonia South. These species density and abundance estimates are documented in the annexes above. However, the following species were recorded insufficiently or in low abundance and are therefore not discussed in further detail in this Technical Report:

- Pink-footed goose;
- Mallard;
- Common gull;
- Arctic tern;
- Black guillemot;
- Great northern diver;
- Sooty shearwater; and
- Manx shearwater.

4.2 Deceased Individuals

4.2.1.1 Within the Caledonia OWF (plus a 4km buffer), 91 deceased birds were recorded in total across all baseline surveys. They were recorded in the May to July and September to October 2021, April to September and December 2022 surveys (Table 4–1).

4.2.1.2 Whilst it is not uncommon for small numbers of records of deceased birds to be made during surveys of this nature, it is noteworthy that higher numbers of deceased gannet were recorded in the June 2022 and July 2022 surveys (Table 4–1). It is reasonable to assume that many of these records would have been associated with the outbreak of Highly Pathogenic Avian Influenza (HPAI) reported across many colonies during the 2022 breeding season.

Table 4–1: Raw counts of deceased bird species recorded within the Survey Area during the May 2021 to April 2023 survey period.

Survey	Common Gull	Herring Gull	Gull Species	Guillemot/ Razorbill	Fulmar	Gannet	Unidentified Bird Species	Total
May-21	-	-	1	-	-	-	-	1
Jun-21	-	1	-	-	-	-	1	2
Jul-21	-	-	-	-	-	1	-	1
Sep-21	-	-	-	2	-	2	1	5
Oct-21	-	-	-	2	-	-	-	2
Apr-22	-	-	-	1	-	-	2	3
May-22	1	-	-	1	3	1	4	10
Jun-22	-	-	-	-	-	9	1	10
Jul-22	-	-	-	2	3	38	4	47
Aug-22	-	-	1	-	1	1	5	8
Sep-22	-	-	-	-	-	1	-	1
Dec-22	-	-	-	-	-	1	-	1

4.3 Abundance Estimates

4.3.1 Collision Risk

4.3.1.1 Methods for calculating abundance estimates using MRSea data are detailed within Volume 7B, Appendix 6-1, Annex 15: MRSea Method Statement. For MRSea data, the median was chosen as a more representative measure of central tendency. Therefore, an SD is not available for model-based estimates for inclusion within stochastic collision risk modelling. As such, design-based estimates would be used for collision risk modelling to conform with NatureScot guidance for collision risk modelling. This approach was presented to NatureScot and agreed with NatureScot within an email dated an email dated 07 August 2024.

4.3.2 Distributional Responses

4.3.2.1 The distributional responses assessment has been run using the design-based and/or the model-based density estimates (as outlined within Table 4-2 below). This approach varied by species depending on the amount of data and whether MRSea was able to run:

- For guillemot, MRSea could be run for all surveys, as such, MRSea values have been used within assessments for displacement;
- For puffin, razorbill and kittiwake MRSea could be run for all surveys within the breeding season, as such, MRSea values have been used within assessments for displacement during the breeding season. Within the non-breeding season, there are a significant number of gaps within the MRSea data due to zero counts and low numbers, as such, design-based abundance estimates have been used within assessments for displacement during the non-breeding season; and
- For gannet, there are a significant number of gaps within the MRSea data due to zero counts and low numbers, as such, design-based abundance estimates have been used within assessments for displacement during both the breeding and non-breeding season.

4.3.2.2 This approach was presented to NatureScot (01 July 2024) and agreed with NatureScot within in an email dated 07 August 2024. Comparisons between MRSea and design-based estimates are presented within Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates. This appendix also clearly shows which figures have been taken through to assessment. In addition, distribution maps generated using MRSea are presented within Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report.

Table 4–2: Approach taken within assessments regarding design-based and model-based/MRSea abundance estimates for displacement.

Species	Behaviour	Number of Surveys Total		Number of Surveys MRSea Data		Recommendation	
		Breeding Season	Non-breeding Season	Breeding Season	Non-breeding Season	Breeding Season	Non-breeding Season
Guillemot	All	10	14	10	14	MRSea	MRSea
Razorbill	All	10	14	10	7	MRSea	Design-based
Puffin	All	9 or 10	14 or 15	8 or 9	3 or 4	MRSea	Design-based
Gannet	All	14	10	8	2	Design-based	Design-based
Kittiwake	All	10	14	10	7	MRSea	Design-based

5 Species Accounts

5.1 Laridae

5.1.1 Kittiwake

Defined Seasons

5.1.1.1 Kittiwake seasonal definitions are presented in Table 5–1 as per the NatureScot (2020[71]) guidance. Separate BDMPS seasons have been provided as per Furness (2015[48]) (Table 5–2).

Table 5–1: Defined seasons in the Scottish Marine Environment used in the assessment for kittiwake (NatureScot, 2020[71]).

Breeding Season	Non-breeding Season	Pre-breeding Migration Season
Mid-April to August	**September to Early April**	Early April
Time periods in **bold** are those used by the assessment.		

Table 5–2: Non-breeding season BDMPS periods based on Furness (2015[48]) used in the apportionment of kittiwake to specific populations.

Autumn	Winter Period	Spring
September to December (August to December)	-	**January to Mid-April** (January to April)
Seasonal definitions used for additional assessment are in **bold**. Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–1), with the original definitions as per Furness (2015[48]) provided in parentheses where different.		

Overview

5.1.1.2 Kittiwake are small (38-40 cm long) surface feeding gulls (Coulson, 2011[74]; Del Hoyo *et al*., 1996[41]) which form large colonies during the breeding season and disperse offshore for the non-breeding season (Coulson, 2011[74]; Waggitt *et al*., 2019[37]).

5.1.1.3 During the breeding season, breeding birds can travel widely to forage, with a mean maximum foraging range ± standard deviation (MMF±SD) of 156 ±114.5km (Woodward *et al.,* 2019[56]), though typical foraging ranges can be considerably shorter or longer depending on a range of factors. For example, recent tracking data of 287 foraging trips recorded from 12 tagged kittiwakes

breeding within the Buchan Ness to Collieston Coast SPA in 2023 were used to estimate a MMF±SD of 38.14±12.09km (Johnston *et al.,* 2024[60]).

5.1.1.4 Kittiwake predominantly feed on energy rich prey such as sandeel (*Ammodytes* sp.), sprat (*Sprattus sprattus*) and juvenile herring (*Clupea harengus*) during the breeding season (Lewis *et al.,* 2001[75]; Bull *et al*., 2004[76]). As surface feeders, these birds are sensitive to changes in prey availability within the water column (Furness and Tasker, 2000[77]). Links between sandeel abundance and kittiwake breeding productivity have been documented in multiple instances (Frederiksen *et al.,* 2004[78]; Carroll *et al.,* 2017[79]; Searle *et al.,* 2023[80]).

Conservation Status

5.1.1.5 Kittiwake are red listed on the UK Birds of Conservation Concern List due to marked population declines (Stanbury *et al.,* 2021[81]), and are classified as vulnerable by the IUCN red list (BirdLife International, 2019[82]).

Vulnerability to Climate Change

5.1.1.6 Kittiwake populations are projected to decline considerably by 2050 in western Scotland and Northern Ireland (the INTERREG VA area) based on population estimates from 1998 to 2002 (Davies *et al.,* 2021[39]). Marine Protected Area Management and Monitoring (MarPAMM) predict (with moderate confidence) that kittiwake have a high vulnerability to climate change in the INTERREG VA area (Davies *et al*., 2021[39]). Models of seabird at-sea distribution presented in Searle *et al.* (2022[80]) showed that kittiwake displayed a preference for colder water temperatures and thus would likely respond negatively to climate-change related warming. These results also showed that, under future climate projections (2070-2099), kittiwake abundances would likely decrease and suggested a large decline in productivity (Searle *et al*., 2022[80]). This is not unexpected, since the sandeel on which kittiwake rely are also predicted to be impacted by climate change.

Regional and National Population Trends

5.1.1.7 For kittiwake, the Seabirds Count (2015-2021) reported approximately 121,082 AON in Scotland, a decline of 57% AON since the Seabird 2000 count (1998-2002) (Burnell *et al*., 2023[83]), with declines in numbers of this species a continuation of a global decline which has been occurring for decades.

5.1.1.8 An assessment of colony counts was undertaken by the RSPB following the first outbreak of HPAI (2021-2022 outbreak), the total number of kittiwake across all sites surveyed in 2023 (which covered 38% of the UK breeding population) increased by 8% compared to the pre-HPAI baseline count for these colonies (from 86,708 to 93,221 AON) (Tremlett *et al*., 2024[84]). In Scotland, the 2023 counts at many SPAs were greater than the baseline counts, with an overall increase of 21% recorded across the colonies

surveyed. Colony-specific trends were variable, with population increases of over a third seen at several Scottish SPAs (Cape Wrath, Fowlsheugh, Marwick Head, North Caithness Cliffs, North Colonsay and Western Cliffs and St Kilda) while decreases of over a third were seen elsewhere (Copinsay and Sumburgh Head). At Buchan Ness to Collieston Cliffs SPA, located in the Moray Firth, an increase in breeding kittiwake numbers of 20% between 2022 and 2023 was reported. There was no obvious pattern to changes in abundance. It is important to note that counts undertaken in 2023 were undertaken prior to the further 2023 HPAI outbreak, so any changes due to HPAI events since 2023 are not captured in the most recently available data.

5.1.1.9 In 2015, the biogeographic population with connectivity to UK waters (adults and immatures) was 5,100,000 individuals (UK and overseas) (Furness, 2015[48]).

DAS Baseline Overview

5.1.1.10 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-8 and Table 2-9;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-8 and Table 2-9; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-4 and Table 2-5.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-7 and Table 2-8;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-6 and Table 2-7; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-3 and Table 2-4;
- Caledonia South:

- Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-7 and Table 2-8;
- Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-7 and Table 2-8; and
- Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-4 and Table 2-5.

5.1.1.11 Figure 5-1 presents the abundance of kittiwake (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.1.1.12 A total of 5,366 kittiwake were recorded in the Survey Area during both years of baseline surveys. Kittiwake were recorded in every survey. Kittiwake were the most abundant during the breeding season (April to August), with a peak of abundance in June 2022 in Caledonia OWF and Caledonia OWF plus 2km buffer, and in July 2021 in the Survey Area:

- 502 individuals were recorded in Caledonia OWF in June 2022, resulting in an unapportioned mean abundance estimate of 2,885 [1,109; 4,925] and an apportioned mean abundance estimate of 2,885 [868; 5,781] individuals. Both equated to a mean density estimate of 6.75 birds/km^2.
- 723 individuals were recorded in Caledonia OWF plus 2km buffer in June 2022, resulting in an unapportioned mean abundance estimate of 4,142 [1,908; 6,761] and an apportioned mean abundance estimate of 4,142 [1,358; 8,005] individuals. These equated to mean density estimates of 6.44 (unapportioned) and 6.43 (apportioned) birds/km^2.
- 1,083 individuals were recorded in the Survey Area in July 2021, resulting in an unapportioned mean abundance estimate of 6,539 [1,787; 12,788] and apportioned mean abundance estimate of 6,545 [1,613; 12,890] individuals. Both equated to a mean density estimate of 7.40 birds/km^2.

5.1.1.13 In both breeding seasons covered by the baseline surveys, apportioned mean kittiwake abundances across the Survey Area grew steadily throughout the first half of the breeding season, with peaks observed in June (2022) or July (2021). This is likely associated at least in part with breeding adult birds carrying out foraging trips from nearby breeding colonies. Mean apportioned abundances were considerably lower in August 2021 and 2022 than the preceding months. This would be expected since this is the time at which birds tend to leave the seas close to breeding colonies, in order to spend the non-breeding season in more oceanic areas.

5.1.1.14 Reductions in mean apportioned abundance in the nine breeding season surveys, outside the survey month with the peak mean apportioned abundance (July 2021), varied from 8% to 93%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period.

5.1.1.15 Kittiwake abundance was the lowest during the non-breeding season (September to March) with a wintering peak of abundance in November 2021 in Caledonia OWF, and September 2021 in Caledonia OWF plus 2km buffer and the Survey Area:

- 74 individuals were recorded in Caledonia OWF in November 2021, resulting in an unapportioned mean abundance estimate of 430 [197; 685] and an apportioned mean abundance estimate of 430 [198; 708] individuals. Both equated to a mean density estimate of 1.01 birds/km^2.
- 129 individuals were recorded in Caledonia OWF plus 2km buffer in September 2021, resulting in an unapportioned mean abundance estimate of 741 [129; 1,969] and an apportioned mean abundance estimate of 741 [144; 1,998] individuals. Both equated to a mean density estimate of 1.15 birds/km^2.
- 158 individuals were recorded in the Survey Area in September 2021, resulting in an unapportioned mean abundance estimate of 925 [187; 2,341] and an apportioned mean abundance estimate of 925 [219; 2,329] individuals. Both equated to a mean density estimate of 1.05 birds/km^2.

5.1.1.16 During the two non-breeding seasons covered by the baseline surveys, the trends observed in apportioned mean kittiwake abundance were characterised by relatively consistent and low apportioned mean abundances of birds across all reporting regions in the Survey Area. Apportioned mean abundances were lowest in the winter months across both survey years, with peak mean apportioned abundances occurring in the autumn. Most of the 13 surveys in the non-breeding season other than the peak month reported considerably lower mean apportioned abundances of birds than the peak month. Reductions in mean apportioned abundance relative to the peak were between 10% to 98%, with most surveys reporting reductions closer to the upper limit. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period, with many of the surveys recording apportioned mean kittiwake abundances considerably lower than the peak mean apportioned abundance.

5.1.1.17 The 95% confidence intervals calculated for the mean abundances were often relatively high even for surveys where CV values were low (e.g., July 2021 for the Survey Area). This is perhaps a consequence of the numbers of birds in single samples (i.e., images) being highly variable. Where reporting regions were smaller (e.g., Caledonia OWF), it is possible that there was lower

variability between samples, resulting in tighter 95% confidence intervals about the mean abundance estimate.

5.1.1.18 Good measures of precision were calculated for most survey months (CV ≤0.16). This was particularly the case for months during the breeding season (April to August), which is when the majority of records of this species were made. Within Caledonia OWF, a single survey during the breeding season had a precision value of CV >0.16 (April 2022; 0.17). Outside the breeding season, CV values of 0.2 to 0.4 for Caledonia OWF were more common. For Caledonia OWF plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia OWF, indicating higher precision within these reporting regions.

Caledonia North

5.1.1.19 A total of 2,373 kittiwake were recorded in Caledonia North Survey Area during both years of baseline surveys. Kittiwake were recorded in every survey, except in December 2022 in Caledonia North. Kittiwake were the most abundant during kittiwake breeding season (April to August), with a peak of abundance in May 2022:

- 188 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 1,091 [337; 1,805] and an apportioned mean abundance estimate of 1,091 [383; 1,857] individuals. These equated to mean density estimates of 5.00 (unapportioned) and 4.99 (apportioned) birds/km^2.
- 465 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 2,648 [1,196; 4,134] and an apportioned mean abundance estimate of 2,648 [1,065; 4,584] individuals. These equated to mean density estimates of 7.06 (unapportioned) and 7.05 (apportioned) birds/km^2.
- 532 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 3,093 [1,372; 4,896] and an apportioned mean abundance estimate of 3,094 [1,245; 5,384] individuals. Both equated to a mean density estimate of 5.55 birds/km^2.

5.1.1.20 Temporal patterns of kittiwake abundance in Caledonia North Survey Area varied considerably between the 2021 and 2022 breeding seasons. In 2021, low mean apportioned abundances of kittiwake occurred in every month with the exception of July, when an obvious peak occurred within Caledonia North Survey Area. Both Caledonia North and Caledonia North plus 2km buffer recorded a lesser peak in the same month. In the 2022 breeding season, the peak mean apportioned abundance of kittiwake was recorded in May 2022 across all reporting regions, which was also the peak breeding season count for kittiwake in Caledonia North across the whole baseline survey programme. Mean apportioned kittiwake abundance reduced month by month thereafter. Both April and August surveys within the survey period recorded low mean apportioned abundances of kittiwake. The temporal variation within Caledonia

North Survey Area during both breeding seasons is somewhat different to that recorded for both Caledonia South Survey Area, and the Survey Area as a whole.

5.1.1.21 Reductions in mean apportioned abundance in the eight breeding season surveys outside the peak survey month varied from 1% to 99%, with most surveys falling towards the upper extent of this range. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period, with many of the surveys recording apportioned mean kittiwake abundances considerably lower than the peak mean apportioned abundance.

5.1.1.22 During both years of surveys, kittiwake abundance was the lowest during the non-breeding season (September to March) with a wintering peak of abundance in November 2021:

- 64 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 374 [216; 608] and an apportioned mean abundance estimate of 375 [205; 602] individuals. These equated to mean density estimates of 1.71 (unapportioned) and 1.72 (apportioned) birds/km^2.
- 96 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 548 [319; 804] and an apportioned mean abundance estimate of 548 [308; 850] individuals. Both equated to a mean density estimate of 1.46 birds/km^2.
- 138 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 806 [531; 1,133] and an apportioned mean abundance estimate of 806 [498; 1,180] individuals. Both equated to a mean density estimate of 1.45 birds/km^2.

5.1.1.23 During the two non-breeding seasons covered by the baseline surveys, the trends observed in apportioned mean kittiwake abundance were characterised by relatively consistent and low apportioned mean abundances across all reporting regions within Caledonia North Survey Area. Apportioned mean abundances were lowest in the winter months across both survey years, with peak mean apportioned abundances occurring in the autumn. Most of the 13 surveys in the non-breeding season, other than the peak month (November 2021), reported considerably lower mean apportioned abundances of birds than the peak month. Reductions in mean apportioned abundance relative to the peak were between 62% to 98%, with most surveys reporting reductions closer to the upper limit. This indicates that the mean apportioned abundances were somewhat variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period.

5.1.1.24 Good measures of precisions were calculated for most survey months (CV ≤0.16). This was particularly the case for months during the breeding season

(April to August), which is when the majority of records were made. Within Caledonia North, four out of ten surveys carried out during the breeding season had a precision value of CV ≤0.16, with a further three surveys reporting a precision value of ≤0.2. Outside the breeding season, CV values of 0.2 to 0.5 for Caledonia North were more common. For Caldonia North plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia North, indicating higher precision within these reporting regions. The precision values for Caledonia North were generally higher than the equivalent values for Caledonia OWF, which is likely a product of a reduced number of records, coupled with lower transect numbers and lengths within these reporting regions relative to Caledonia OWF. Despite this, confidence in the kittiwake abundance and density estimates for Caledonia North and Caledonia North plus buffers generated from the baseline survey data is still considered to be reasonably good, particularly for abundance and densities recorded during the breeding season.

Caledonia South

5.1.1.25 A total of 4,049 kittiwake were recorded in Caledonia South Survey Area during both years of baseline surveys. Kittiwake were recorded in every survey. Kittiwake were the most abundant during kittiwake breeding season, with a peak of abundance in June 2022 in Caledonia South and Caledonia South plus 2km buffer, and in July 2022 in Caledonia South Survey Area:

- 410 individuals were recorded in Caledonia South in June 2022, resulting in an unapportioned mean abundance estimate of 2,375 [1,071; 4,089] and an apportioned mean abundance estimate of 2,375 [718; 4,732] individuals. Both equated to a mean density estimate of 11.29 birds/km^2.
- 615 individuals were recorded in Caledonia South plus 2km buffer in June 2022, resulting in an unapportioned mean abundance estimate of 3,491 [1,686; 5,484] and an apportioned mean abundance estimate of 3,492 [1,113; 6,359] individuals. Both equated to a mean density estimate of 9.71 birds/km^2.
- 861 individuals were recorded in Caledonia South Survey Area in July 2022, resulting in an unapportioned mean abundance estimate of 4,985 [1,233; 9,628] and an apportioned mean abundance estimate of 4,985 [1,439; 9,755] individuals. These equated to mean density estimates of 9.35 (unapportioned) and 9.34 (apportioned) birds/km^2. However, in July 2021, the unapportioned and apportioned mean abundance estimates were higher with 5,146 [1,358-1,489; 9,542-10,148] individuals, which equated to mean density estimates of 9.65 (unapportioned) and 9.64 (apportioned) birds/km^2.

5.1.1.26 In both breeding seasons covered by the baseline surveys, apportioned mean kittiwake abundances across Caledonia South Survey Area grew steadily throughout the first half of the breeding season, with peaks observed in June or July depending on the reporting region and year in question. This is likely associated, at least in part, with breeding adult birds carrying out foraging

trips from nearby breeding colonies. Mean apportioned abundances were considerably lower in August 2021 and 2022 than the preceding months. This would be expected since this is the time at which birds tend to leave the seas close to breeding colonies, in order to spend the non-breeding season in more oceanic areas.

5.1.1.27 Reductions in mean apportioned abundance in the breeding season surveys outside the peak survey month varied from 0% to 95%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period.

5.1.1.28 During both years of surveys, kittiwake abundance was the lowest during the non-breeding season (September to March) with a wintering peak of abundance in October 2021 in Caledonia South and in September 2021 in Caledonia South plus buffers:

- 18 individuals were recorded in Caledonia South in October 2021, resulting in an unapportioned mean abundance estimate of 105 [47; 187] and an apportioned mean abundance estimate of 106 [38; 199] individuals. Both equated to a mean density estimate of 0.50 birds/km^2.
- 122 individuals were recorded in Caledonia South plus 2km buffer in September 2021, resulting in an unapportioned mean abundance estimate of 705 [122; 2,000] and an apportioned mean abundance estimate of 705 [122; 1,994] individuals. Both equated to a mean density estimate of 1.96 birds/km^2.
- 148 individuals were recorded Caledonia South Survey Area in September 2021, resulting in an unapportioned mean abundance estimate of 859 [148; 2,247] and an apportioned mean abundance estimate of 860 [170; 2,276] individuals. Both equated to a mean density estimate of 1.61 birds/km^2.

5.1.1.29 During the two non-breeding seasons covered by the baseline surveys, the trends observed in apportioned mean kittiwake abundance were characterised by relatively consistent and low apportioned mean abundances across all reporting regions within Caledonia South Survey Area. Apportioned mean abundances were lowest in the winter months across both survey years, with peak mean apportioned abundances occurring in the autumn. Most of the 13 surveys in the non-breeding season other than the peak month reported considerably lower mean apportioned abundances of birds than the peak month. Reductions in mean apportioned abundance relative to the peak were between 24% to 99%, with most surveys reporting reductions closer to the upper limit. This indicates that the mean apportioned abundances were quite variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period, with many of the surveys recording apportioned mean kittiwake abundances considerably lower than the peak mean apportioned abundance.

5.1.1.30 The 95% confidence intervals calculated for the mean abundances were often relatively high even for surveys where CV values were low (e.g., July 2021 and July 2022 for Caledonia South Survey Area). This is perhaps a consequence of the numbers of birds in single samples (i.e., images) being highly variable. Where reporting regions were smaller (e.g., Caledonia South), it is possible that there was lower variability between samples, resulting in tighter 95% confidence intervals about the mean abundance estimate.

5.1.1.31 Good measures of precisions were calculated for most survey months (CV ≤0.16). This was particularly the case for months during the breeding season (April to August), which is when the majority of records were made. Within Caledonia South, nine out of ten surveys carried out during the breeding season had a precision value of CV ≤0.16. Outside the breeding season, CV values of 0.2 to 0.5 for Caledonia South were more common, with small numbers of outliers. For Caledonia South plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia South, indicating higher precision within these reporting regions. The precision values for Caledonia South were generally higher (indicating lower precision) than the equivalent values for Caledonia OWF, which is likely a product of a reduced number of records, coupled with lower transect numbers and lengths within these reporting regions relative to Caledonia OWF.

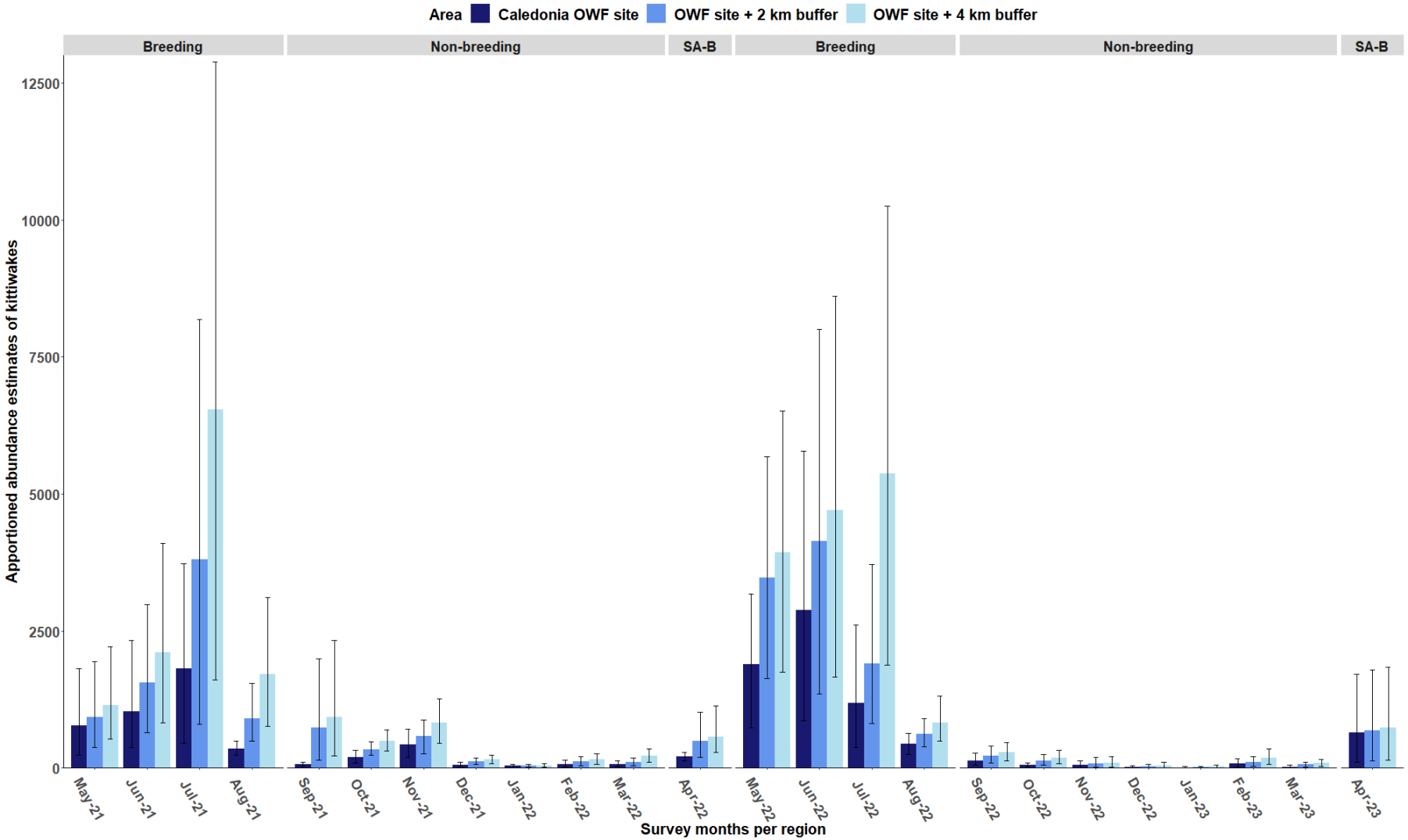


Figure 5-1: Bar plot of monthly apportioned abundance estimates (with 95% confidence intervals) of the total kittiwake recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Kittiwake seasonal periods are also displayed. SA-B corresponds to month split between breeding site attendance (SA) and breeding (B).

Spatial Distribution and Flight Direction

Spatial Distribution

5.1.1.32 Kittiwake were more widely distributed throughout the Caledonia OWF (plus a 4km buffer) in May 2021, October 2021, December 2021 to June 2022, August 2022, and February 2023. From June to September 2021, and in July and October 2022 and March 2023, their distribution was more concentrated in Caledonia South and the Caledonia South 4km Buffer Zone. Most kittiwake were recorded in the north and west of the Survey Area in November 2021. In September 2022 and April 2023, kittiwake were present in the north and south of the Caledonia OWF (plus a 4km buffer). Most kittiwake were recorded in the eastern side of the Survey Area near the boundary between Caledonia North and Caledonia South in November 2022 and in the east of buffer and southwest corner of Caledonia South in December 2022. In January 2023, they were recorded in the north of Caledonia North 4km Buffer Zone, in the south of Caledonia North and in the south of Caledonia South.

5.1.1.33 Distribution maps generated using MRSea (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) indicated that kittiwake were widely distributed throughout the Caledonia OWF and 4km buffer during the breeding season, with higher concentrations in the south of the area. In the non-breeding season, overall numbers declined, but again were generally higher in the south.

5.1.1.34 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

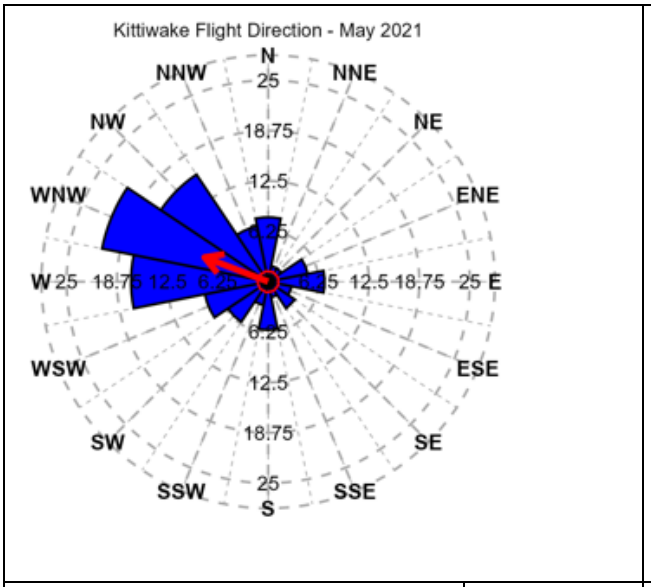
- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).Flight Direction

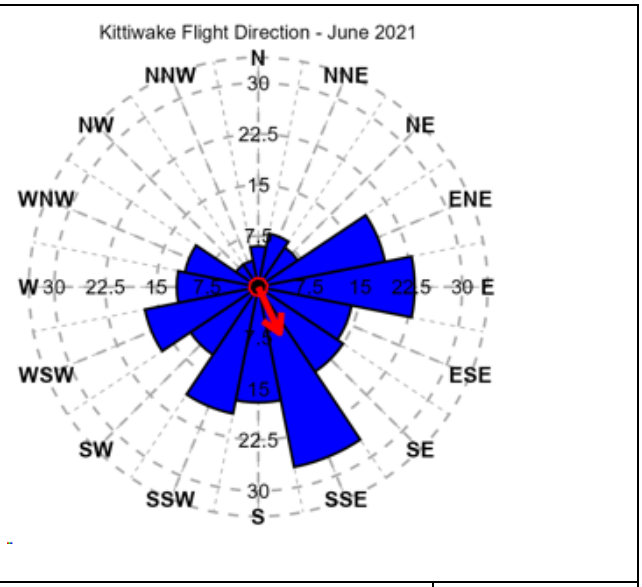
5.1.1.35 Figure 5-2 presents the flight direction of kittiwake within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.1.1.36 Significant predominant direction of flight was recorded in:

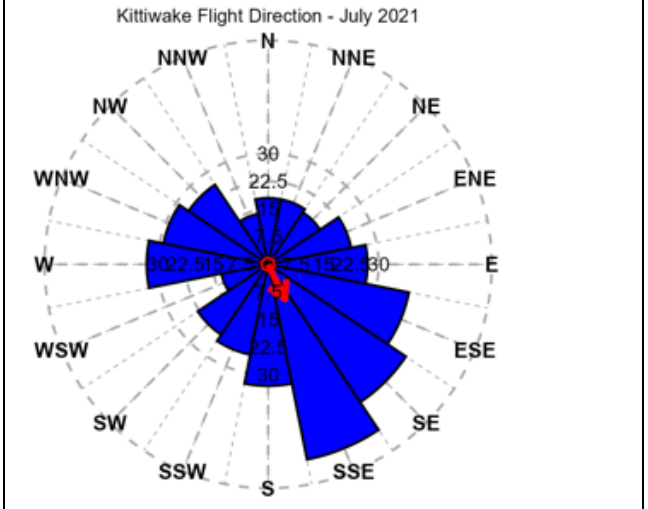
- May
  - 2021 west-northwest
  - 2022 west-southwest
- June
  - 2021 south-southeast
  - 2022 northeast

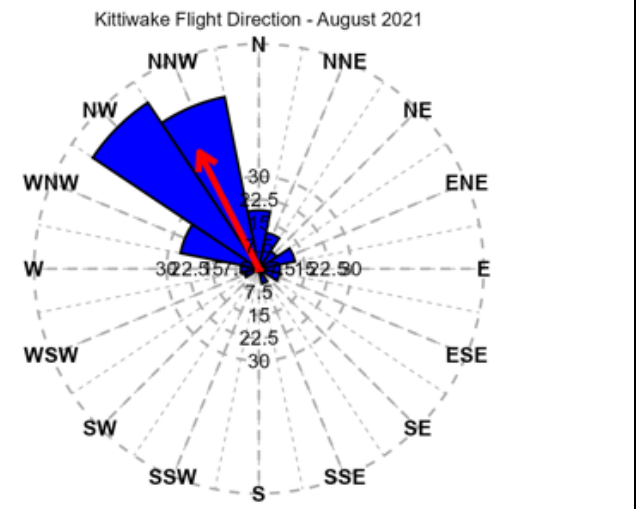
- July
  - 2021 south-southeast
  - 2022 south-southeast
- August
  - 2021 north-northwest
  - 2022 west-southwest
- September
  - 2021 west-southwest
  - 2022 west
- October
  - 2021 south-southwest
  - 2022 southwest
- November
  - 2021 southwest
  - 2022 south-southeast
- December
  - 2021 west-northwest
- February
  - 2023 east-southeast
- March
  - 2022 south-southeast
- April
  - 2022 east-southeast
  - 2023 south-southeast



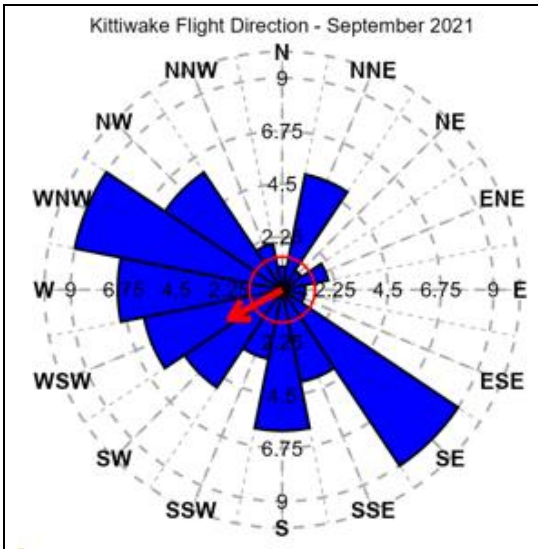


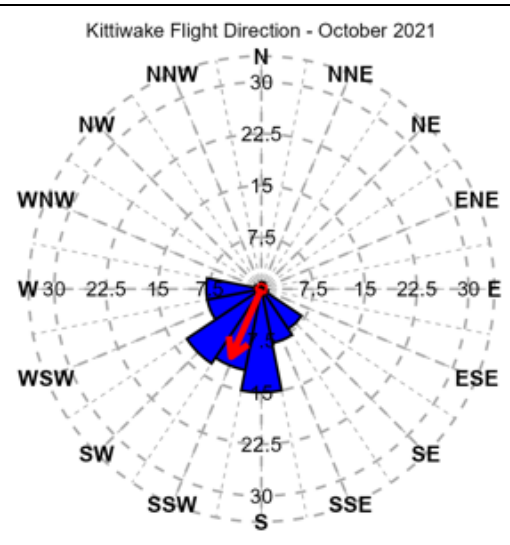
Number of Observations	117	Number of Observations	215
Mean Vector (μ)	291.934	Mean Vector (μ)	155.316
Length of Mean Vector (r)	0.402	Length of Mean Vector (r)	0.276
Rayleigh Test (Z)	18.863	Rayleigh Test (Z)	16.360
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001



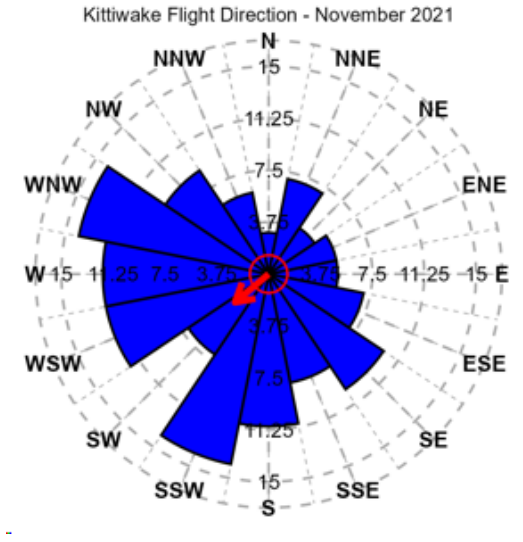


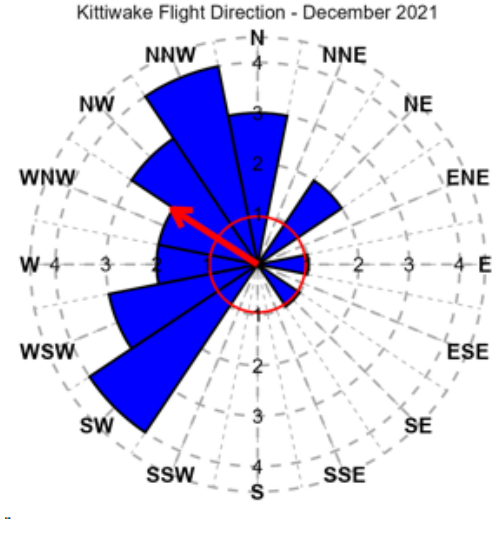
Number of Observations	437	Number of Observations	232
Mean Vector (μ)	154.589	Mean Vector (μ)	333.917
Length of Mean Vector (r)	0.194	Length of Mean Vector (r)	0.655
Rayleigh Test (Z)	16.481	Rayleigh Test (Z)	99.433
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001



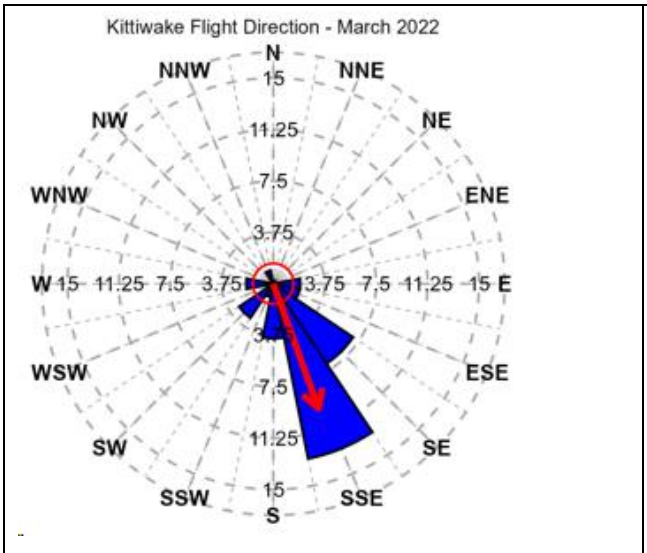


Number of Observations	68	Number of Observations	75
Mean Vector (μ)	241.079	Mean Vector (μ)	204.475
Length of Mean Vector (r)	0.282	Length of Mean Vector (r)	0.717
Rayleigh Test (Z)	5.424	Rayleigh Test (Z)	38.587
Rayleigh Test (p)	0.004	Rayleigh Test (p)	<0.001

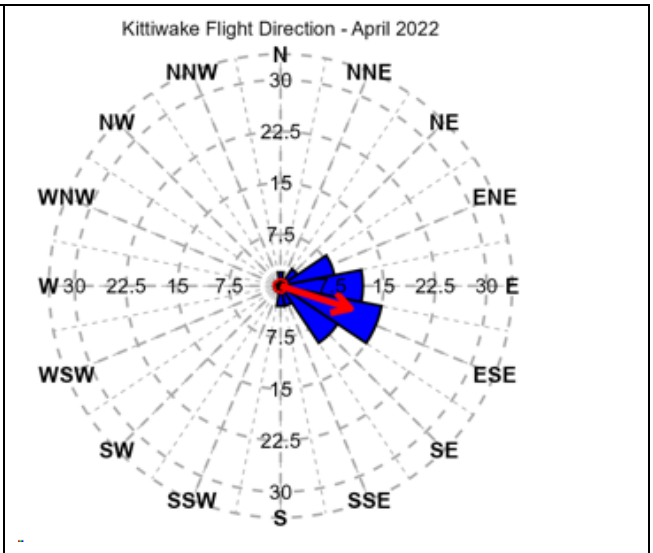




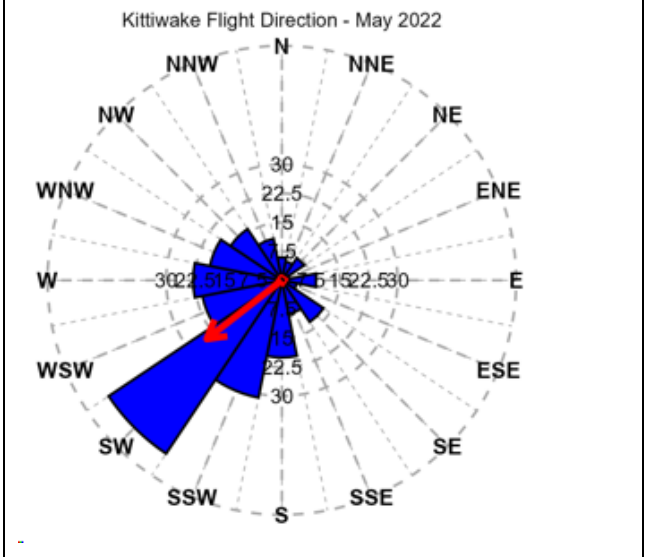
Number of Observations	134	Number of Observations	25
Mean Vector (μ)	230.689	Mean Vector (μ)	303.250
Length of Mean Vector (r)	0.227	Length of Mean Vector (r)	0.501
Rayleigh Test (Z)	6.906	Rayleigh Test (Z)	6.279
Rayleigh Test (p)	0.001	Rayleigh Test (p)	0.001



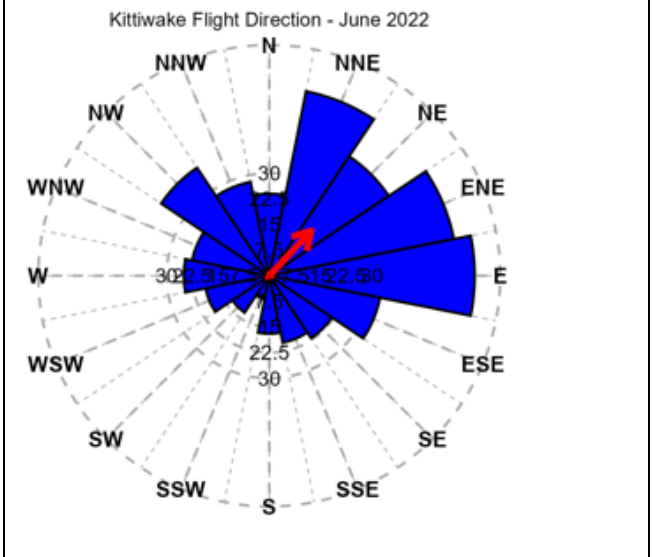
Number of Observations	35
Mean Vector (μ)	160.209
Length of Mean Vector (r)	0.743
Rayleigh Test (Z)	19.311
Rayleigh Test (p)	<0.001



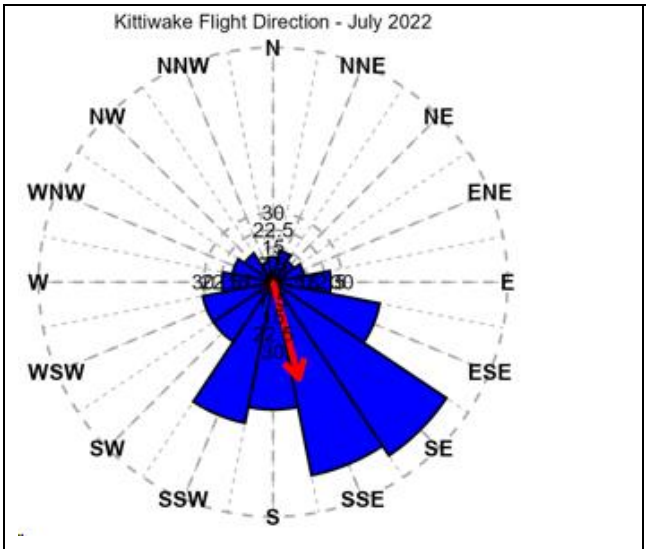
Number of Observations	60
Mean Vector (μ)	108.084
Length of Mean Vector (r)	0.714
Rayleigh Test (Z)	30.550
Rayleigh Test (p)	<0.001

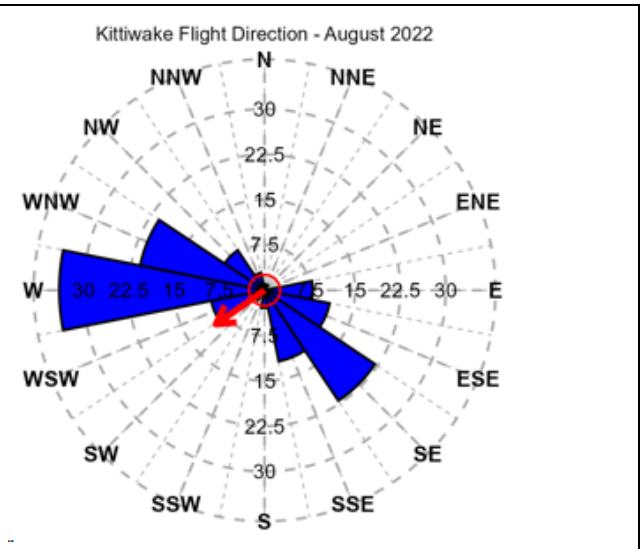


Number of Observations	250
Mean Vector (μ)	232.740
Length of Mean Vector (r)	0.458
Rayleigh Test (Z)	52.352
Rayleigh Test (p)	<0.001

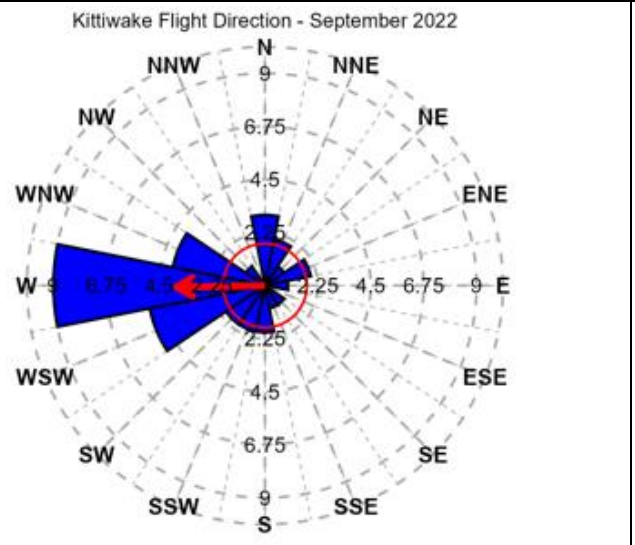


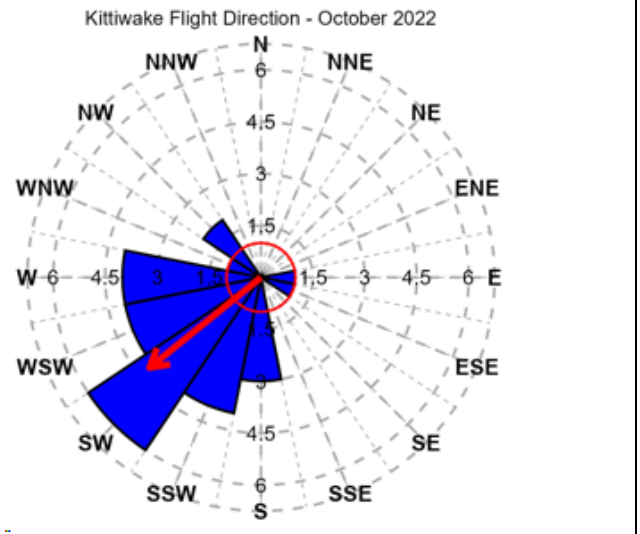
Number of Observations	481
Mean Vector (μ)	43.805
Length of Mean Vector (r)	0.299
Rayleigh Test (Z)	43.103
Rayleigh Test (p)	<0.001



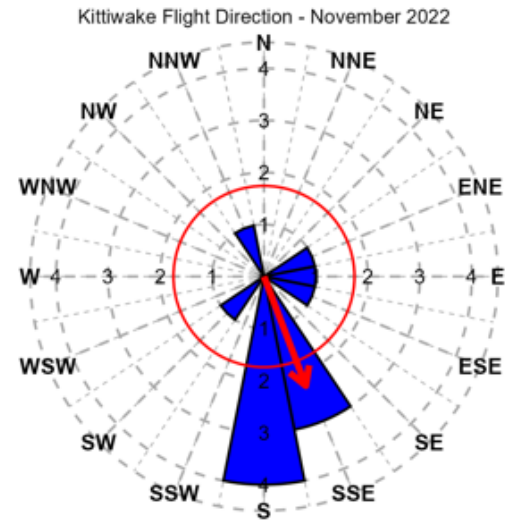


Number of Observations	540	Number of Observations	135
Mean Vector (μ)	165.085	Mean Vector (μ)	235.020
Length of Mean Vector (r)	0.477	Length of Mean Vector (r)	0.288
Rayleigh Test (Z)	122.964	Rayleigh Test (Z)	11.226
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001

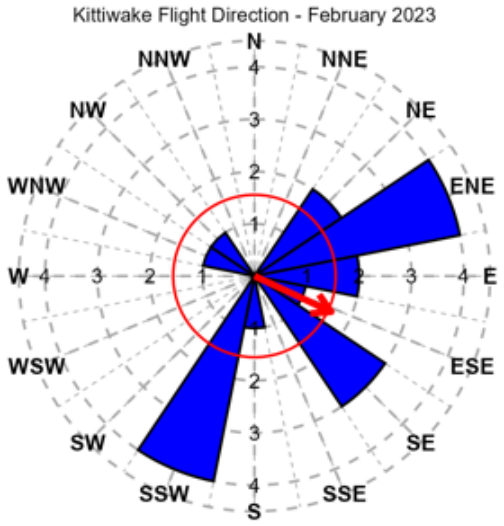




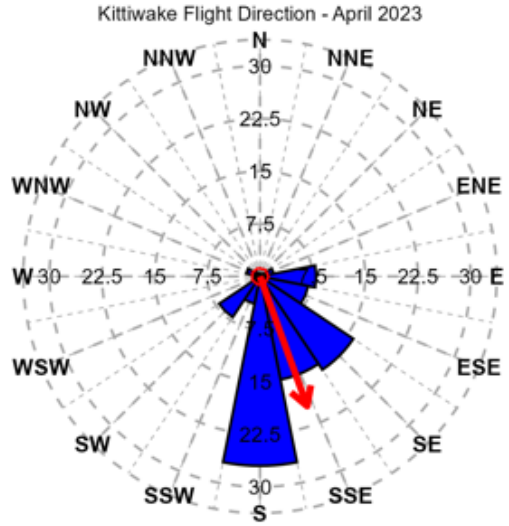
Number of Observations	36	Number of Observations	26
Mean Vector (μ)	269.557	Mean Vector (μ)	231.834
Length of Mean Vector (r)	0.418	Length of Mean Vector (r)	0.690
Rayleigh Test (Z)	6.294	Rayleigh Test (Z)	12.369
Rayleigh Test (p)	0.002	Rayleigh Test (p)	<0.001



Number of Observations	12
Mean Vector (μ)	159.037
Length of Mean Vector (r)	0.563
Rayleigh Test (Z)	3.798
Rayleigh Test (p)	0.019



Number of Observations	19
Mean Vector (μ)	115.393
Length of Mean Vector (r)	0.404
Rayleigh Test (Z)	3.100
Rayleigh Test (p)	0.043



Number of Observations	91
Mean Vector (μ)	160.200
Length of Mean Vector (r)	0.728
Rayleigh Test (Z)	48.244
Rayleigh Test (p)	<0.001

Figure 5-2: Summary of flight direction of kittiwake within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.1.1.38 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-3).

<table>
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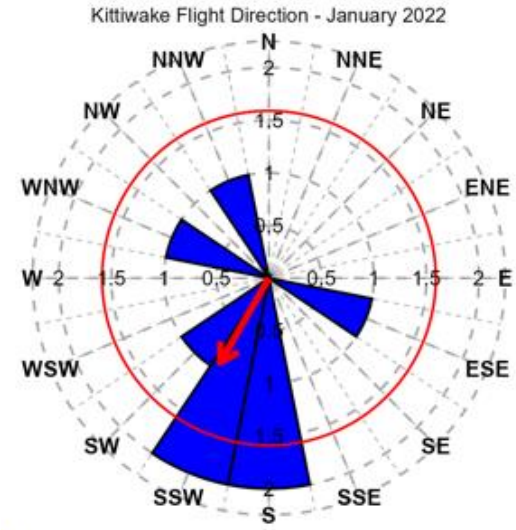
<td colspan="2"> 
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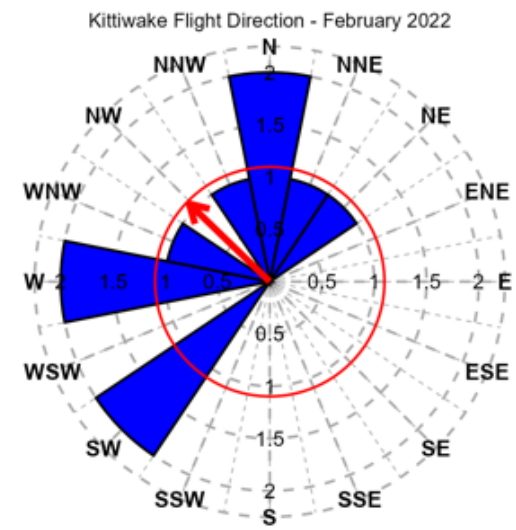
<td colspan="2"> 
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</tr>
<tr><td>Number of Observations</td><td>8</td><td>Number of Observations</td><td>10</td></tr>
<tr><td>Mean Vector (μ)</td><td>210.895</td><td>Mean Vector (μ)</td><td>314.472</td></tr>
<tr><td>Length of Mean Vector (r)</td><td>0.463</td><td>Length of Mean Vector (r)</td><td>0.536</td></tr>
<tr><td>Rayleigh Test (Z)</td><td>1.712</td><td>Rayleigh Test (Z)</td><td>2.872</td></tr>
<tr><td>Rayleigh Test (p)</td><td>0.184</td><td>Rayleigh Test (p)</td><td>0.053</td></tr>
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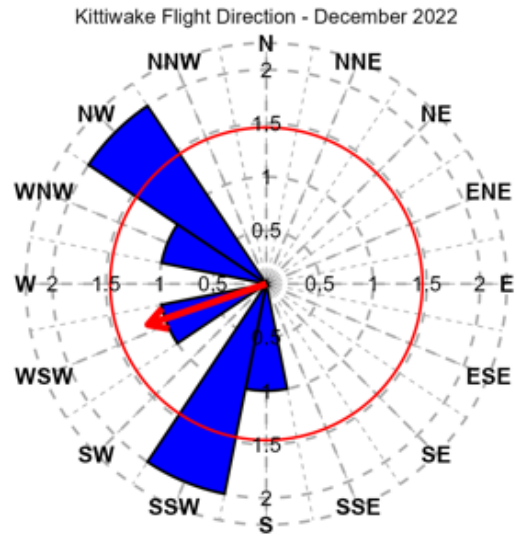
<td colspan="2"> 
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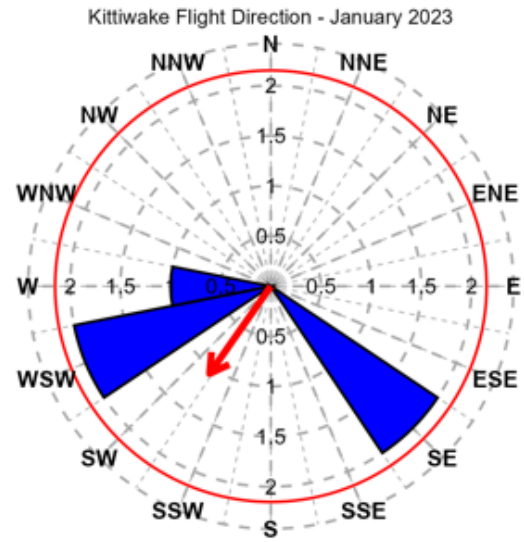
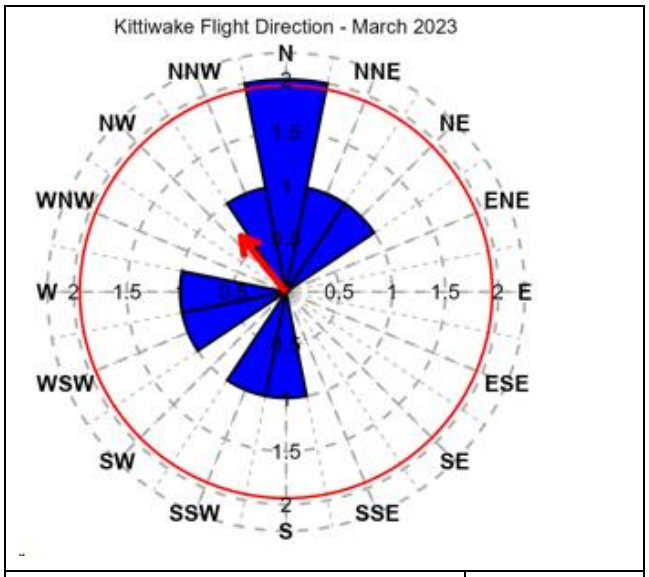
<td colspan="2"> 
</td>
</tr>
<tr><td>Number of Observations</td><td>7</td><td>Number of Observations</td><td>5</td></tr>
<tr><td>Mean Vector (μ)</td><td>251.984</td><td>Mean Vector (μ)</td><td>215.638</td></tr>
<tr><td>Length of Mean Vector (r)</td><td>0.585</td><td>Length of Mean Vector (r)</td><td>0.532</td></tr>
<tr><td>Rayleigh Test (Z)</td><td>2.396</td><td>Rayleigh Test (Z)</td><td>1.415</td></tr>
<tr><td>Rayleigh Test (p)</td><td>0.088</td><td>Rayleigh Test (p)</td><td>0.255</td></tr>
</table>



Number of Observations	9
Mean Vector (μ)	321.313
Length of Mean Vector (r)	0.336
Rayleigh Test (Z)	1.019
Rayleigh Test (p)	0.372

Figure 5-3: Summary of flight direction of kittiwake within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.1.1.39 As recommended by the NatureScot (2023[1]) guidance, kittiwake has been scoped into the assessment for:

- Potential operational phase displacement; and
- Potential collision risk.

5.1.1.40 As a result, detailed consideration of mean seasonal peak abundance (all birds), and monthly flying bird density is provided in the following sections.

Seasonal Peak

5.1.1.41 The peaks used for the matrix-based distributional response assessment have been presented in Table 5–3. The offshore ornithology distributional responses assessment has been carried out separately for the Caledonia OWF, Caledonia North and Caledonia South. The peaks have been defined using the seasonal definitions presented in Table 5–1 and Table 5–2.

5.1.1.42 See Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates for the density and population estimate of all kittiwake in the Caledonia OWF, Caledonia North and Caledonia South (plus a 2km buffer) used within assessments.

5.1.1.43 Kittiwake were present in the greatest abundance during the breeding season (April to August), with a peak abundance of 2,039 within Caledonia OWF (plus a 2km buffer); 710 birds within Caledonia North (plus a 2km buffer) and 1,530 birds within Caledonia South (plus a 2km buffer).

5.1.1.44 Outside the breeding season fewer kittiwake were present with a peak estimate of 483 birds within Caledonia OWF (plus a 2km buffer); 321 birds within Caledonia North (plus a 2km buffer) and 427 within Caledonia South (plus a 2km buffer).

Table 5–3: Seasonal Peaks of kittiwake within Caledonia OWF (+2km buffer), Caldonia North (+2km buffer) and Caledonia South (+2km buffer), during the NatureScot defined seasons and the BDMPS Non-breeding Seasons as per Furness (2015[48]).

Defined Season	Breeding Season	Non-breeding Season	Autumn Migration	Spring Migration
Array Area + 2km buffer				
Caledonia OWF	2,039 (1,868 / 2,210)	483 (741 / 225)	483 (741 / 225)	115 (120 / 109)
Caledonia North	710 (426 / 995)	321 (548 / 93)	321 (548 / 93)	76 (94 / 57)
Caledonia South	1,530 (1,650 / 1,410)	427 (705 / 149)	427 (705 / 149)	50 (42 / 57)

Note, the seasonal peaks from Year 1 and Year 2 of DAS data used to calculate the mean seasonal peaks are provided within the brackets '()'.

Note, the seasonal peaks have been calculated using model-based median abundance for the breeding season (Mid-April to August) and design-based mean abundance for the non-breeding season (September to mid-April).

Density in Flight

5.1.1.45 The monthly density estimates (birds/km^2) of birds in flight used for the assessment of potential collision risk for kittiwake have been presented in Table 5–4 and Figure 5-4. The monthly density estimates are used in CRM for the individual assessments for Caledonia OWF, Caledonia North and Caledonia South.

5.1.1.46 Kittiwake were recorded in the greatest density during the breeding season (April to August), with a peak density of 4.31 birds/km^2 (June 2022) within Caledonia OWF; 2.32 birds/km^2 (June 2022) within Caledonia North and 6.39 birds/km^2 (June 2022) within Caledonia South.

5.1.1.48 Outside the breeding season fewer kittiwake were present with the greatest density of 1.06 birds/km^2 (April 2023) recorded within Caledonia OWF; 0.34 birds/km^2 (April 2022) within Caledonia North and 1.97 birds/km^2 (April 2023) within Caledonia South.

Table 5–4: Estimated densities (birds/km^2) of flying kittiwake across the 24-month survey period for Caledonia OWF, Caledonia North and Caledonia South.

Year	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Caledonia OWF												
1	0.83	1.04	1.77	0.79	0.15	0.42	0.94	0.12	0.10	0.09	0.15	0.47
2	1.27	4.31	1.90	1.02	0.26	0.08	0.08	0.03	0.03	0.12	0.01	1.06
Caledonia North												
1	1.18	0.57	0.57	0.58	0.13	0.43	1.63	0.13	0.13	0.10	0.22	0.34
2	1.75	2.32	0.75	0.76	0.26	0.03	0.11	0	0.03	0.13	0.03	0.18
Caledonia South												
1	0.47	1.52	3.18	0.99	0.17	0.42	0.22	0.11	0.06	0.08	0.08	0.60
2	0.77	6.39	3.07	1.28	0.25	0.14	0.06	0.07	0.03	0.11	0	1.97
Note, estimates calculated using design-based analysis. Data include "no-identification" birds apportioned to species level.												

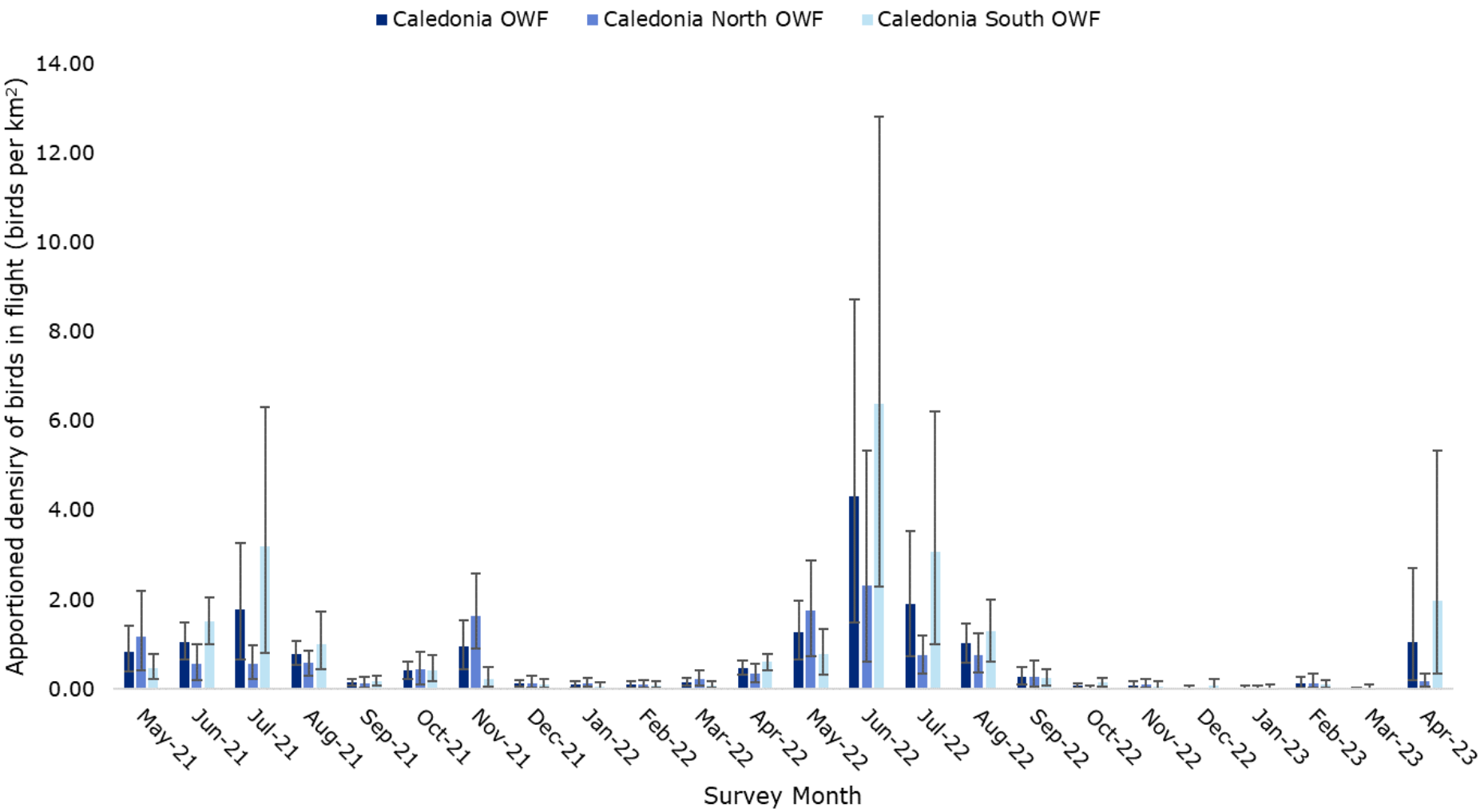


Figure 5-4: Bar plot of monthly apportioned densities (birds/km^2) of flying kittiwake (with 95% confidence intervals) recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period.

5.1.2 Great Black-backed Gull

Defined Seasons

5.1.2.1 Great black-backed gull seasonal definitions are presented in Table 5–5 as per the NatureScot (2020[71]) guidance. As there is only one non-breeding season for great black-backed gull within Furness (2015[48]), no separate BDMPS seasons have been provided.

Table 5–5: Defined seasons in the Scottish Marine Environment used in the assessment for great black-backed gull (NatureScot, 2020[71]).

Breeding Season	Non-breeding Season	Pre-breeding Migration Season
Late March to August	**September to Early March**	March
Time periods in **bold** are those used by the assessment.		

Overview

5.1.2.2 Great black-backed gulls are largest gull species in the north Atlantic, with their breeding season occurring late April to August (NatureScot, 2020[71]). These gulls are generalist feeders, utilising sources of food including human waste, fish, intertidal species, fish offal as well as seabirds and small mammals (Lopez *et al*., 2022[85]).

5.1.2.3 Great black-backed gulls breed in coastal locations particularly in the Outer and Inner Hebrides and the Northern Isles of Scotland (Mitchell *et al*., 2004[44]). Roof-nesting colonies are distributed mainly in the Aberdeen and Inverness (Mitchell *et al*., 2004[44]) areas. This species travels moderate distances with MMF±SD of 73±0km (Woodward *et al*., 2019[56]). Evidence from breeding locations beyond the UK indicates that during the breeding season, this species tends to predominantly utilise coastal areas for foraging (Maynard and Ronconi, 2018[86]; Borrmann *et al.,* 2019[87]), which if also the case in the Moray Firth may reduce interactions with OWFs during this time.

5.1.2.4 Some great black-back gulls disperse south after breeding, to the coasts of the Irish and North Seas (Calladine *et al*., 2006[88]). The winter distribution of this species is similar to their breeding, occurring in inland and lowland areas during the winter (Monaghan, 1986[89]).

Conservation Status

5.1.2.5 Great black-backed gull is Amber-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]) due to moderate declines in both breeding and non-breeding populations.

Vulnerability to Climate Change

5.1.2.6 Searle *et al*. (2022[80]) produced models which predicted that under future climate projection (2070-2099), great black-backed gull breeding success will decline in the North Sea. Davies *et al*. (2021[39]) predicted that breeding success will increase slightly (+ 2%) in the INTERREG VA area (covering the west coast of Scotland and Northern Ireland) for 2050 (considered to be a "low impact, low confidence" prediction by the authors of that study.

Regional and National Population Trends

5.1.2.7 The Seabirds Count (Burnell *et al.,* 2023[83]) reported a reduction of 43% in Britain and Ireland relative to the Seabird 2000 count (carried out between 1998 and 2002), which represents a considerable acceleration in population decline relative to pre-Seabird 2000 counts. Declines were greater in Scotland, with 5,404 AON recording, representing a reduction of 63% since the 2000 Seabird Census (1998-2002) (Burnell *et al.,* 2023[83]). These national declines were driven extensively by population loss in the northern isles, which is historically the UK breeding stronghold for this species. At a more regional level, declines were generally smaller around the Moray Firth area between the Seabird 2000 count and the Seabird Census (Burnell *et al.,* 2023[83]).

5.1.2.8 The cause of declines both in the UK and further afield is generally not well understood and thought to be driven by a range of factors (Lopez *et al*., 2022[85]). The reduction in availability of anthropogenic food sources (such as fishery discards) has been shown to be a contributing factor of some population decline (Lopez *et al*., 2022[85]; Burnell *et al.,* 2023[83]). For example, southeastern Canada introduced a discard moratorium in 1992 which is thought to have contributed to the breeding decline in great black-backed gull due to the reduced availability of discards (Wilhelm *et al*., 2016[90]). Great black-backed gulls in the North Sea are expected to be impacted by the ongoing reduction in discards (occurring since 1990) and the 2015 discard ban in European Union waters (Bicknell *et al*., 2013[91]; Sherley *et al*., 2020[92]). Therefore, this species is also likely to be affected by the enacted UK Fisheries Act 2020 (HM Government, 2020[93]) which include a scheme to prevent discarding. In some areas of Scotland, links between fishery landings and great black-backed gull populations have been made, with anecdotal evidence that declines could be understood as a return to more “natural” levels, with populations being artificially high over recent decades due to food sources from the fishing industry.

DAS Baseline Overview

5.1.2.9 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying

and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-10 and Table 2-11;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-10 and Table 2-11; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-6 and Table 2-7.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-9 and Table 2-10;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-8 and Table 2-9; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-5 and Table 2-6.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-9 and Table 2-10;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-9 and Table 2-10; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-6 and Table 2-7.

5.1.2.10 Figure 5-5 presents the abundance of great black-backed gulls (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km buffer and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.1.2.11 A total of 540 great black-backed gulls were recorded in the Survey Area during both years of baseline surveys. Great black-backed gulls were most abundant during the non-breeding season (September to March). In Caledonia OWF, they were only recorded during this season, with the exception of August 2022 where an apportioned mean abundance of 1 [0, 3] individual was estimated. In total, great black-backed gulls were recorded in 13, 17, and 17 of the 24 baseline surveys in Caledonia OWF, Caledonia OWF plus 2km buffer, and the Survey Area, respectively. In August 2022 and April 2023, great black-backed gulls have been recorded after apportioning despite not being directly recorded during the relevant survey. This represents apportioning of black-backed gulls and/or large gull species into the great black-backed gull category, following the hierarchy outlined in Section 3.2.3.

5.1.2.12 Peak numbers of great black-backed gull were recorded in November 2021:

- 73 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 424 [197; 755] and an apportioned mean abundance estimate of 473 [189; 923] individuals. These equated to mean density estimates of 0.99 (unapportioned) and 1.11 (apportioned) birds/km^2.
- 119 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 681 [383; 1,058] and an apportioned mean abundance estimate of 760 [372; 1,294] individuals. These equated to mean density estimates of 1.06 (unapportioned) and 1.18 (apportioned) birds/km^2.
- 163 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 949 [553; 1,444] and an apportioned mean abundance estimate of 1,046 [519; 1,745] individuals. These equated to mean density estimates of 1.07 (unapportioned) and 1.18 (apportioned) birds/km^2.

5.1.2.13 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned abundances of great black-backed gull within the Survey Area occurred in November 2021 and October 2022, with other months considerably lower in mean apportioned abundances than the overall peak for the two years of surveys (November 2021). In the 2021/22 non-breeding season, apportioned mean abundances were generally higher in the autumn than the winter period, with birds largely absent by the spring, presumably as birds move towards their breeding colonies. In the 2022/23 non-breeding season, mean apportioned abundances were comparable throughout most of the season. A key difference between the two non-breeding periods were the overall numbers of birds present, with the 2021/22 non-breeding season surveys recording larger numbers of birds than the 2022/23 non-breeding season surveys. Reductions in mean apportioned abundance relative to the peak were between 55% to 99%, with most surveys reporting reductions closer to the upper limit. This indicates that the mean apportioned

abundances were somewhat variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period.

5.1.2.14 Great black-backed gulls were absent from Caledonia OWF during the breeding season (April to July) and in March during the breeding site attendance period. However, low numbers of individuals (≤5) were recorded in both 2km and 4km Buffer Zones during the aforementioned periods.

5.1.2.15 The 95% confidence intervals calculated for the mean abundances were sometimes relatively high even for surveys where CV values were low (e.g., September 2021 and November 2021 for the Survey Area). This is perhaps a consequence of the numbers of birds in single samples (i.e., images) being highly variable. Where reporting regions were smaller (e.g., Caledonia OWF), it is possible that there was lower variability between samples, resulting in tighter 95% confidence intervals about the mean abundance estimate.

5.1.2.16 Good measures of precisions were calculated for the survey months where larger numbers of great black-backed gulls were recorded (CV ≤0.16). Outside these months, CV values of 0.2 to 0.6 for Caledonia OWF were more common, with larger values reported in surveys where fewer birds were observed. For Caledonia OWF plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia OWF, indicating higher precision within these reporting regions. This was likely a product of an increased number of records, coupled with higher transect numbers and lengths within these reporting regions relative to Caledonia OWF.

Caledonia North

5.1.2.17 A total of 376 great black-backed gulls were recorded in Caledonia North Survey Area during both years of baseline surveys. Great black-backed gulls were most abundant in all reporting regions during the non-breeding season. They were recorded from September 2021 to February 2022 and September 2022 to February 2023 in Caledonia North while they were additionally present in low numbers in August 2021, March 2022 and March 2023 in Caledonia North plus 2km and 4km buffers. In August 2022, great black-backed gulls have been recorded after apportioning despite not being directly recorded during the relevant survey. This represents apportioning of black-backed gulls and/or large gull species into the great black-backed gull category, following the hierarchy outlined in Section 3.2.3.

5.1.2.18 Peak numbers were recorded in November 2021:

- 15 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 88 [41; 134] and an apportioned mean abundance estimate of 93 [36; 155] individuals. These equated to mean density estimates of 0.40 (unapportioned) and 0.43 (apportioned) birds/km^2.
- 54 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 308 [154; 491] and an

apportioned mean abundance estimate of 335 [140; 614] individuals. These equated to mean density estimates of 0.82 (unapportioned) and 0.89 (apportioned) birds/km^2.

- 84 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 490 [274; 747] and an apportioned mean abundance estimate of 533 [228; 976] individuals. These equated to mean density estimates of 0.88 (unapportioned) and 0.96 (apportioned) birds/km^2.

5.1.2.19 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned great black-backed gull abundances occurred within Caledonia North Survey Area in November 2021, October 2022 or January 2023 (depending on the reporting region), with other months considerably lower in mean apportioned abundances than the overall peak for the two years of surveys, in November 2021. In the 2021/22 non-breeding season, apportioned mean abundances were generally higher in the autumn than the winter period, with birds largely absent by the spring, presumably as birds move towards their breeding colonies. In the 2022/23 non-breeding season, mean apportioned abundances were comparable throughout most of the season. A key difference between the two non-breeding periods were the overall numbers of birds present, with the 2021/22 non-breeding season surveys recording larger numbers of birds than the 2022/23 non-breeding season surveys.

5.1.2.20 Reductions in mean apportioned abundance relative to the peak were between 12% to 99%, with most surveys reporting reductions closer to the upper limit. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period, with many of the surveys recording apportioned mean abundances for this species that were considerably lower than the peak mean apportioned abundance.

5.1.2.21 Great black-backed gulls were recorded absent from Caledonia North Survey Area during the breeding season (April to July). They were only recorded in low numbers in March during the breeding site attendance period in Caledonia North 2km and 4km Buffer Zones.

5.1.2.22 The 95% confidence intervals calculated for the mean abundances were sometimes relatively high even for surveys where CV values were low (e.g., September 2021 and November 2021 for Caledonia North Survey Area). This is perhaps a consequence of the numbers of birds in single samples (i.e., images) being highly variable. Where reporting regions were smaller (e.g., Caledonia North), it is possible that there was lower variability between samples, resulting in tighter 95% confidence intervals about the mean abundance estimate.

5.1.2.23 Good measures of precisions were calculated for the survey months where larger numbers of great black-backed gulls were recorded (CV ≤0.16).

Outside these months, CV values of around 0.2 to 0.7 for Caledonia North were more common, with larger values reported in surveys where fewer birds were observed. For Caledonia North plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia North, indicating higher precision within these reporting regions. This was likely a product of an increased number of records, coupled with higher transect numbers and lengths within these reporting regions relative to Caledonia North.

Caledonia South

5.1.2.24 A total of 258 great black-backed gulls were recorded in Caledonia South Survey Area during both years of baseline surveys. Great black-backed gulls were only recorded from November 2021 to February 2022, September to November 2022 and January to February 2023 in Caledonia South. They were additionally recorded in low numbers in March 2022 and March 2023 in Caledonia North plus 2km buffer and additionally in April 2023 in Caledonia South Survey Area. In April 2023, great black-backed gulls have been recorded, in Caledonia South plus 2km buffer, after apportioning despite not being directly recorded during the relevant survey. This represents apportioning of black-backed gulls and/or large gull species into the great black-backed gull category, following the hierarchy outlined in Section 3.5

5.1.2.25 Great black-backed gulls were the most abundant during the non-breeding season (September to February), with peak numbers in November 2021:

- 58 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 334 [127; 651] and an apportioned mean abundance estimate of 377 [129; 776] individuals. These equated to mean density estimates of 1.59 (unapportioned) and 1.79 (apportioned) birds/km^2.
- 74 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 424 [212; 739] and an apportioned mean abundance estimate of 481 [240; 892] individuals. These equated to mean density estimates of 1.18 (unapportioned) and 1.34 (apportioned) birds/km^2.
- 96 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 552 [259; 937], and an apportioned mean abundance estimate of 632 [278; 1,132] individuals. These equated to mean density estimates of 1.03 (unapportioned) and 1.18 (apportioned) birds/km^2.

5.1.2.26 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned abundances of great black-backed gull occurred in Caledonia South Survey Area in November 2021 and October 2022, with other months considerably lower in mean apportioned abundances than the overall peak for the two years of surveys, in November 2021. Other than this large peak mean abundance, mean apportioned abundances were comparable

throughout most of the non-breeding season surveys covered by the baseline survey period.

5.1.2.27 Reductions in mean apportioned abundance relative to the peak were between 74% to 99%, indicating relatively low variability in mean apportioned abundances in non-breeding season surveys relative to the mean peak abundance.

5.1.2.28 Great black-backed gulls were mostly absent from Caledonia South Survey Area during the breeding season (April to July), with the exception of April 2023 where they were recorded in low numbers in Caledonia South 4km Buffer Zone. This led to small numbers of apportioned birds being allocated to this species within other regions within Caledonia South Survey Area.

5.1.2.29 The 95% confidence intervals calculated for the mean abundances were sometimes relatively high even for surveys where CV values were low (e.g., November 2021 for Caledonia North Survey Area). This is perhaps a consequence of the numbers of birds in single samples (i.e., images) being highly variable. Where reporting regions were smaller (e.g., Caledonia South), it is possible that there was lower variability between samples, resulting in tighter 95% confidence intervals about the mean abundance estimate.

5.1.2.30 Good measures of precision were calculated for the survey months where larger numbers of great black-backed gulls were recorded (CV ≤0.16). Outside these months, CV values of around 0.2 to 0.5 for Caledonia South were more common, with larger values reported in surveys where fewer birds were observed. For Caledonia South plus buffers, CV values were generally lower than the corresponding CV values for Caledonia South, indicating higher precision within these reporting regions. This was likely a product of an increased number of records, coupled with higher transect numbers and lengths within these reporting regions relative to Caledonia South.

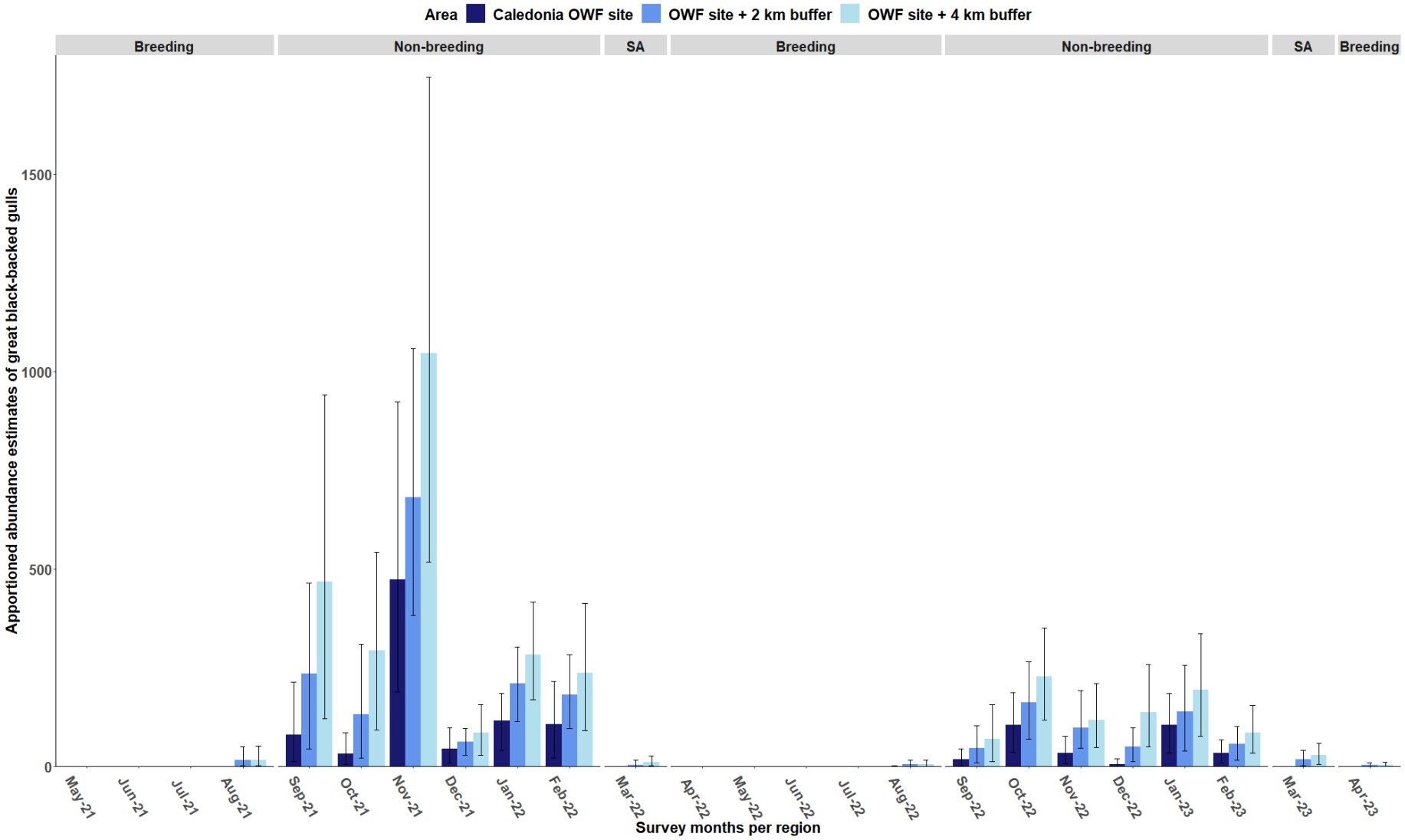


Figure 5-5: Bar plot of monthly apportioned abundance estimates (with 95% confidence intervals) of total great black-backed gulls recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Great black-backed gull seasonal periods are also displayed. SA stands for breeding site attendance.

Spatial Distribution and Flight Direction

Spatial Distribution

5.1.2.31 In August 2021, September 2021, October 2021, and September 2022, great black-backed gulls were concentrated in the west of the Caledonia OWF (plus a 4km buffer), predominantly within the 4km Buffer Zone, in the vicinity of operational Moray East wind turbines. In December 2021, they were distributed in the south and west of the Caledonia OWF (plus a 4km buffer), with most individuals within the 4km Buffer Zone. During the November 2021, January 2022, February 2022 and October 2022 surveys, they were widely distributed throughout the Caledonia OWF (plus a 4km buffer). The two individuals recorded in March 2022 were both within the 4km Buffer Zone; one in Caledonia North 4km Buffer Zone near the Caledonia North boundary and one in the northwest of Caledonia South Buffer Zone. In November 2022, great black-backed gulls were scattered throughout the Caledonia OWF (plus a 4km buffer), with highest numbers along the boundary between Caledonia North and Caledonia South, and southern parts of Caledonia South 4km Buffer Zone. In December 2022, individuals were predominantly recorded within the Caledonia OWF (plus a 4km buffer), with most of them recorded in the west and east of Caledonia North Buffer Zone. In January 2023, they were mainly recorded towards the centre of the Caledonia OWF (plus a 4km buffer), while individuals occurred more scattered across the Survey Area in February and in the west of the Caledonia OWF (plus a 4km buffer) in March 2023.

5.1.2.32 Distribution maps generated using MRSea (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) suggest that all great black-backed gulls are minimally distributed throughout the study area for both years of surveys. Higher densities are estimated along the central eastern boundary of the study area.

5.1.2.33 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

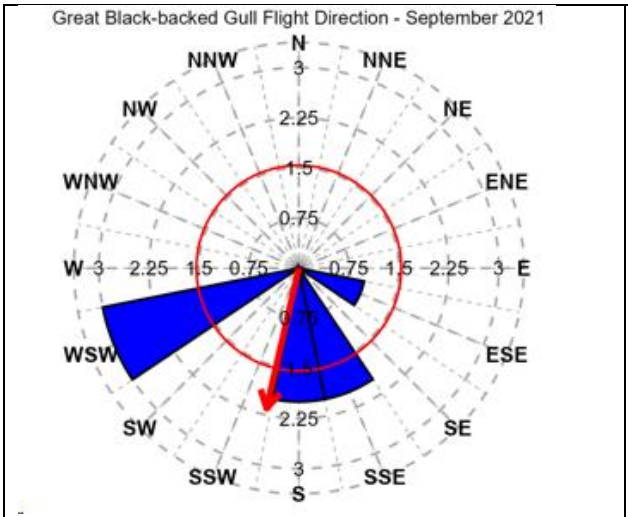
- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

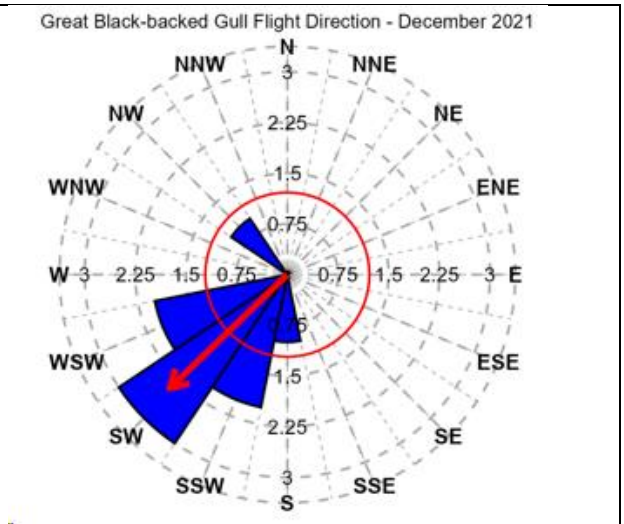
Flight Direction

5.1.2.34 Figure 5-6 presents the flight direction of great black-backed gull within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

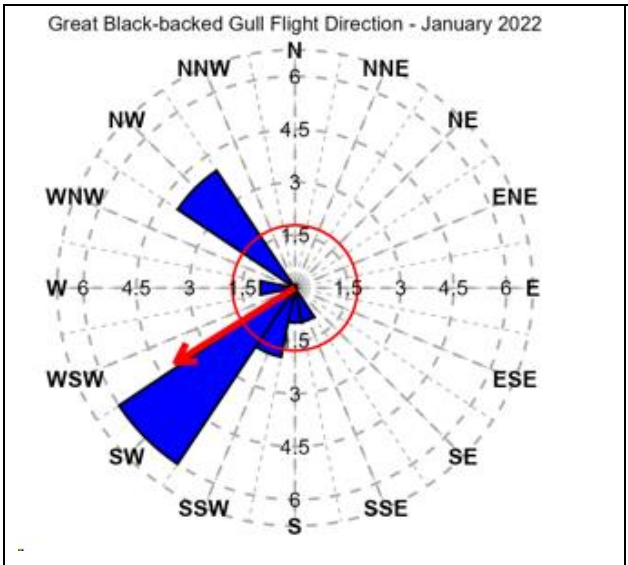
5.1.2.35 Significant predominant direction of flight was recorded in:

- September
  - 2021 south-southwest
- December
  - 2021 southwest
  - 2022 west
- January
  - 2022 west-southwest
  - 2023 south-southwest
- February
  - 2022 south
- November
  - 2022 south-southeast

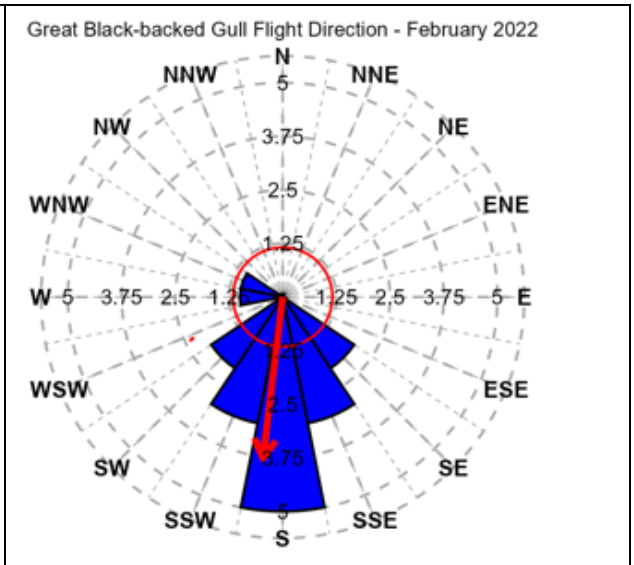




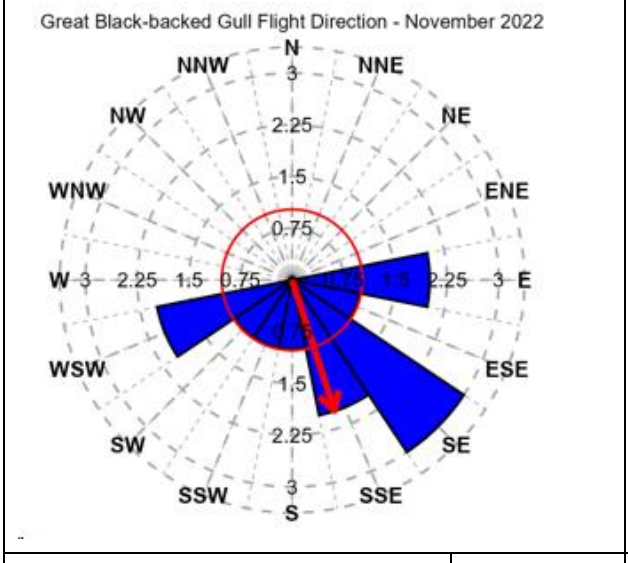
Number of Observations	8	Number of Observations	9
Mean Vector (μ)	193.006	Mean Vector (μ)	226.451
Length of Mean Vector (r)	0.718	Length of Mean Vector (r)	0.807
Rayleigh Test (Z)	4.119	Rayleigh Test (Z)	5.861
Rayleigh Test (p)	0.011	Rayleigh Test (p)	0.001



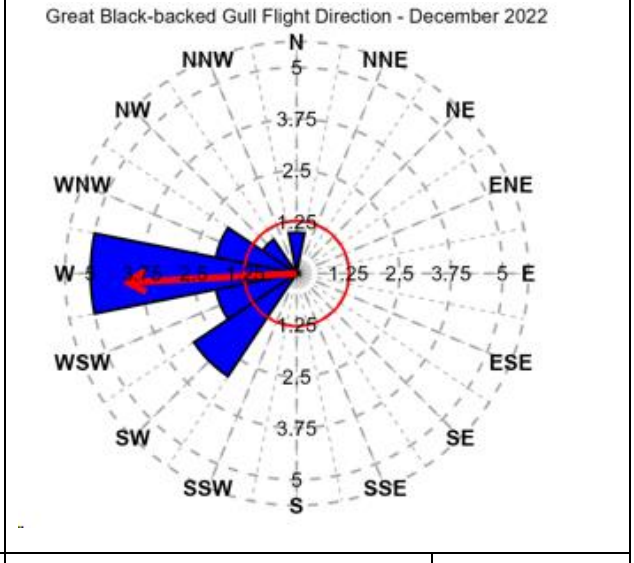
Number of Observations	15
Mean Vector (μ)	238.347
Length of Mean Vector (r)	0.662
Rayleigh Test (Z)	6.569
Rayleigh Test (p)	<0.001



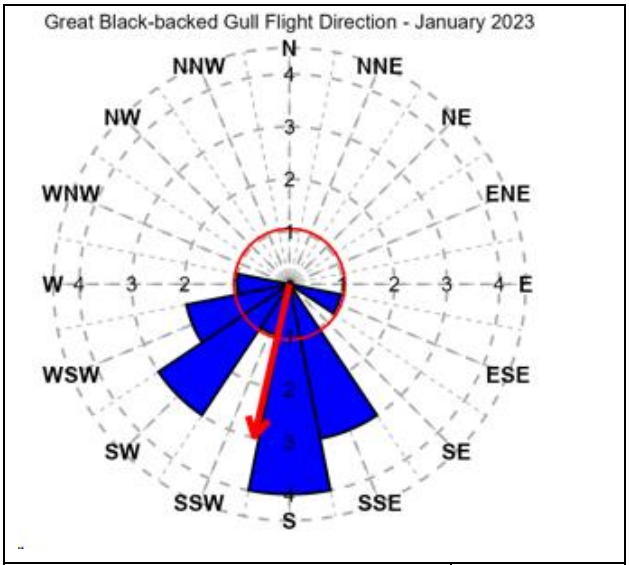
Number of Observations	17
Mean Vector (μ)	188.949
Length of Mean Vector (r)	0.756
Rayleigh Test (Z)	9.726
Rayleigh Test (p)	<0.001



Number of Observations	13
Mean Vector (μ)	162.164
Length of Mean Vector (r)	0.664
Rayleigh Test (Z)	5.729
Rayleigh Test (p)	0.002



Number of Observations	14
Mean Vector (μ)	267.340
Length of Mean Vector (r)	0.821
Rayleigh Test (Z)	9.437
Rayleigh Test (p)	<0.001



Number of Observations	15
Mean Vector (μ)	193.113
Length of Mean Vector (r)	0.742
Rayleigh Test (Z)	8.260
Rayleigh Test (p)	<0.001

Figure 5-6: Summary of flight direction of great black-backed gull within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.1.2.37 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-7).

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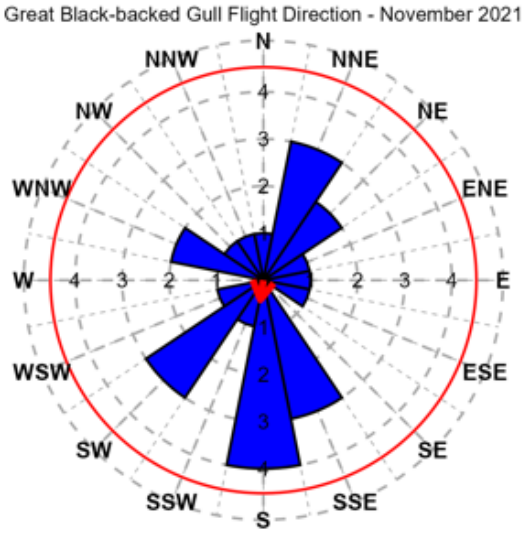
<td colspan="2"> 
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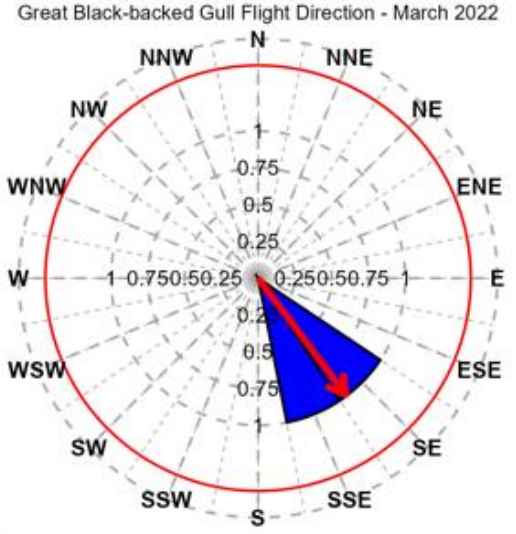
<td colspan="2"> 
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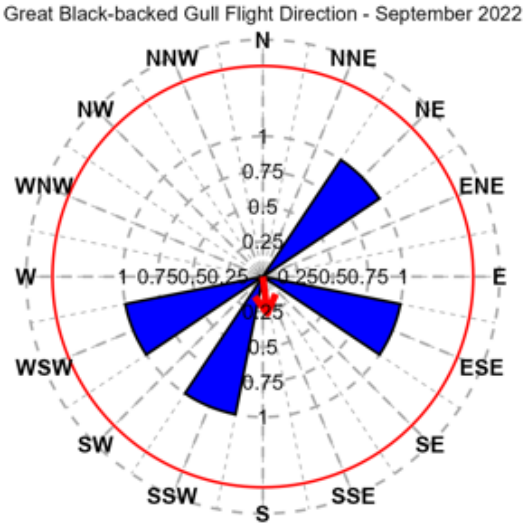
<td colspan="2"> 
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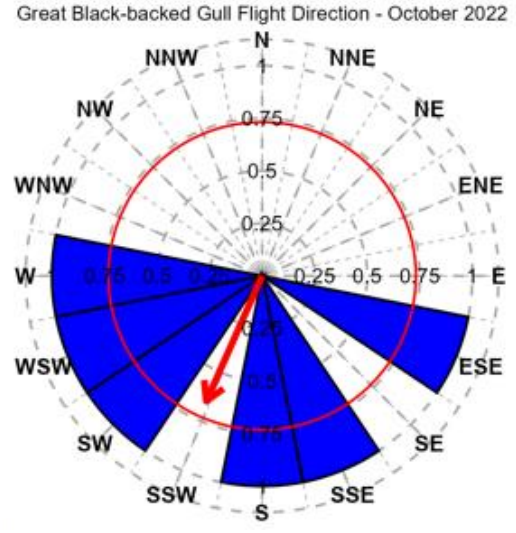
<td colspan="2"> 
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<tr><td>Length of Mean Vector (r)</td><td>0.264</td><td>Length of Mean Vector (r)</td><td>0.652</td></tr>
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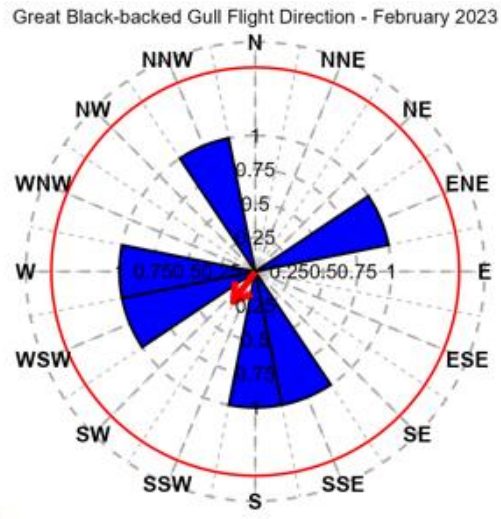
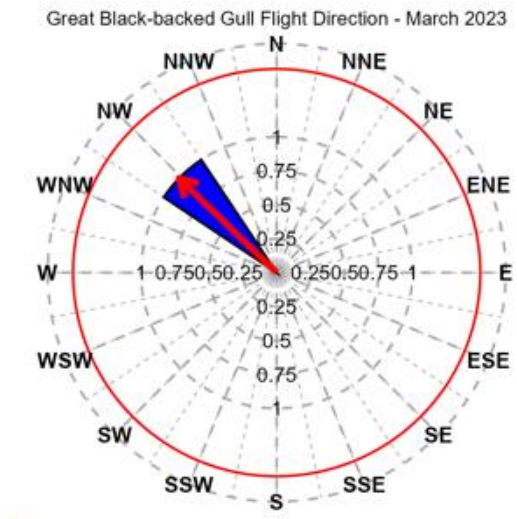




Number of Observations	6	Number of Observations	1
Mean Vector (μ)	216.380	Mean Vector (μ)	314.195
Length of Mean Vector (r)	0.276	Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	0.458	Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.652	Rayleigh Test (p)	0.512

Figure 5-7: Summary of flight direction of great black-backed gull within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.1.2.38 As recommended by the NatureScot (2023[1]) guidance, great black-backed gull has been scoped into the assessment for:

- Potential collision risk.

5.1.2.39 As a result, detailed consideration of monthly flying bird density is provided in the following sections.

Density in Flight

5.1.2.40 The monthly density estimates (birds/km^2) of birds in flight used for the assessment of potential collision risk for great black-backed gull have been presented in Table 5–6 and Figure 5-8. The monthly density estimates are used in CRM for the individual assessment within Caledonia OWF, Caledonia North and Caledonia South.

5.1.2.41 No great black-backed gull were recorded in flight during the breeding season (late-March to August) within Caledonia OWF; Caledonia North and Caledonia South.

5.1.2.43 During the non-breeding season (September to early-March) the greatest density of great black-backed gulls were recorded in November 2022 within Caledonia OWF (0.23 birds/km^2); 0.21 birds/km^2 in January 2022 within Caledonia North and 0.30 birds/km^2 in November 2022 within Caledonia South.

Table 5–6: Estimated densities (birds/km^2) of flying great black-backed gull across the 24-month survey period for Caledonia OWF, Caledonia North and Caledonia South.

Year	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Caledonia OWF												
1	0	0	0	0	0.05	0	0.23	0.05	0.08	0.11	0	0
2	0	0	0	0	0.03	0.03	0.07	0.02	0.18	0.04	0	0
Caledonia North												
1	0	0	0	0	0.11	0	0.16	0.05	0.08	0.10	0	0
2	0	0	0	0	0.05	0.05	0.08	0.03	0.21	0	0	0
Caledonia South												
1	0	0	0	0	0	0	0.30	0.06	0.08	0.13	0	0
2	0	0	0	0	0	0	0.04	0	0.14	0.08	0	0
Note, estimates calculated using design-based analysis. Data include "no-identification" birds apportioned to species level.												

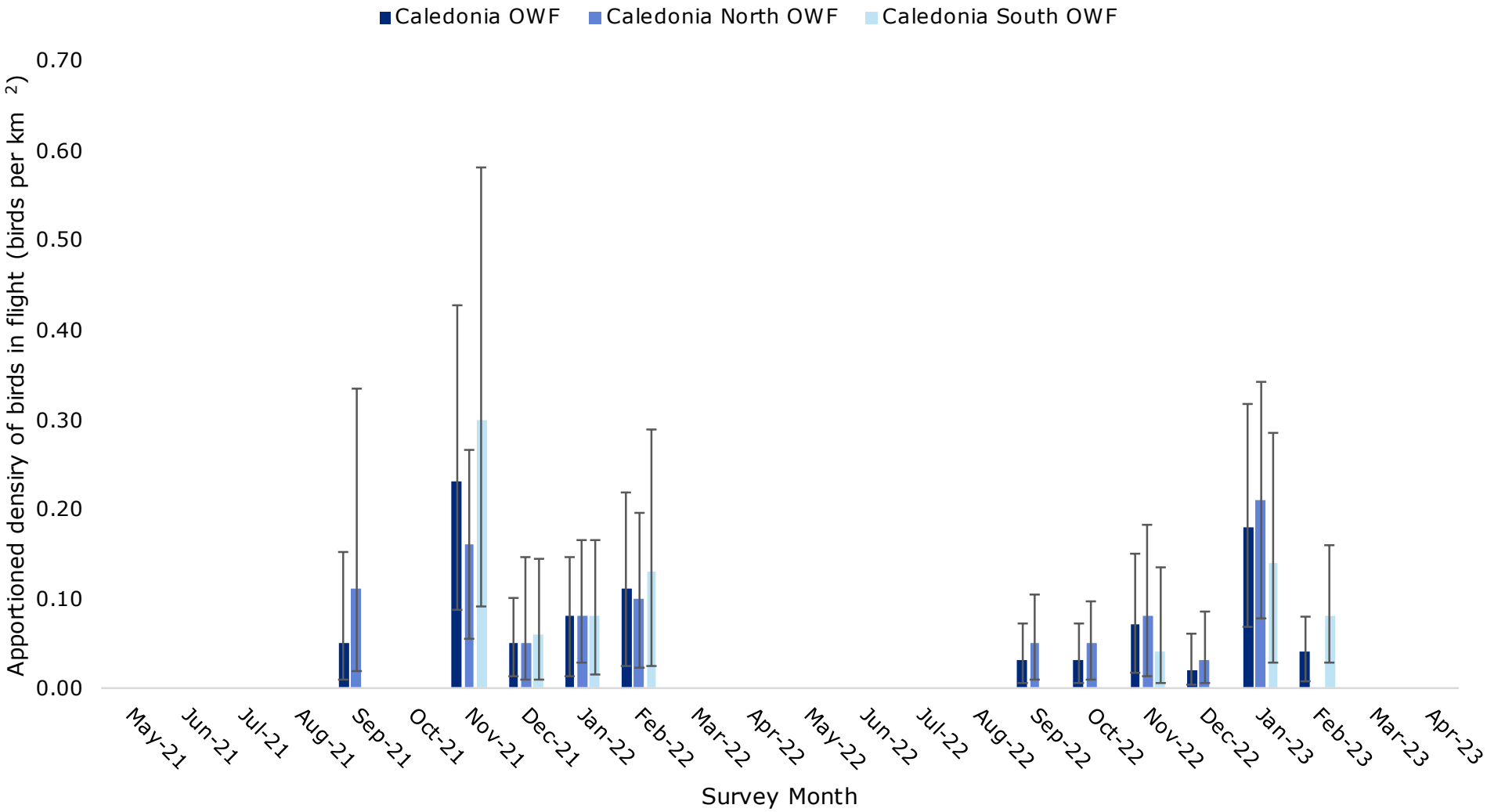


Figure 5-8: Bar plot of monthly apportioned densities (birds/km^2) of flying great black-backed gull (with 95% confidence intervals) recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period.

5.1.3 Herring Gull

Defined Seasons

5.1.3.1 Herring gull seasonal definitions are presented in Table 5–7 as per the NatureScot (2020[71]) guidance. As there is only one non-breeding season for herring gull within Furness (2015[48]), no separate BDMPS seasons have been provided.

Table 5–7: Defined seasons in the Scottish Marine Environment used in the assessment for herring gulls (NatureScot, 2020[71]).

Breeding Season	Non-breeding Season	Pre-breeding Migration Season
April to August	**September to March**	March
Time periods in **bold** are those used by the assessment.		

Overview

5.1.3.2 Herring gulls are predominantly coastal nesting birds, though they are also commonly found breeding at inland locations. The breeding season for herring gull is considered to be April to August (NatureScot, 2020[71]).

5.1.3.3 This species is concentrated particularly around the Scottish coastline during the breeding season, with the dispersal of gulls directed into the North Sea but general dispersal across the whole of Britain and Ireland (Waggitt *et al*., 2019[37]). During the breeding season this species tends to travel moderate distances from breeding sites for prey with an MMF±SD of 58.8±26.5km (Woodward *et al*., 2019[37]). Herring gulls breeding in urban areas around the east-coast towns and cities of Scotland, with smaller colonies across the central Belt in Berwickshire, Ayrshire and Dumfries (Calladine *et al*., 2006[88]).

5.1.3.4 Herring gulls are opportunistic feeders capable of utilising a range of food sources. During the nesting and incubation period, they can specialise in feeding either on intertidal species, human waste or other seabirds, or can also be generalists (Pierotti and Annett, 1991[94]).

5.1.3.5 The decline in the herring gull population since 1970 is considered to be attributed to mortality from botulism by feeding at landfills, reduced discards and culling events (Coulson, 2015[95]). Furthermore, large gulls are likely to be affected by the enacted 2015 fishery discard ban in European Union waters and the UK discard ban (Bicknell *et al*., 2013[91]; HM Government, 2020[93]) due their consumption of discards (Garthe and Scherp, 2003[96]; Schwemmer and Garthe, 2005[97]).

Conservation Status

5.1.3.6 Based on declines across the UK, this species is currently Red-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]).

Vulnerability to Climate Change

5.1.3.7 Herring gull are projected (with poor confidence) to be highly vulnerable to climate change in INTERREG VA (Davies *et al*., 2021[39]). Herring gull are predicted to decline in population size by 15% by 2050 under modelled climate change scenarios, which is a slower rate compared to the rest of the Britain and Ireland (29%) (Davies *et al*., 2021[39]).

Regional and National Population Trends

5.1.3.8 The biogeographic population (UK and overseas) of herring gull is estimated to be 1,098,000 IND, with 543,000 individuals comprising of the national population. During the non-breeding season (September to March), 466,511 individuals are located in the North Sea and Channel (Furness, 2015[48]). The Scottish population estimate was 71,659 AON during Seabird 2000 census (Madden and Newton, 2004[98] ; Mitchell *et al.*, 2004[44]). The herring gull population was considered stable in Scotland between 2011-2018 (Scottish Government, 2020[99]); however, Burnell *et al.* (2023[83]) noted a decline in breeding numbers at Scottish natural sites of 44% between Seabird 2000 and the Seabird Census. According the BTO (2024[10]), the recent Seabird Count (2015-2021) for herring gull reported 37,349 AON at natural sites only, a reduction of 44% since the Seabird 2000 census (1998-2002) (JNCC, 2020[50]). Scotland holds half of the British and Irish nesting population (the total of which represents up to 43% of the global population when birds breeding both at natural and in urban locations are considered) (NatureScot, 2024[71]). According to the Seabirds Count (Burnell *et al*., 2023[83]) there are approximately 100,161 AON in Scotland (combined urban and natural population, with 62,812 urban gull nests).

5.1.3.9 When examining the regional populations of herring gull, the potential impacts of HPAI should be considered as herring gull are known to be highly vulnerable to disease. This statement is supported by an assessment of colony counts undertaken by the RSPB following the first outbreak of HPAI (2021-2022 outbreak), as the total number of herring gull across all sites surveyed in 2023 (27% of the natural-nesting UK population of breeding herring gull was surveyed) decreased by 7% compared to the pre-HPAI baseline count for these colonies (from 17,721 to 16,535 AONs) (Tremlett *et al*., 2024[84]). Substantial declines occurred at three Scottish colonies; Canna and Sanday, Forth Islands, and Fowlsheugh. It is important to note that counts made by the RSPB in 2023 were undertaken prior to the further 2023 HPAI outbreak. Therefore, it is extremely likely

that updated counts are required for this species to improve evidence and update the baseline characterisation for impacts.

DAS Baseline Overview

5.1.3.10 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-12 and Table 2-13;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-12 and Table 2-13; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-8 and Table 2-9.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-11 and Table 2-12;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-10 and Table 2-11; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-7 and Table 2-8.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-11 and Table 2-12;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-11 and Table 2-12; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-8 and Table 2-9.

5.1.3.11 Figure 5-9 presents the abundance of herring gull (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km buffer and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.1.3.12 A total of 99 herring gulls were recorded in the Survey Area during both years of baseline surveys. Herring gulls were recorded in low numbers in all baseline surveys, except August 2021, April, May, August and September 2022, January and April 2023. Herring gulls were the most abundant during the non-breeding season (September to March), with peak numbers recorded in November 2021:

- Seven individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 41 [7; 93], and an apportioned mean abundance estimate of 45 [7; 99] individuals. These equated to mean density estimates of 0.10 (unapportioned) and 0.11 (apportioned) birds/km^2.
- 14 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 80 [29; 137] and an apportioned mean abundance estimate of 87 [26; 176] individuals. These equated to mean density estimates of 0.12 (unapportioned) and 0.14 (apportioned) birds/km^2.
- 14 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 81 [29; 146] and an apportioned mean abundance estimate of 90 [27; 176] individuals. These equated to mean density estimates of 0.09 (unapportioned) and 0.10 (apportioned) birds/km^2.

5.1.3.13 During the non-breeding seasons covered by the baseline surveys, herring gull numbers peaked in November 2021 and December 2022, with numbers steadily growing each month prior to the peak. Both January to March periods covered by the baseline surveys recorded low numbers of birds. Whilst birds were present more consistently than the breeding season, it is still considered that Caledonia Survey Area is situated is of limited importance to this species during the non-breeding season.

5.1.3.14 Numbers of herring gulls recorded in the breeding season (April to August) were generally slightly lower than during the non-breeding season. The peak abundance was recorded in July 2022:

- Six individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 35 [6; 82], and an apportioned mean abundance estimate of 63 [11; 152] individuals. These equated to mean density estimates of 0.08 (unapportioned) and 0.15 (apportioned) birds/km^2.
- Seven individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 40 [7; 92]

and an apportioned mean abundance estimate of 77 [20; 175] individuals. These equated to mean density estimates of 0.06 (unapportioned) and 0.12 (apportioned) birds/km^2.

- 29 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 169 [53; 310] and an apportioned mean abundance estimate of 219 [41; 494] individuals. These equated to mean density estimates of 0.19 (unapportioned) and 0.25 (apportioned) birds/km^2.

5.1.3.15 In March 2022 and 2023, during the breeding site attendance period, only a single individual was recorded in the Survey Area. In March 2022, an unapportioned mean abundance of 5 [1; 16] and an apportioned mean abundance of 10 [2; 32] individuals were estimated across all regions. This equated to mean density estimates of 0.01 (unapportioned) and 0.02 (apportioned) birds/km^2.

5.1.3.16 In both breeding seasons covered by the baseline surveys, apportioned mean herring gull abundances across the Survey Area were very low in April to June (being almost completely absent between April to June 2022), with larger (though still modest) numbers of birds present in July. Birds were absent in August 2021 and 2022. This indicates that the area in which Caledonia Survey Area is situated is of limited importance to this species during the breeding season.

5.1.3.17 Measures of precisions were high (indicating lower levels of precision), which is likely related to the low numbers of individuals recorded in each reporting region during each survey (CV >0.16).

Caledonia North

5.1.3.18 A total of 59 herring gulls were recorded in Caledonia North Survey Area during both years of baseline surveys. Herring gulls were recorded in low numbers in Caledonia North Survey Area in May, July, and September to December 2021, February, March, June, July, October to December 2022, and March 2023. Herring gulls were the most abundant during the non-breeding season, with peak numbers recorded in October 2021 in Caledonia North, and November 2021 in Caledonia North plus 2km buffer and Caledonia North Survey Area:

- Three individuals were recorded in Caledonia North in October 2021, resulting in an unapportioned mean abundance estimate of 18 [3; 41] and an apportioned mean abundance estimate of 27 [5; 64] individuals. These equated to mean density estimates of 0.08 (unapportioned) and 0.12 (apportioned) birds/km^2.
- Eight individuals were recorded in Caledonia North plus 2km buffer in November 2021, resulting in an unapportioned mean abundance estimate of 46 [8; 91] and an apportioned mean abundance estimate of 48 [11; 104] individuals. These equated to mean density estimates of 0.12 (unapportioned) and 0.13 (apportioned) birds/km^2.

- Nine individuals were recorded in Caledonia North Survey Area in November 2021, resulting in an unapportioned mean abundance estimate of 53 [12; 105] and an apportioned mean abundance estimate of 57 [12; 116] individuals. Both equated to a mean density estimate of 0.10 birds/km^2.

5.1.3.19 During the non-breeding seasons covered by the baseline surveys, herring gull numbers peaked in November 2021 and December 2022, with numbers steadily growing each month prior to the peak. Both January to March periods covered by the baseline surveys recorded very low numbers of birds. Birds were completely absent from the surveys on a number of occasions. It is considered that Caledonia North Survey Area is situated is of limited importance to this species during the non-breeding season.

5.1.3.20 Low numbers of herring gulls were recorded during the breeding season (April to August) in Caledonia North Survey Area. Peak counts were recorded in July 2022 in Caledonia North and Caledonia North plus 2km buffer, and July 2021 in Caledonia North Survey Area:

- Two individuals were recorded in Caledonia North in July 2022, resulting in an unapportioned and apportioned mean abundance estimate of 12 [2; 23] individuals. This equated to a mean density estimate of 0.05 birds/km^2.
- Three individuals were recorded in Caledonia North plus 2km buffer in July 2022, resulting in an unapportioned mean abundance estimate of 17 [3; 34], and apportioned mean abundance estimate of 17 [6; 34] individuals. Both equated to a mean density estimate of 0.05 birds/km^2.
- 16 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 97 [16; 291] and an apportioned mean abundance estimate of 108 [18; 319] individuals. These equated to mean density estimates of 0.17 (unapportioned) and 0.19 (apportioned) birds/km^2.

5.1.3.21 In both breeding seasons covered by the baseline surveys, apportioned mean herring gull abundances across Caledonia North Survey Area were very low between April to June, with larger (though still modest) numbers of birds present in July. Birds were absent in August 2021 and 2022. This indicates that the area in which Caledonia Survey Area is situated is of limited importance to this species during the breeding season.

5.1.3.22 Measures of precisions were high (indicating lower levels of precision), which is likely related to the low numbers of individuals recorded in each reporting region during each survey (CV >0.16).

Caledonia South

5.1.3.23 A total of 60 herring gulls were recorded in Caledonia South Survey Area during both years of baseline surveys. Herring gulls were recorded in low numbers in Caledonia South Survey Area in June 2021, November 2021 to

February 2022, July 2022, October to December 2022 and February 2023. Herring gulls were the more abundant during the non-breeding season.

5.1.3.24 Peak numbers were recorded in November 2021:

- Six individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 35 [6; 81] and an apportioned mean abundance estimate of 39 [7; 93] individuals. These equated to mean density estimates of 0.17 (unapportioned) and 0.19 (apportioned) birds/km^2.
- Eight individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 46 [8; 97] and an apportioned mean abundance estimate of 51 [14; 121] individuals. These equated to mean density estimates of 0.13 (unapportioned) and 0.14 (apportioned) birds/km^2.
- Eight individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 46 [8; 98] and an apportioned mean abundance estimate of 51 [9; 120] individuals. These equated to mean density estimates of 0.09 (unapportioned) and 0.10 (apportioned) birds/km^2.

5.1.3.25 During the non-breeding seasons covered by the baseline surveys, herring gull numbers peaked in November 2021 and December 2022. Both January to March periods covered by the baseline surveys recorded very low numbers of birds. Birds were completely absent from the surveys on a number of occasions. It is considered that Caledonia South Survey Area is situated is of limited importance to this species during the non-breeding season.

5.1.3.26 Herring gulls were the most abundant during the breeding season in Caledonia South and Caledonia South plus 2km buffer ($n \leq 8$) while a peak number was recorded in July 2022 in Caledonia South Survey Area:

- Four individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 23 [4; 70] and an apportioned mean abundance estimate of 47 [8; 137] individuals. These equated to mean density estimates of 0.11 (unapportioned) and 0.22 (apportioned) birds/km^2.
- Six individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 35 [6; 87] and an apportioned mean abundance estimate of 70 [41; 168] individuals. These equated to mean density estimates of 0.10 (unapportioned) and 0.19 (apportioned) birds/km^2.
- 28 individuals in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 162 [41; 307] and an apportioned mean abundance estimate of 208 [36; 465] individuals. These equated to mean density estimates of 0.30 (unapportioned) and 0.39 (apportioned) birds/km^2.

5.1.3.27 In both breeding seasons covered by the baseline surveys, apportioned mean herring gull abundances across Caledonia South Survey Area were very low between April to June, with larger (though still modest) numbers of birds present in July 2022 (though not July 2021). Birds were absent in August 2021 and 2022. This indicates that the area in which Caledonia Survey Area is situated is of limited importance to this species during the breeding season.

5.1.3.28 Measures of precisions were high (indicating lower levels of precision), which is likely related to the low numbers of individuals recorded in each reporting region during each survey (CV >0.16).

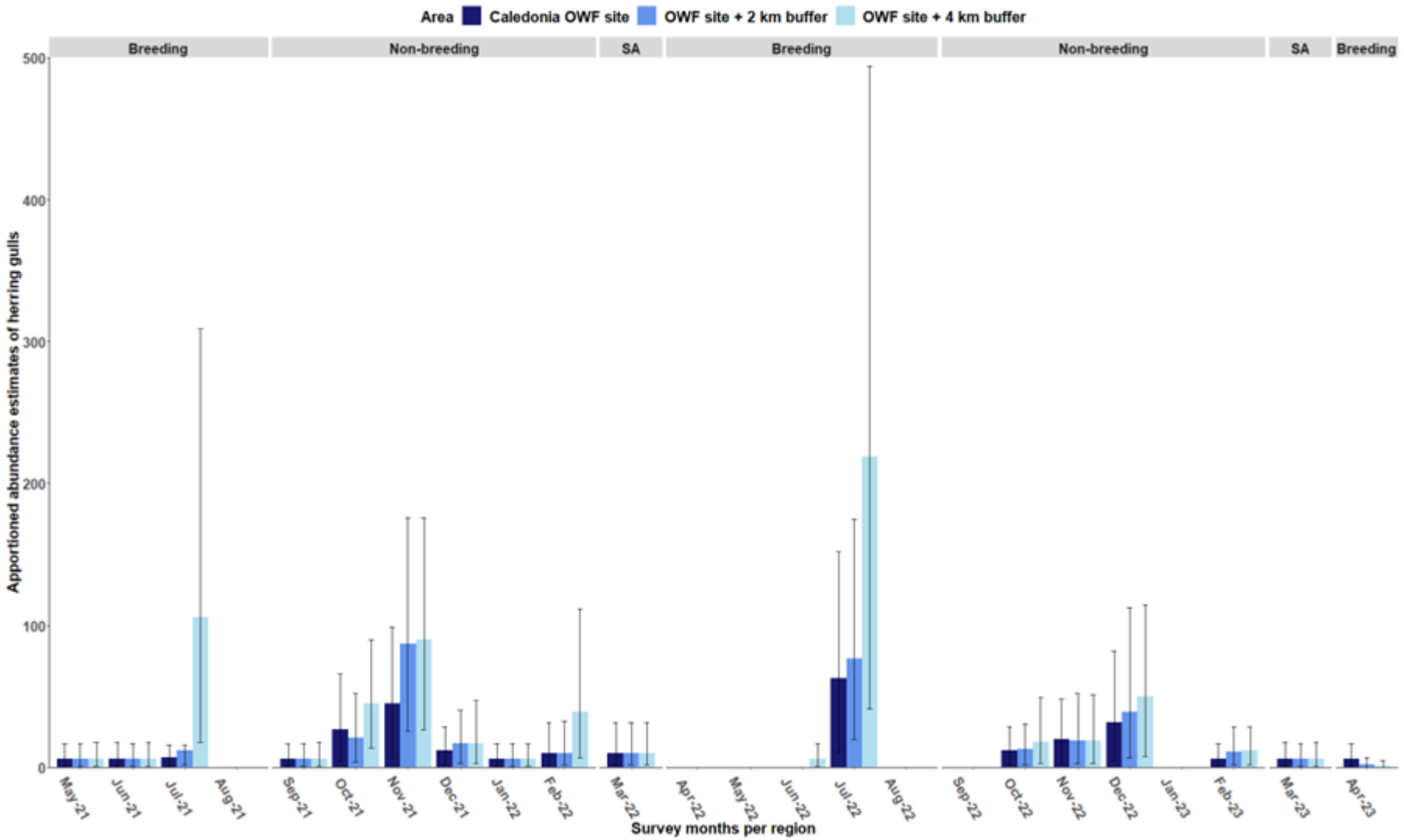


Figure 5-9: Bar plot of monthly apportioned abundance estimates (with 95% confidence intervals) of total herring gulls recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Herring gull seasonal periods are also displayed. SA stands for breeding site attendance.

Spatial Distribution and Flight Direction

Spatial Distribution

5.1.3.29 Herring gull were recorded in the north of Caledonia North in May 2021, March 2022 and 2023, whereas they were recorded in Caledonia South in January 2022. During July 2021, September2021, and October 2021, and June 2022, they were concentrated in the west of Caledonia North, where individuals largely occurred within the 4km Buffer Zone. Herring gulls were loosely distributed across central parts of Caledonia OWF and the 4km Buffer Zone between November and December 2021 as well as December 2022. A more southern distribution was recorded in February 2022 and 2023, July 2022, October 2022, and November 2022.

5.1.3.30 Distribution maps generated using MRSea (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) suggest that herring gull occur in minimal numbers throughout the study area. The highest densities were modelled to be along the southern edge during the first year.

5.1.3.31 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

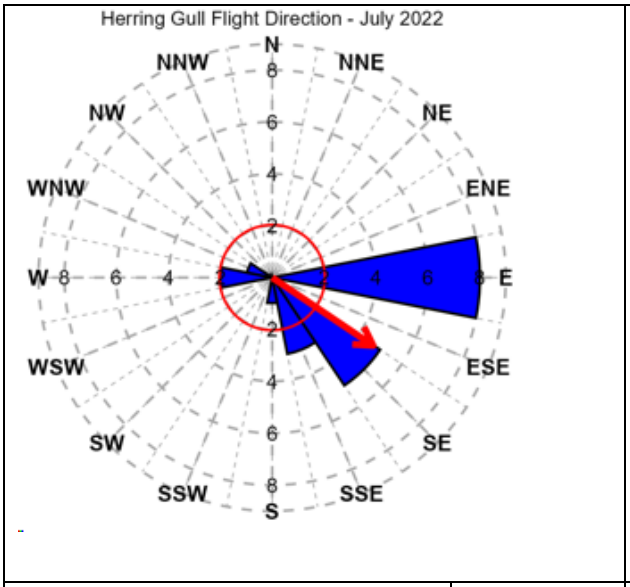
- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

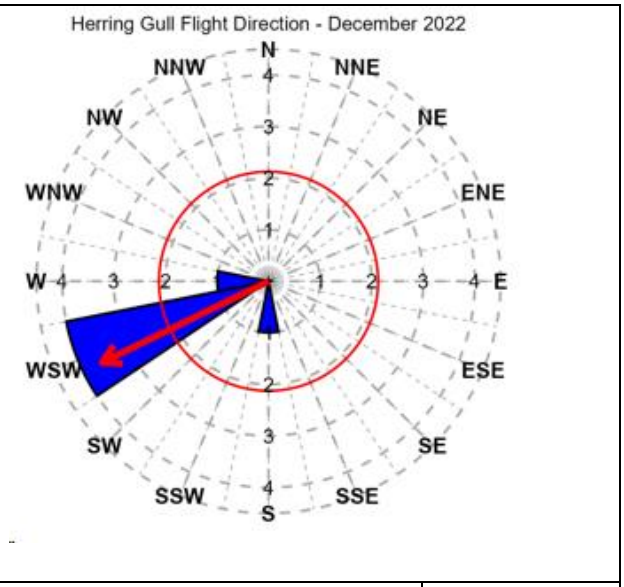
Flight Direction

5.1.3.32 Figure 5-10 presents the flight direction of herring gull within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.1.3.33 Significant predominant direction of flight was recorded in:

- July
  - 2022 southeast
- December
  - 2022 west-southwest

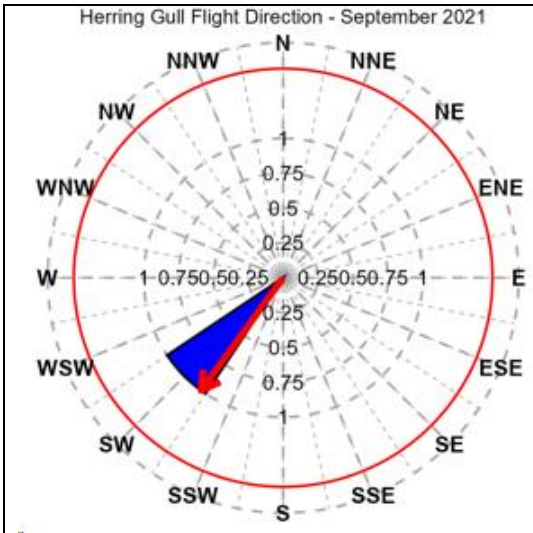


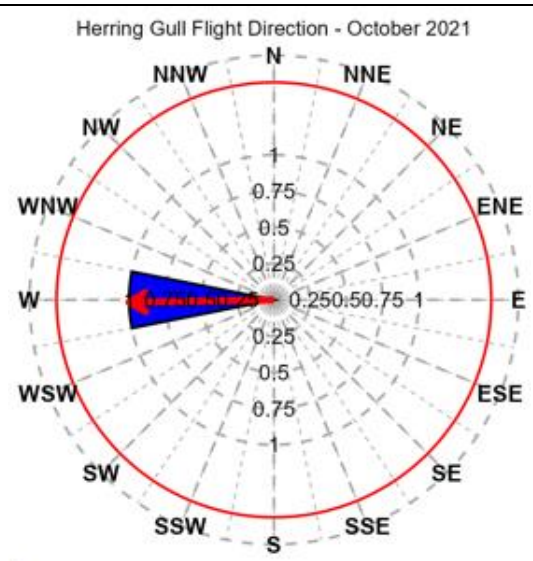


Number of Observations	20	Number of Observations	6
Mean Vector (μ)	124.391	Mean Vector (μ)	244.054
Length of Mean Vector (r)	0.586	Length of Mean Vector (r)	0.897
Rayleigh Test (Z)	6.877	Rayleigh Test (Z)	4.831
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	0.003

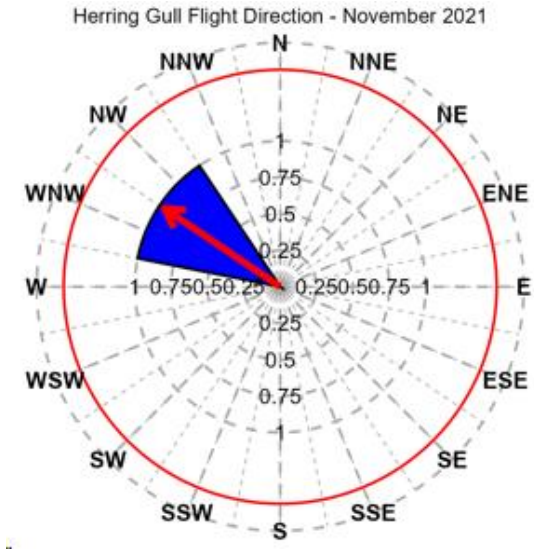
Figure 5-10: Summary of flight direction of herring gull within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

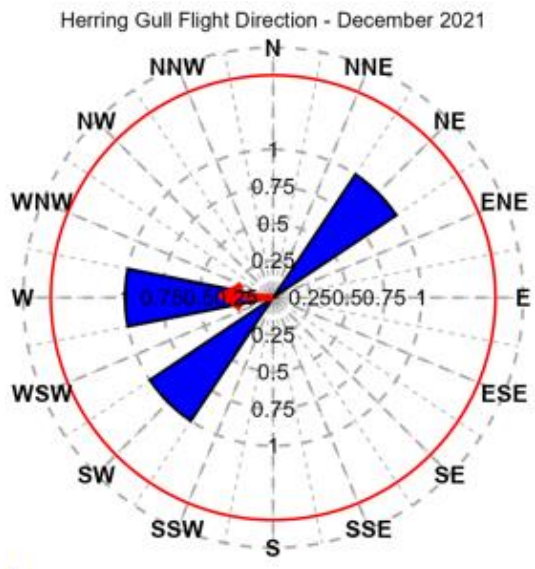
5.1.3.34 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-11).



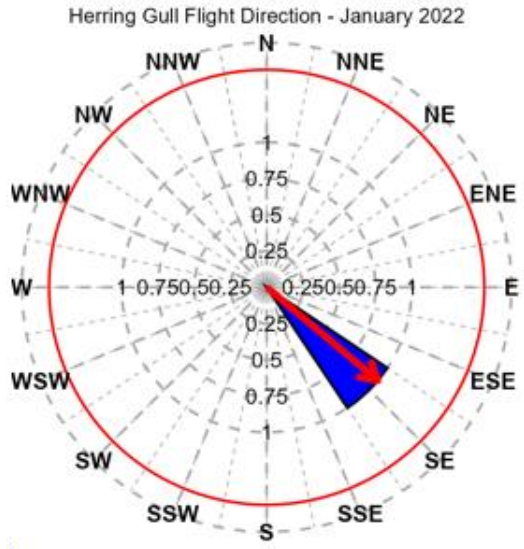


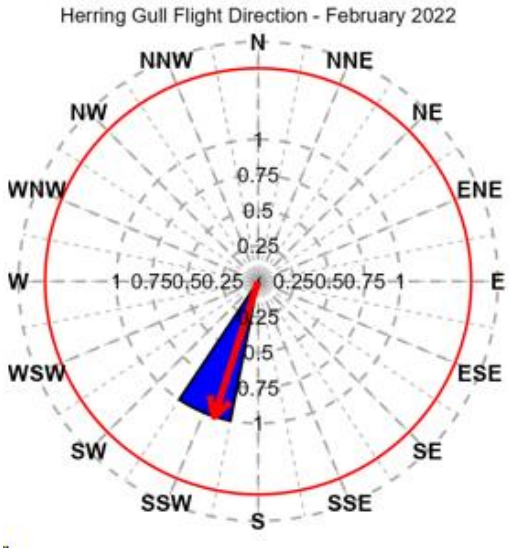
Number of Observations	1	Number of Observations	1
Mean Vector (μ)	216.702	Mean Vector (μ)	269.184
Length of Mean Vector (r)	1.000	Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000	Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512	Rayleigh Test (p)	0.512



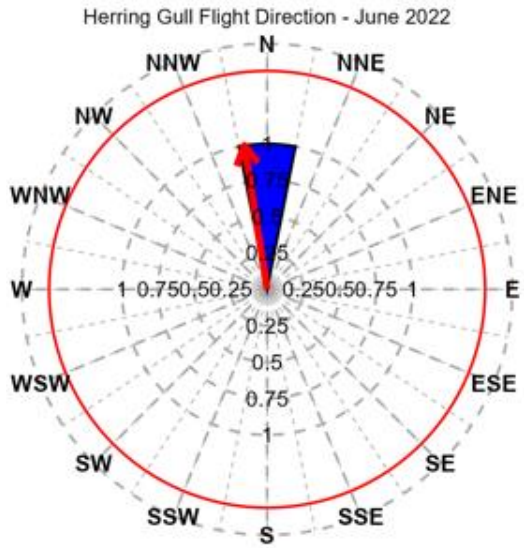


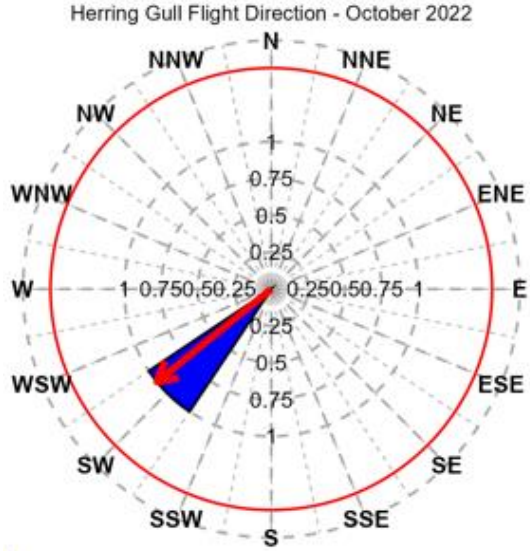
Number of Observations	2	Number of Observations	3
Mean Vector (μ)	304.130	Mean Vector (μ)	272.152
Length of Mean Vector (r)	0.961	Length of Mean Vector (r)	0.343
Rayleigh Test (Z)	1.846	Rayleigh Test (Z)	0.354
Rayleigh Test (p)	0.168	Rayleigh Test (p)	0.737



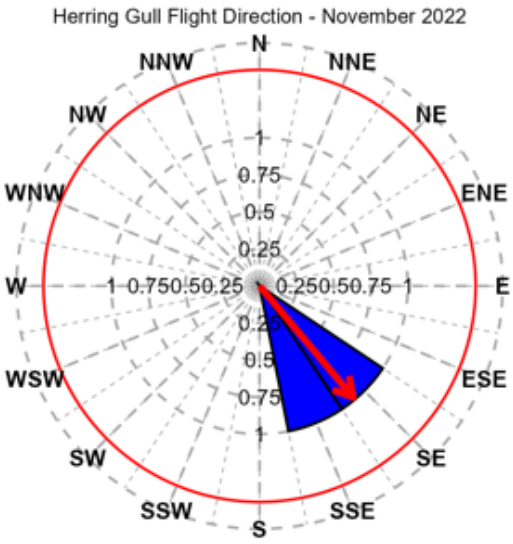


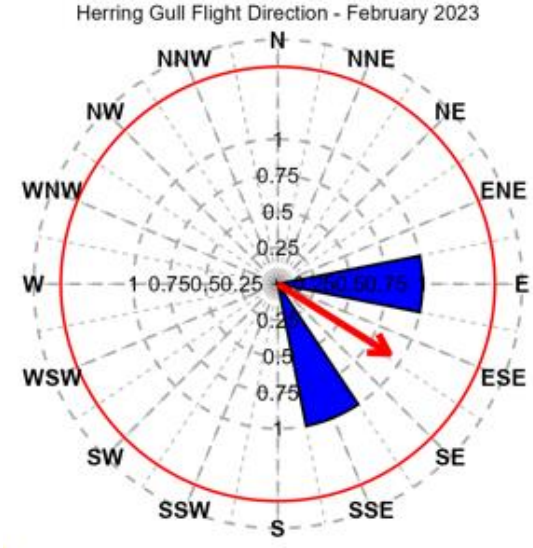
Number of Observations	1	Number of Observations	1
Mean Vector (μ)	130.886	Mean Vector (μ)	198.056
Length of Mean Vector (r)	1.000	Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000	Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512	Rayleigh Test (p)	0.512





Number of Observations	1	Number of Observations	1
Mean Vector (μ)	351.371	Mean Vector (μ)	231.440
Length of Mean Vector (r)	1.000	Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000	Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512	Rayleigh Test (p)	0.512





Number of Observations	2	Number of Observations	2
Mean Vector (μ)	140.560	Mean Vector (μ)	122.846
Length of Mean Vector (r)	0.981	Length of Mean Vector (r)	0.904
Rayleigh Test (Z)	1.924	Rayleigh Test (Z)	1.634
Rayleigh Test (p)	0.152	Rayleigh Test (p)	0.217

Figure 5-11: Summary of flight direction of herring gull within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.1.3.35 As recommended by the NatureScot (2023[1]) guidance, herring gull has been scoped into the assessment for:

- Potential collision risk.

5.1.3.36 As a result, detailed consideration of monthly flying bird density is provided in the following sections.

Density in Flight

5.1.3.37 The monthly density estimates (birds/km^2) of birds in flight used for the assessment of potential collision risk for herring gull have been presented in Table 5–8 and Figure 5-12. The monthly density estimates are used in CRM for the individual assessment within Caledonia OWF, Caledonia North and Caledonia South.

5.1.3.38 No herring gull were recorded in flight during the breeding season (April to August) within Caledonia OWF, Caledonia North and Caledonia South.

5.1.3.39 During the non-breeding season (September to March) the greatest density of herring gull were recorded in December 2022 within Caledonia OWF (0.05 birds/km^2); 0.05 birds/km^2 in December 2021 within Caledonia North and 0.08 birds/km^2 in November 2022 within Caledonia South.

Table 5–8: Estimated densities (birds/km^2) of all flying herring gull across the 24-month survey period for Caledonia OWF, Caledonia North and Caledonia South.

Year	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Caledonia OWF												
1	0	0	0	0	0.01	0.01	0.02	0.03	0.01	0.01	0	0
2	0	0	0	0	0	0	0.03	0.05	0	0.01	0	0
Caledonia North												
1	0	0	0	0	0.03	0.03	0	0.05	0	0	0	0
2	0	0	0	0	0	0	0	0.03	0	0	0	0
Caledonia South												
1	0	0	0	0	0	0	0.03	0	0.03	0.02	0	0
2	0	0	0	0	0	0	0.08	0.07	0	0.03	0	0
Note, estimates calculated using design-based analysis. Data include "no-identification" birds apportioned to species level.												

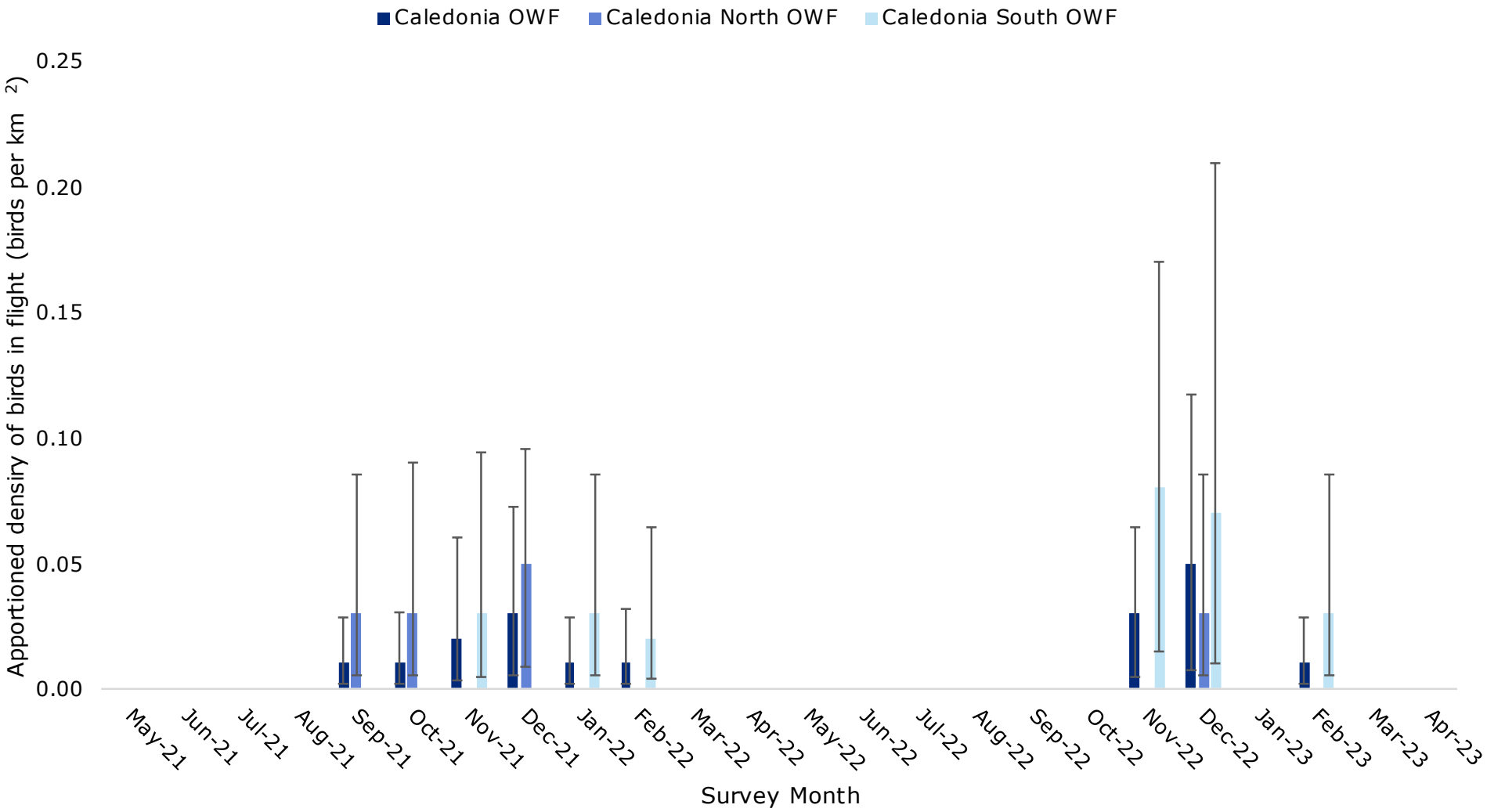


Figure 5-12: Bar plot of monthly apportioned densities (birds/km^2) of flying herring gull (with 95% confidence intervals) recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period.

5.1.4 Lesser Black-backed Gull

Defined Seasons

5.1.4.1 Lesser black-backed gull seasonal definitions are presented in Table 5–9 as per the NatureScot (2020[71]) guidance. Separate BDMPS seasons have been provided as per Furness (2015[48]) (Table 5–10).

Table 5–9: Defined seasons in the Scottish Marine Environment used in the assessment for lesser black-backed gulls (NatureScot, 2020[71]).

Breeding Season	Non-breeding Season
April to August	Not present in significant numbers (in Scottish marine areas)
Time periods in **bold** are those used by the assessment.	

Table 5–10: Non-breeding season BDMPS periods based on Furness (2015)[48] used in the apportionment of lesser black-backed gull to specific populations.

Autumn Migration	Winter Period	Spring Migration	Non-breeding
August to October	**November to February**	**March to April**	September to March
Seasonal definitions used for additional assessment are in **bold**.			
Note, seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–9), with the original definitions as per Furness (201548) provided in parentheses where different.			

Overview

5.1.4.2 Lesser black-backed gull are colonial nesting birds, found on offshore island and inshore freshwater areas, coastal cliffs, sand dunes, salt marshes and on rooftops (Mitchell *et al*., 2004[44]). Roof nesting is widespread around the central Belt and east-coast of Scotland with numbers of urban nesting birds increasing between 1999-2002 (Mitchell *et al*., 2004[44]; Calladine *et al*., 2006[88]), and even more so in recent years, to the extent where over three times more birds are thought to nest in urban areas in Scotland than rural areas (Burnell *et al.,* 2023[83]). NatureScot (2020[71]) define the lesser black-backed gull breeding season as occurring between late March to August.

5.1.4.3 Lesser black-backed gull are generalist feeders able to make use of many food sources near to their breeding locations. They are likely to be affected by the 2015 fishery discard ban in European Union waters and the 2020 UK discard ban (Bicknell *et al*., 2013[91]; HM Government, 2020[93]) due their

consumption of discards (Garthe and Scherp, 2003[96]; Schwemmer and Garthe, 2005[97]). That said, impacts could be offset by a towards other sources of food (Gyimesi *et al*., 2016[100]).

5.1.4.4 Lesser black-backed gull summer distribution is considerably lower in the northern North Sea compared to the southern North Sea (around the Firth Forth) (Waggitt *et al*., 2019[37]). This species has a greater MMF±1SD (236 ± 109km) compared to other large gulls (Woodward *et al*., 2019[56]), with coastal-based individuals feeding primarily out to sea, as demonstrated by their diet (Kubetzki and Garthe, 2003[101]). After the breeding season, lesser black-backed gull migrate to wintering areas in the Bay of Biscay and West Africa (Stone *et al*., 1995[32]), although there has been an increase in number of birds that remain within their breeding range throughout the year (Calladine *et al*., 2006[88]).

Conservation Status

5.1.4.5 This species is Amber listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]) as the UK holds the majority of the global breeding population (Calladine *et al*., 2006[88]).

Vulnerability to Climate Change

5.1.4.6 Lesser black-backed gull are predicted to increase by 9% between 1998-2002 and 2050 under climate change in the INTERREG VA area (Davies *et al*., 2021[39]). The INTERREG VA area will remain a suitable location for the population with this species having a low risk and very high opportunity (with poor confidence) under predicted 2050 climatic condition (Davies *et al*., 2021[39]).

Regional and National Population Trends

5.1.4.7 The total biogeographic population (UK and overseas) is estimated to be 864,000 individuals, with 292,000 individuals in the UK alone (Furness, 2015[48]). Furness (2015[48]) defines lesser black-backed gull biologically relevant seasons as autumn migration (August to October), spring migration (March to April) and migration-free winter (November to February). The population estimate of lesser black-backed gull in the UK North Sea and Channel during the Autumn migration is 209,007 individuals, with 197,483 individuals in the spring migration and in the migration-free winter the population is 39,314 individuals (Furness, 2015[48]).

5.1.4.8 According the BTO (2024[10]), the recent Seabird Count (2015-2021) for lesser black-backed gull reported 21,565 AON, a decrease by 49% since the 2000 Seabird census (1998-2002). According to The Seabirds Count (Burnell *et al*., 2023[83]) there are approximately 49,662 AON in Scotland (combined urban and natural site population, with 38,661 urban nesting

gulls. There is currently no recent productivity data for lesser black-backed gull, with the last productivity rate from 2014 being 0.26 chicks fledges per pair (JNCC, 2021a[102]). However, it is likely that the productivity rates of urban nesting gulls is considerably higher than this (Burnell *et al.,* 2023[83]). The population is considered stable in the West Highland and Forth and Tay region (Scottish Government, 2020[99]).

DAS Baseline Overview

5.1.4.9 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-16 and Table 2-17;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-16 and Table 2-17; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-10 and 2-11.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-15 and Table 2-16;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-14 and Table 2-15; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-9 and Table 2-10.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-15 and Table 2-16;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-15 and Table 2-16; and

- Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-10 and Table 2-11.

Caledonia OWF

5.1.4.10 A total of 12 lesser black-backed gulls were recorded in the Survey Area during both years of baseline surveys. Individuals were only recorded during the breeding season (mid-March to August), in July 2021 and May to July 2022. Peak numbers were recorded in July 2022 across the Survey Area, with four individuals recorded in Caledonia OWF and Caledonia OWF plus 2km buffer, and six individuals recorded in the Survey Area. The latter resulted in an unapportioned mean abundance estimate of 35 [6; 94] and an apportioned mean abundance estimate of 56 [9; 184] individuals. These equated to mean density estimates of 0.04 (unapportioned) and 0.06 (apportioned) birds/km^2.

5.1.4.11 The very low number of lesser black-backed gulls recorded within the Survey Area in both years of surveys indicates a lack of connectivity between the area of sea, in which Caledonia OWF is situated, and the single SPA breeding colony of this species (Forth Islands SPA), which was identified by the HRA Screening Report (Application Document 12: Offshore HRA Screening Report) as potentially having connectivity with Caledonia OWF during the breeding season.

5.1.4.12 Measures of precisions were high (indicating lower levels of precision), which is likely related to the low numbers of individuals recorded in each reporting region during each survey (CV >0.16).

Caledonia North

5.1.4.13 Six lesser black-backed gulls were recorded in Caledonia North Survey Area. In Caledonia North and Caledonia North plus 2km buffer, two individuals were recorded in June 2022. However, peak numbers were recorded in July 2021 in Caledonia North Survey Area with three individuals recorded. The latter resulted in an unapportioned mean abundance estimate of 18 [3; 48] and an apportioned mean abundance estimate of 25 [4; 75] individuals, which equated to mean density estimates of 0.03 (unapportioned) and 0.05 (apportioned) birds/km^2.

5.1.4.14 Measures of precisions were high (indicating lower levels of precision), which is likely related to the low numbers of individuals recorded in each reporting region during each survey (CV >0.16).

Caledonia South

5.1.4.15 Six lesser black-backed gulls were recorded in Caledonia South Survey Area. In Caledonia South and Caledonia South plus 2km buffer, four individuals were recorded in July 2022. However, peak numbers were recorded in July 2022 in Caledonia South Survey Area with six individuals recorded. The latter resulted in an unapportioned mean abundance estimate of 35 [6; 93] and an apportioned mean abundance estimate of 58 [10; 190] individuals, which equated to mean density estimates of 0.07 (unapportioned) and 0.11 (apportioned) birds/km^2.

Spatial Distribution and Flight Direction

Spatial distribution

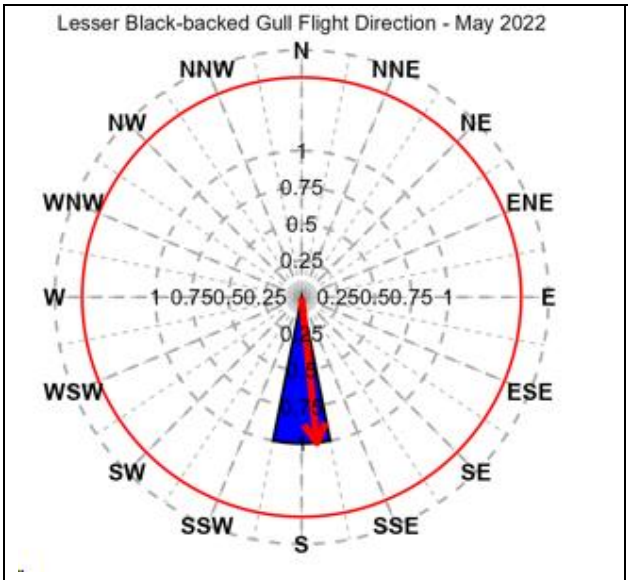
5.1.4.16 Lesser black-backed gulls were recorded in the west of Caledonia North Buffer Zone, towards the southern end of the area occupied by Moray East wind turbines. A single individual occurred in the northeast of Caledonia North Buffer Zone in May 2022, while two lesser black-backed gulls were recorded at the northern tip of Caledonia North in June 2022. In contrast, individuals were concentrated in the southwest of the Survey Area, in southwest of Caledonia South and within the Buffer Zone.

5.1.4.17 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

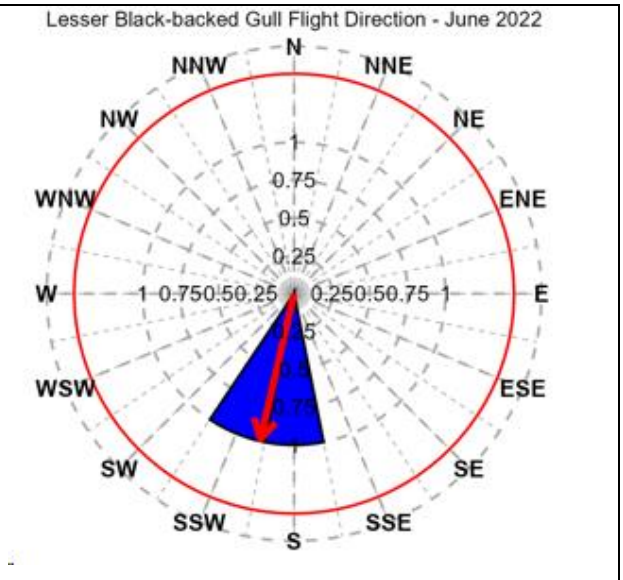
- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

Flight Direction

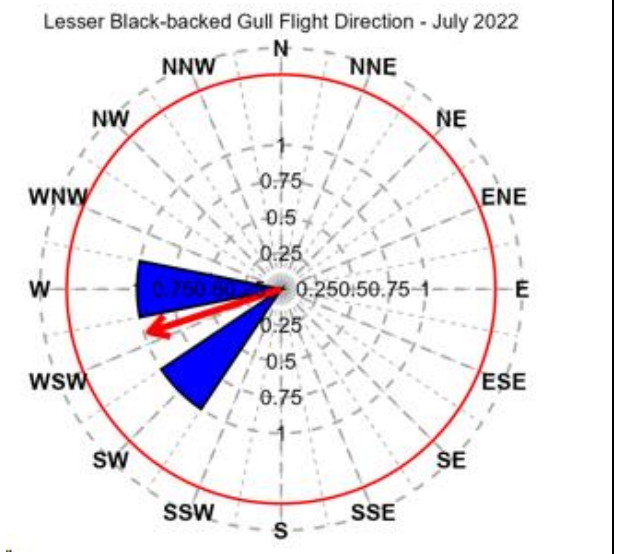
5.1.4.18 As very few birds were recorded in flight, they were too infrequent to determine any preference in flight direction (Figure 5-13).



Number of Observations	1
Mean Vector (μ)	174.117
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512



Number of Observations	2
Mean Vector (μ)	193.852
Length of Mean Vector (r)	0.985
Rayleigh Test (Z)	1.939
Rayleigh Test (p)	0.149



Number of Observations	2
Mean Vector (μ)	252.014
Length of Mean Vector (r)	0.961
Rayleigh Test (Z)	1.848
Rayleigh Test (p)	0.167

Figure 5-13: Summary of flight direction of lesser black-backed gull within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.1.4.19 As recommended by the NatureScot (2023[1]) guidance, lesser black-backed gull has been scoped into the assessment for:

- Potential collision risk.

5.1.4.20 As a result, detailed consideration of monthly flying bird density is provided in the following sections.

Density in Flight

5.1.4.21 The monthly density estimates (birds/km^2) of birds in flight used for the assessment of potential collision risk for lesser black-backed gull have been presented in Table 5–11. The monthly density estimates are used in CRM for the individual assessment within Caledonia OWF, Caledonia North and Caledonia South.

5.1.4.22 No lesser black-backed gull were recorded in flight during the non-breeding season (September to March) within Caledonia OWF; Caledonia North and Caledonia South.

5.1.4.23 During the breeding season (April to August) the greatest density of lesser black-backed gull were recorded in June 2022 within Caledonia OWF (0.03 birds/km^2); 0.05 birds/km^2 in June 2022 within Caledonia North and no lesser black-backed gull were recorded in flight within Caledonia South.

Table 5–11: Estimated densities (birds/km^2) of all flying lesser black-backed gull across the 24-month survey period for Caledonia OWF, Caledonia North and Caledonia South.

Year	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Caledonia OWF												
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0.03	0	0	0	0	0	0	0	0	0	0
Caledonia North												
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0.05	0	0	0	0	0	0	0	0	0	0
Caledonia South												
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
Note, estimates calculated using design-based analysis. Data include "no-identification" birds apportioned to species level.												

5.2 Sternidae

5.2.1 Common Tern

Defined Seasons

5.2.1.1 Common tern seasonal definitions are presented in Table 5–12 as per the NatureScot (2020[71]) guidance. Separate BDMPS seasons have been provided as per Furness (2015[48]) (Table 5–13).

Table 5–12: Defined seasons in the Scottish Marine Environment used in the assessment for common tern (NatureScot, 2020[71]).

Breeding Season	Non-breeding Season
May to mid-September	Not present in significant numbers (in Scottish marine areas)
Time periods in **bold** are those used by the assessment.	

Table 5–13: Non-breeding season BDMPS periods based on Furness (2015)[48] used in the apportionment of common tern to specific populations.

Autumn Migration	Winter Period	Spring Migration	Non-breeding
Late-July to early September	-	**April to May**	September to April
Seasonal definitions used for additional assessment are in **bold**. Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–12), with the original definitions as per Furness (201548) provided in parentheses where different.			

Overview

5.2.1.2 Common tern have a widespread breeding range in the British Isles, extending around coastlines and inland (Mitchell *et al.*, 2004[44]). This species breeding season occurs May to mid-September (NatureScot, 2020[71]). Sandeel are an important prey species for terns around the Shetland Islands (Furness and Tasker, 2000[77]).

5.2.1.3 Tern species are only abundant in the summer (Stone *et al.*, 1995[32]). Common tern tend to forage close to the coast in shallow bays which reflected by their low MMF±SD of 18.0±8.9km (Woodward *et al.*, 2019[56]). The Scottish peak abundances are around the Firth Forth and Moray Firth, with many colonies scattered around Orkney and Shetland (Mitchell *et al.*, 2004[44]). Winter migration to south to west Africa tends to occur from September (Stone *et al.*, 1995[32]).

5.2.1.4 Tern are ground nesting species and are vulnerable mammalian predation (Clode and McDonald, 2002[103]). Predation by American mink (*Neogale vison*) caused decline of productivity for common and Arctic tern in the west of Scotland (1992 to 1993) (Criak, 1995,[104]; 1997[105]). Furthermore, common tern are vulnerable to severe weather, reduced prey availability (albeit less than Arctic tern) and human disturbance at nesting sites (Furness and Tasker, 2000[77]; Green, 2017[106]; Thompson *et al*., 1999[107]). Common tern around Shetland were more capable to switch prey items compared to Arctic tern in periods of low sandeel abundance in 1988 (Uttley *et al*., 1989[108]).

Conservation Status

5.2.1.5 Common tern is currently Amber-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]).

Vulnerability to Climate Change

5.2.1.6 Common tern populations are predicted to increase by 4% between 1998-2002 and 2050 under the climate change scenarios modelled in the INTERREG VA area (Davies *et al*., 2021[39]). The INTERREG VA area will continue to represent a suitable location for the population with this species having a low risk and very high opportunity (with poor confidence) under potential 2050 climatic conditions (Davies *et al*., 2021[39]).

Regional and National Population Trends

5.2.1.7 For common tern, the Seabirds Count (2015-2021) reported approximately 4,071 AON in Scotland, a decline of 23% AON since the Seabird 2000 count (1998-2002) (Burnell *et al*., 2023[83]). This contrasts with Scottish Government (2020[99]), which considers breeding common tern to be an increasing population at the national level, based on population estimates from 2011-2018. It is considered that Burnell *et al.* (2023[83]) provides the more accurate picture of common tern population trends.

5.2.1.8 The biogeographic population (UK and overseas) of common tern is 480,000 individuals, with 40,000 individuals estimated from the UK alone (Furness, 2015[48]). Furness (2015[48]) defined this species migration seasons to be autumn migration (late July to early September) and spring migration (April to May). The common tern migration population is estimated to be 144,911 in the UK North Sea and Channel (Furness, 2015[48]).

5.2.1.9 When examining the regional populations of common tern, the potential impacts of HPAI should be considered as common tern are known to vulnerable to disease. This statement is supported by an assessment of colony counts undertaken by the RSPB following the first outbreak of HPAI (2021-2022 outbreak), as the total number of common tern across all sites surveyed in 2023 (40% of the UK population of breeding common tern was

surveyed) decreased by 42% compared to the pre-HPAI baseline count for these colonies (from 4,913 to 2,867 AON) (Tremlett *et al*., 2024[84]). Yet, it is important to note that counts made by the RSPB in 2023 were undertaken prior to the further 2023 HPAI outbreak. Therefore, it is extremely likely that updated counts are required for this species to improve evidence and update the baseline characterisation for impacts.

DAS Baseline Overview

5.2.1.10 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-20 and Table 2-21; and
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-20 and Table 2-21.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-19 and Table 2-20; and
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-17 and Table 2-18.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-19 and Table 2-20; and
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-19 and Table 2-20.

Caledonia OWF

5.2.1.11 Three common tern were recorded in the Survey Area during the first year of the baseline surveys, and none in the second year. Common terns were recorded in the August 2021 survey only, specifically within Caledonia North. Abundance and density estimates were therefore very low. Although no common terns were definitively identified in August 2022, apportioning of 'commic' terns gave an abundance estimate of 6 [1; 17] in Caledonia OWF and all reporting region within Caledonia North Survey Area.

5.2.1.12 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region.

Caledonia North

5.2.1.13 Three common tern were recorded in the Caledonia North during the first year of the baseline surveys (August 2021), and none in the second year. Abundance and density estimates were therefore very low. Although no common terns were definitively identified in August 2022, apportioning of 'commic' terns gave an abundance estimate of 6 [1; 17] in Caledonia OWF and all reporting region within Caledonia North Survey Area.

5.2.1.14 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region.

Caledonia South

5.2.1.15 No common tern were recorded in Caledonia South.

Spatial Distribution and Flight Direction

Spatial Distribution

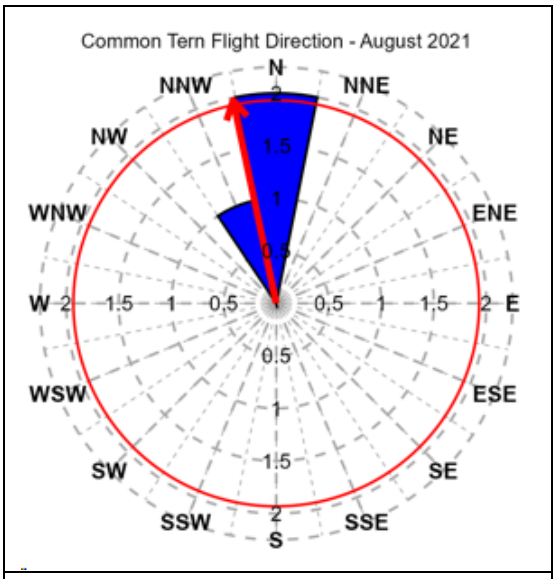
5.2.1.16 In August 2021, all common terns were recorded in the southwest of Caledonia North towards the boundary between Caledonia South within the 4km Buffer Zone.

5.2.1.17 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

Flight Direction

5.2.1.18 Common tern recorded in flight had a predominant direction of north-northwest (Figure 5-14).



Number of Observations	3
Mean Vector (μ)	348.854
Length of Mean Vector (r)	0.987
Rayleigh Test (Z)	2.923
Rayleigh Test (p)	0.038

Figure 5-14: Summary of flight direction of common terns within surveys where a significant direction was recorded during May 2021 and April 2023 survey period.

Predicted Impacts

5.2.1.19 Common tern have not been scoped in for the assessment of potential collision risk due their low presence within the 24-month surveys.

5.2.2 Arctic Tern

Defined Seasons

5.2.2.1 Arctic tern seasonal definitions are presented in Table 5–14 as per the NatureScot (2020[71]) guidance. Separate BDMPS seasons have been provided as per Furness (2015[48]) (Table 5–15).

Table 5–14: Defined seasons in the Scottish Marine Environment used in the assessment for Arctic tern (NatureScot, 2020[71]).

Breeding Season	Non-breeding Season
May to August	Not present in significant numbers (in Scottish marine areas)
Time periods in **bold** are those used by the assessment.	

Table 5–15: Non-breeding season BDMPS periods based on Furness (2015)[48] used in the apportionment of Arctic tern to specific populations.

Autumn Migration	Winter Period	Spring Migration	Non-breeding
July to early September	-	**April to May**	May to early-August
Seasonal definitions used for additional assessment are in **bold**. Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–14), with the original definitions as per Furness (201548) provided in parentheses where different.			

Overview

5.2.2.2 Arctic tern are the most abundant tern species breeding in the UK (Mitchell *et al*., 2004[44]; Burnell *et al.,* 2023[83]). Their population is particularly concentrated in the Northern Isles due to their preference for breeding at higher latitudes than other tern species (Mitchell *et al*., 2004[44]; Stone *et al*., 1995[32]; Burnell *et al.,* 2023[83]).

5.2.2.3 The northern North Sea is an important area for tern species during the breeding season, since they are found moderate to high densities in this area (Stone *et al*., 1995[32]; Waggitt *et al.,* 2019[37]). Arctic tern have a low MMF±SD of 25.7±14.8km, travelling slightly further from breeding colonies when compared to common tern (Woodward *et al*., 2019[56]). After the breeding season, Arctic tern has a very long-distance winter migration, wintering in Antarctic (Fijn *et al*., 2013[109]).

Conservation Status

5.2.2.4 This species is Amber listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]).

Vulnerability to Climate Change

5.2.2.5 Arctic tern populations are projected to decline by 75% under modelled 2050 climate condition in the INTERREG VA area (based on the Seabird 2000 estimates) (1998-2002) (Davies *et al*., 2021[39]). MarPAMM predict (with moderate confidence) that Arctic tern have a high vulnerability to climate change (Davies *et al*., 2021[39]).

Regional and National Population Trends

5.2.2.6 For Arctic tern, the Seabirds Count (2015-2021) reported 19,555 AON in Scotland, a decline of 54% AON since the Seabird 2000 count (1998-2002) (Burnell *et al*., 2023[83]). Arctic tern reached their lowest abundance recorded since monitored in 2011, with some gradual increase between 2014 and 2018 until 2019 which was 57% below the 1986 baseline (Scottish Government, 2020[99]; JNCC, 2021b[110]).

5.2.2.7 The estimated Arctic tern population size with biogeographic connectivity to UK waters is estimated to be 158,000 individuals, with the total biogeographic population (UK and overseas) estimated to be 628,000 individuals (Furness, 2015[48]). Arctic tern has a migration BDMPS comprising of autumn migration (July to early-September) and spring migration (April to May) (Furness, 2015[48]). During the migration BDMPS, the population in the UK North Sea and Channel is estimated to be 163,930 individuals (Furness, 2015[48]).

5.2.2.8 When examining the regional populations of Arctic tern, the potential impacts of HPAI should be considered as Arctic tern are known to vulnerable to disease. An assessment of colony counts undertaken by the RSPB following the first outbreak of HPAI (2021-2022 outbreak) estimated that the total number of Arctic tern across all sites surveyed in 2023 (31% of the UK population of breeding common tern was surveyed) decreased by 2% compared to the pre-HPAI baseline count for these colonies (from 7,291 to 7,179 AON) (Tremlett *et al.*, 2024[84]). However, trends were highly variable by colony. It is important to note that counts made by the RSPB in 2023 were undertaken prior to the further 2023 HPAI outbreak. Therefore, it is extremely likely that updated counts are required for this species to improve evidence and update the baseline characterisation for impacts.

DAS Baseline Overview

5.2.2.9 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-22 and Table 2-23; and
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-22 and Table 2-23.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-21 and Table 2-22; and
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-19 and Table 2-20.

- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-21 and Table 2-22; and
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-21 and Table 2-22.

Caledonia OWF

5.2.2.10 A total of 15 Arctic terns were recorded in the Survey Area during the baseline surveys, three individuals in Caledonia North Survey Area and 12 individuals in Caledonia South Survey Area. All records were made within the breeding season for this species (May to August), though the low numbers of birds recorded indicates that the Survey Area is of limited importance to this species. Arctic terns were recorded only in the 2km and 4km Buffer Zones, with none recorded in Caledonia OWF, and subsequently in Caledonia North and Caledonia South. Despite this, some apportioned unidentified terns ('commic' tern and/or tern species) within Caledonia OWF mean that low abundances of Arctic tern were reported in Caledonia OWF during the May 2022 survey. Peak numbers of Arctic terns were recorded in May 2021 in the Survey Area, with 9 individuals, resulting in an unapportioned mean abundance estimate of 53 [12; 117] and an apportioned mean abundance estimate of 77 [16;188] individuals. These equated to mean density estimates of 0.06 (unapportioned) and 0.09 (apportioned) birds/km^2.

5.2.2.11 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region (CV >0.16).

Caledonia North

5.2.2.12 A peak of three individuals was recorded in Caledonia North Survey Area. This resulted in an unapportioned and apportioned mean abundance estimate of 18 [3; 41-47] individuals, which equated to a mean density estimate of 0.03 birds/km^2.

5.2.2.13 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region (CV >0.16).

Caledonia South

5.2.2.14 In Caledonia South Survey Area, six individuals were recorded in May 2021 and August 2022. In May 2021, this resulted in an unapportioned mean abundance estimate of 35 [6; 99] and apportioned mean abundance estimate of 58 [10; 162] individuals. These equated to mean density estimates of 0.07 (unapportioned) and 0.11 (apportioned) birds/km^2. In August 2022, the six individuals resulted in an unapportioned mean abundance estimate of 34 [6; 75] and apportioned mean abundance

estimate of 74 [13; 155] individuals. These equated to mean density estimates of 0.06 (unapportioned) and 0.14 (apportioned) birds/km^2.

5.2.2.15 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region (CV >0.16).

Spatial Distribution and Flight Direction

Spatial distribution

5.2.2.16 Arctic tern were recorded with the Caledonia OWF 4km Buffer Zone in both in May 2021 and August 2022. This species was recorded in the northeast and south of the Caledonia OWF 4km Buffer Zone in May whereas in August this species was only in Caledonia South 4km Buffer Zone, primarily in the east and south of the 4km Buffer zone.

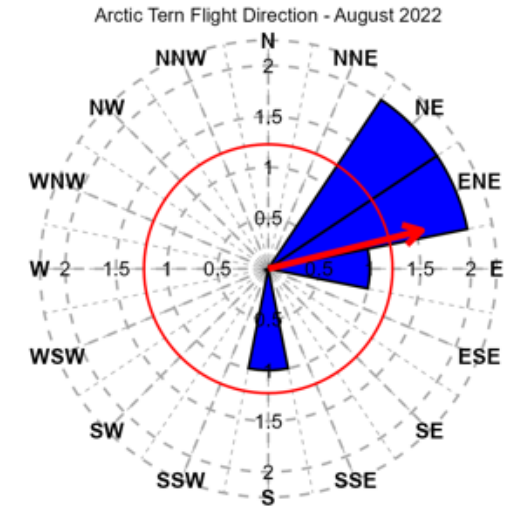
5.2.2.17 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

Flight Direction

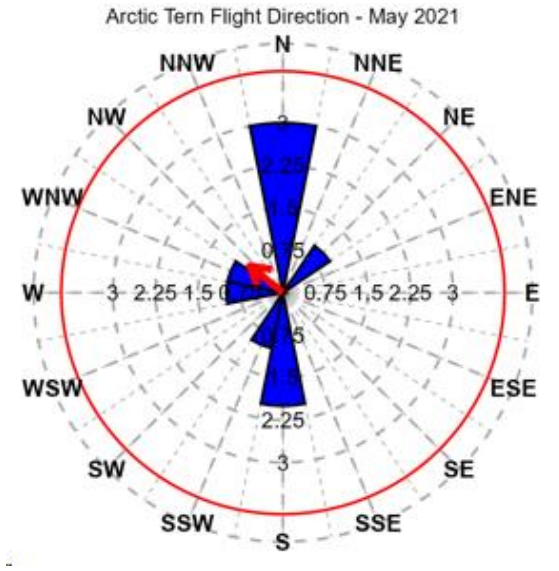
5.2.2.18 In August 2022, Arctic tern were recorded flying in a significant east-northeasterly direction (Figure 5-15).

5.2.2.19 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-16).



Number of Observations	6
Mean Vector (μ)	76.705
Length of Mean Vector (r)	0.778
Rayleigh Test (Z)	3.636
Rayleigh Test (p)	0.019

Figure 5-15: Summary of flight direction within survey where a significant flight direction was recorded during the May 2021 to April 2023 survey period.



Number of Observations	9
Mean Vector (μ)	309.774
Length of Mean Vector (r)	0.251
Rayleigh Test (Z)	0.565
Rayleigh Test (p)	0.582

Figure 5-16: Flight direction of Arctic terns during the survey period.

Predicted Impacts

5.2.2.20 Arctic tern have not been scoped in for the assessment of potential collision risk due their low presence within the 24-month surveys.

5.3 Stercorariidae

5.3.1 Great Skua

Defined Seasons

5.3.1.1 Great skua seasonal definitions are presented in Table 5–16 as per the NatureScot (2020[71]) guidance. Separate BDMPS seasons have been provided as per Furness (2015[48]) (Table 5–17).

Table 5–16: Defined seasons in the Scottish Marine Environment used in the assessment for great skua (NatureScot, 2020[71]).

Breeding Season	Non-breeding Season	Pre-breeding Migration Season
Mid-April to Mid-September	**Mid-September to Mid-April**	Early April
Time periods in **bold** are those used by the assessment.		

Table 5–17: Non-breeding season BDMPS periods based on Furness (2015[48]) used in the apportionment of great skua to specific populations.

Autumn Migration	Winter Period	Spring Migration
Mid-September to October (August to October)	**November to February**	**March to Mid-April** (March to April)
Seasonal definitions used for additional assessment are in **bold**. Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–16), with the original definitions as per Furness (2015[48]) provided in parentheses where different.		

Overview

5.3.1.2 Great skua are highly territorial, with a restricted breeding range confining skuas to the northeast Atlantic (Mitchell *et al.,* 2004[44]). During the Seabird 2000 census there were 16,000 breeding pairs worldwide, with 60% of these located in Scotland (Mitchell *et al*., 2004[44]). More recently, Burnell *et al.* (2023[83]) estimated the breeding Scottish population to be 10,935 territories. Great skua distribution is concentrated in Shetland and Orkney with peak abundance in breeding season (Mitchell *et al*., 2004[44]; Waggitt *et*

al., 2019[37]), and have an extensive MMF±SD of 443.3±487.9km (Woodward *et al*., 2019[56]). Great skua from Scotland tend to disperse in the winter off to northwest Africa and southern Europe (Magnusdottir *et al*., 2012[111]; Waggitt *et al*., 2019[37]).

5.3.1.3 NatureScot (2020[71]) described the great skua breeding season to be late April to early September. In Shetland great skua are generalist feeders, with some specialised individuals feeding on mostly either sandeels, fish discards or birds (Votier *et al*., 2004[112]).

5.3.1.4 Great skua have been listed to extensively exploit fishery discards (Bicknell *et al*., 2013). In Shetland, the sandeel stock reduced significantly between 1973-2017, which can cause prey switching in great skua to discarded whitefish and an increasing proportion of other seabirds in their diet (Church *et al*., 2019[113]). Similar to herring gull, gannet and great black-back gull, this species is likely to be impacted by the 2015 discard ban in European Union waters and the 2020 UK discard ban (Bicknell *et al*., 2013[91]; HM Government, 2020[93]).

Conservation Status

5.3.1.5 This species is currently Amber-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]).

Vulnerability to Climate Change

5.3.1.6 Great skua were listed as a high concern to climate change (Burthe *et al*., 2014[114]). Oswald (2005[115]) found that great skua are likely to be affected to reduced prey availability caused by climate change. Great skua is a cold-adapted species which suffer from heat stress during warm weather. Climate change indirectly affects prey availability to birds while also inducing heat stress on adults (Oswald *et al*., 2008[116]). In response to heat stress, skuas are increasing time spent bathing compared to other activities such as foraging and nest attendance (Oswald *et al*., 2008[116]). In addition, climate change is likely to further reduce their access to breeding habitats and their distribution (JNCC, 2021c[117]).

Regional and National Population Trends

5.3.1.7 According to The Seabirds Count (Burnell *et al*., 2023[83]), the Scottish population of breeding great skua was 10,935 apparently occupied territories (AOT), an increase of 14% since the Seabird 2000 Census (1998-2002). Great skua in Shetland are considered to have a stable population, although productivity has been poor in recent years (0.34 chicks per pair in 2018) with fluctuation between years (Scottish Government, 2020[99]).

5.3.1.8 Great skua populations in the UK have been severely affected by HPAI in recent years. should be considered as great skua are known to be highly

vulnerable to disease. Following the first outbreak of HPAI (2021-2022 outbreak), the total number of great skua across all sites surveyed in 2023 (81% of the UK population of breeding great skua was surveyed) decreased by 76% compared to the pre-HPAI baseline count (from 9,088 to 2,160 AOTs) (Tremlett *et al*., 2024[84]). It is important to note that counts made by the RSPB in 2023 were undertaken prior to the further 2023 HPAI outbreak. Therefore, it is extremely likely that updated counts are required for this species to improve evidence and update the baseline characterisation for impacts.

5.3.1.9 The total biogeographical population (UK and overseas) of great skua with connectivity to UK waters is estimated to 73,000 individuals, including 43,000 individuals (adults and immatures) from the UK alone (Furness, 2015[48]). The non-breeding season is defined as late September to early April (NatureScot, 2020[71]). The seasonal definitions adapted from Furness (2015)[48] biologically defined minimum population scales (BDMPS) to align with the NatureScot (2020[71]) seasonal period for great skua are autumn migration (mid-September), spring migration (March to early April) and migration-free winter (November to February) (Table 5–17). Their autumn migration is estimated to be 19,556 individuals, with 8,485 individuals in their spring migration, and 143 during migration-free winter (Furness, 2015[48]).

DAS Baseline Overview

5.3.1.10 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-24 and Table 2-25;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-24 and Table 2-25; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-14 and Table 2-15.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-23 and Table 2-24;

- Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-21 and Table 2-22; and
- Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-13 and Table 2-14.

- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-23 and Table 2-24;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-23 and Table 2-24; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-13 and Table 2-14.

5.3.1.11 Figure 5-17 presents the abundance of great skua (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia North and Caledonia South, and separately for the OWF+2km and OWF+4km reporting regions.

Caledonia OWF

5.3.1.12 A total of 22 great skuas were recorded in the Survey Area during both years of baseline surveys. Only two great skuas were recorded during the second year of surveys. All records of great skuas were made during the breeding season (mid-April to mid-September).

5.3.1.13 Peak numbers were recorded in July 2021:

- Four individuals were recorded in Caledonia OWF, resulting in an unapportioned and apportioned mean abundance estimates of 24 [4; 65-71] individuals. Both equated to a mean density estimate of 0.06 birds/km^2.
- Six birds were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned and apportioned mean abundance estimate of 35 [6; 93-99] individuals. Both equated to a mean density estimate of 0.05 birds/km^2.
- Ten individuals were recorded in the Survey Area, resulting in an unapportioned and apportioned mean abundance estimates of 60 [4; 65-71] individuals. Both equated to a mean density estimate of 0.07 birds/km^2.

5.3.1.14 Whilst present within the Survey Area during both breeding seasons, the trends observed for great skua abundance in this seasonal period were characterised by relatively consistent and low apportioned mean abundances across all reporting regions. Birds were recorded much more frequently in the 2021 breeding season than in the 2022 breeding season.

5.3.1.15 Great skuas were not recorded during the non-breeding season (mid-September to mid-April).

5.3.1.16 Measures of precision were high in all surveys in which this species was recorded, which is likely related to the low numbers of individuals recorded in each region (CV >0.16).

Caledonia North

5.3.1.17 A total of 16 great skuas were recorded in Caledonia North Survey Area during both years of baseline surveys, with only two of these being recorded during the second year of surveys. The peak count was recorded in August 2021:

- Three individuals were recorded in Caledonia North, resulting in an unapportioned and apportioned mean abundance estimate of 17 [3; 41] individuals. Both equated to a mean density estimate of 0.08 birds/km^2.
- Four individuals were recorded in Caledonia North plus 2km, resulting in an unapportioned and apportioned mean abundance estimate of 23 [4; 57] individuals. Both equated to a mean density estimate of 0.06 birds/km^2.
- Six individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned and apportioned mean abundance estimate of 35 [6; 75] individuals. Both equated to a mean density estimate of 0.06 birds/km^2.

5.3.1.18 Whilst present within Caledonia North Survey Area during both breeding seasons, the trends observed for great skua abundance in this seasonal period were characterised by relatively consistent and low apportioned mean abundances across all reporting regions. Great skuas were recorded much more frequently in the 2021 breeding season than in the 2022 breeding season.

5.3.1.19 Great skuas were absent during the non-breeding season (mid-September to mid-April).

5.3.1.20 Measures of precisions were high, which is likely related to the low numbers of individuals recorded in each region (CV >0.16).

Caledonia South

5.3.1.21 A total of 11 great skuas were recorded in Caledonia South Survey Area during both years of baseline surveys, with a single individual recorded in 2022. All records of great skuas were made, in low numbers, during the breeding season (between mid-April to mid-September. Peak numbers were recorded in July 2021:

- Three individuals were recorded in Caledonia South, resulting in an unapportioned and apportioned mean abundance estimate of 18 [3; 53] individuals. Both equated to a mean density estimate of 0.09 birds/km^2.
- Five individuals were recorded in Caledonia South plus 2km, resulting in an unapportioned and apportioned mean abundance estimate of 30 [5; 90] individuals. Both equated to a mean density estimate of 0.08 birds/km^2.
- Five individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned and apportioned mean abundance estimate of 30 [5; 90] individuals. Both equated to a mean density estimate of 0.06 birds/km^2.

5.3.1.22 Whilst present within Caledonia South Survey Area during both breeding seasons, the trends observed for great skua abundance in this seasonal period were characterised by relatively consistent and low apportioned mean abundances across all reporting regions. Great skuas were recorded much more frequently in the 2021 breeding season than in the 2022 breeding season.

5.3.1.23 Great skuas were recorded absent during the non-breeding season (mid-September to mid-April).

5.3.1.24 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region (CV >0.16).

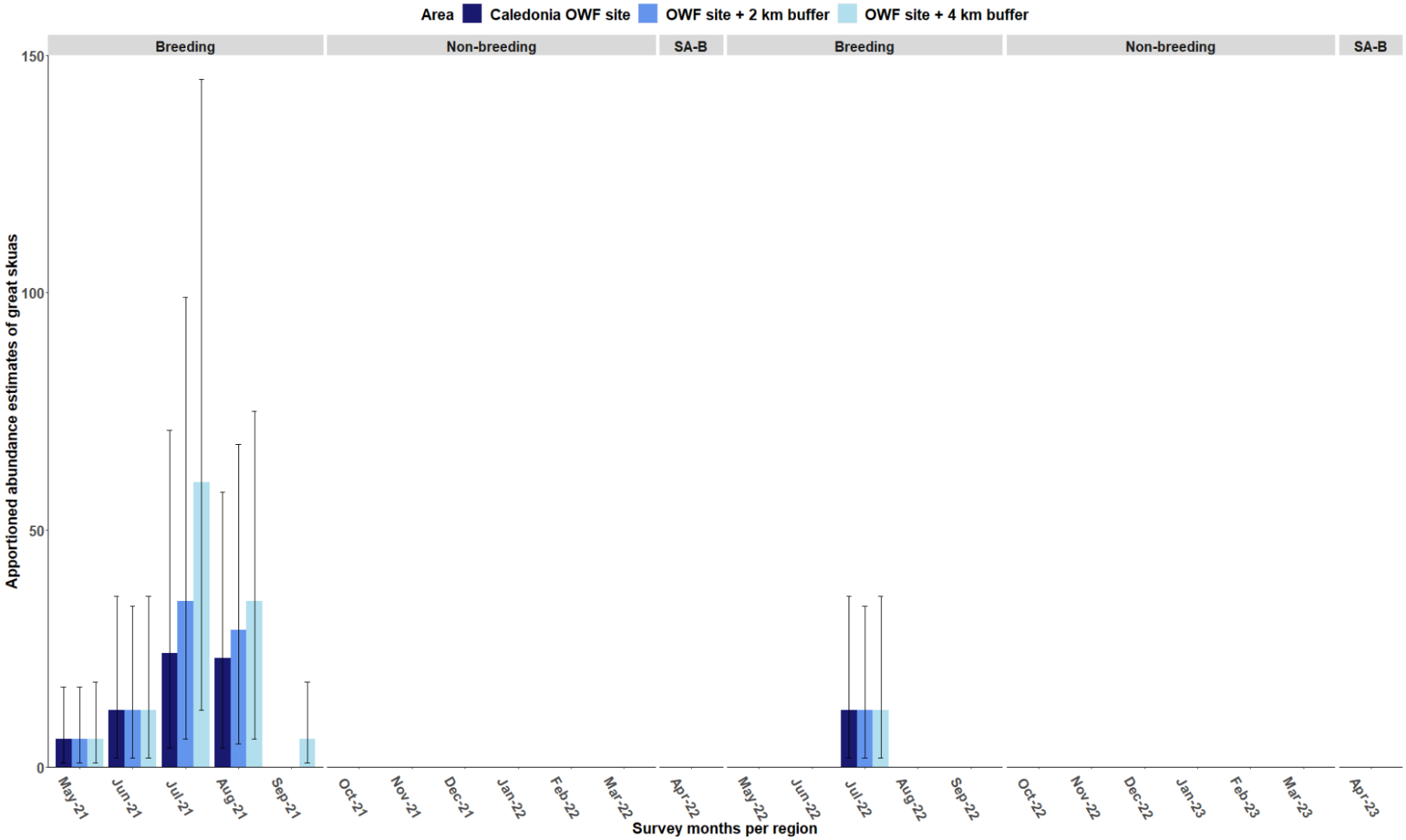


Figure 5-17: Bar plot of the monthly apportioned abundances estimates (with 95% confidence intervals) of total great skuas recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Great skua seasonal periods are also displayed. SA-B corresponds to month split between breeding site attendance (SA) and breeding (B).

Spatial Distribution and Flight Direction

Spatial Distribution

5.3.1.25 In May and June 2021, great skua were recorded within Caledonia North. They were recorded both in northern and southern parts of the Caledonia OWF (plus a 4km buffer) during July 2021 and August 2021 with highest numbers across Caledonia North Survey Area. In September 2021, a single great skua was recorded in the south of the Caledonia South 4km buffer. Two individuals were recorded in the centre of the Caledonia OWF (plus a 4km buffer) in July 2022, one individual was recorded within Caledonia North and one within Caledonia South.

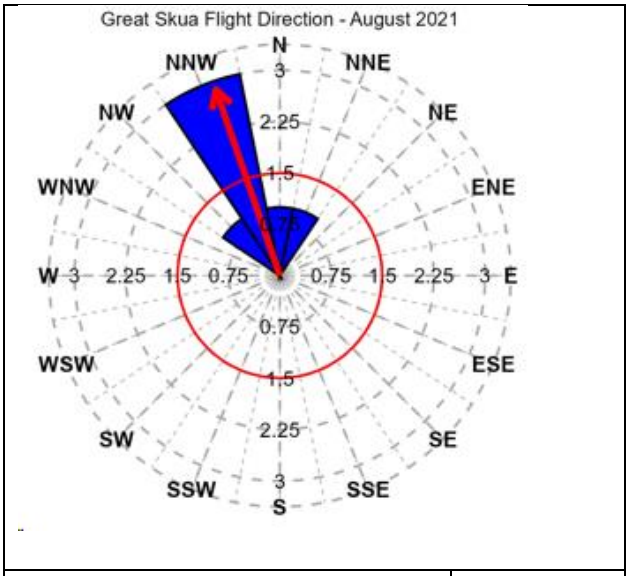
5.3.1.26 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

Flight Direction

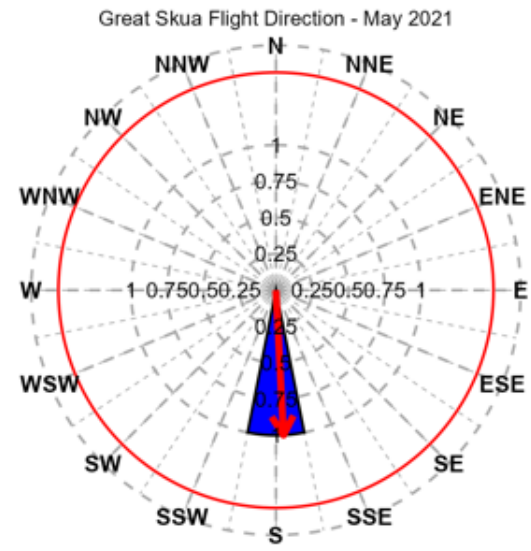
5.3.1.27 In August 2021, great skua were recorded flying in a significantly north-northwest direction (Figure 5-18). The number of great skuas recorded in flight in any other months were too low to determine a significant flight direction.

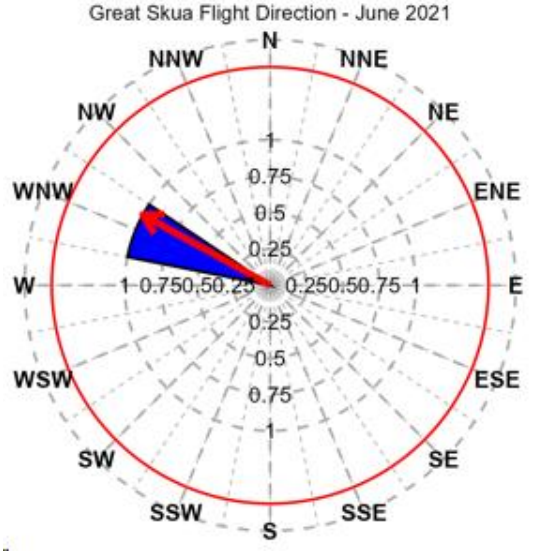
5.3.1.28 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-19).



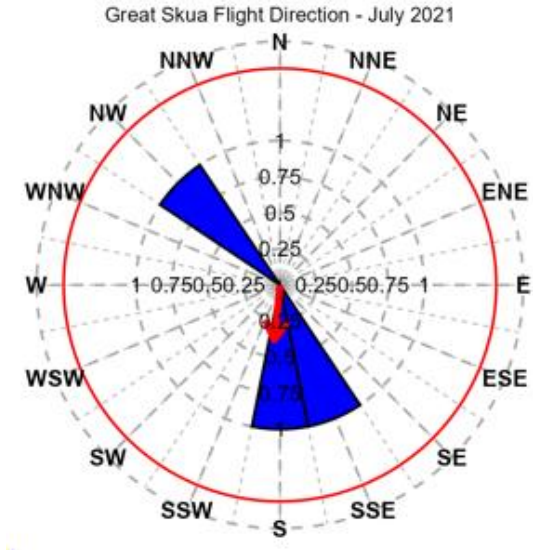
Number of Observations	6
Mean Vector (μ)	341.279
Length of Mean Vector (r)	0.957
Rayleigh Test (Z)	5.499
Rayleigh Test (p)	<0.001

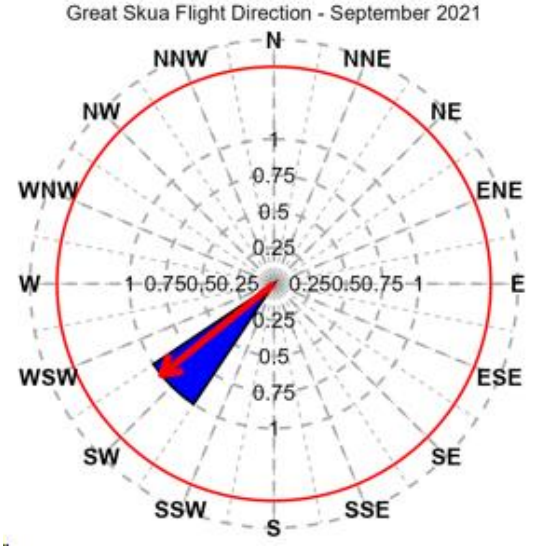
Figure 5-18: Summary of flight direction of great skua within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.



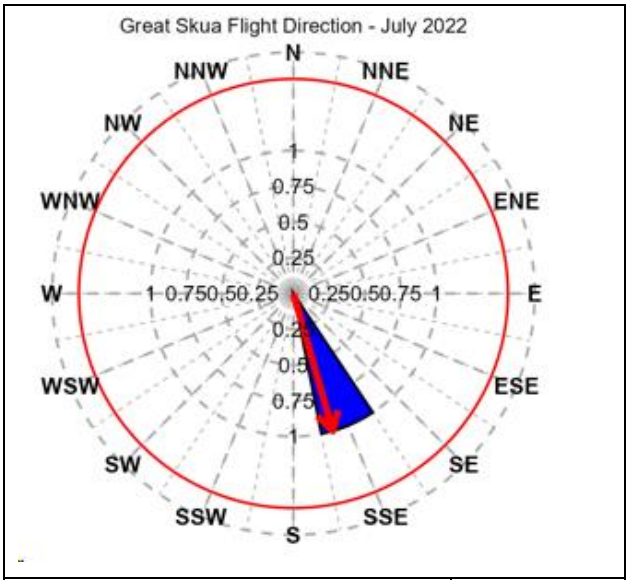


Number of Observations	1	Number of Observations	1
Mean Vector (μ)	177.119	Mean Vector (μ)	299.891
Length of Mean Vector (r)	1.000	Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000	Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512	Rayleigh Test (p)	0.512





Number of Observations	3	Number of Observations	1
Mean Vector (μ)	186.812	Mean Vector (μ)	231.099
Length of Mean Vector (r)	0.383	Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	0.440	Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.683	Rayleigh Test (p)	0.512



Number of Observations	1
Mean Vector (μ)	164.806
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512

Figure 5-19: Summary of flight direction of great skua within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.3.1.30 As recommended by the NatureScot (2023[1]) guidance, great skua has been scoped into the assessment for:

- Potential collision risk.

5.3.1.31 As a result, detailed consideration of mean seasonal peak abundance (all birds), and monthly flying bird density is provided in the following sections.

Density in Flight

5.3.1.32 The monthly density estimates (birds/km^2) used for this assessment have been presented in Table 5–18 and Figure 5-17. The monthly density estimates are used in CRM for the individual assessment within Caledonia OWF, Caledonia North and Caledonia South.

5.3.1.33 During the breeding season (Mid-April to Mid-September) the greatest density of great skua in flight were recorded in August 2021 within Caledonia OWF (0.05 birds/km^2); 0.08 birds/km^2 in August 2021 within Caledonia North and 0.03 birds/km^2 in August 2021 and July 2023 within Caledonia South.

5.3.1.34 No great skua were recorded in flight during the non-breeding season (Mid-September to Mid-April) within Caledonia OWF, Caledonia North and Caledonia South.

Table 5–18: Estimated densities (birds/km^2) of all flying great skua across the 24-month survey period for Caledonia OWF, Caledonia North and Caledonia South.

Year	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Caledonia OWF												
1	0.01	0.01	0.01	0.05	0	0	0	0	0	0	0	0
2	0	0	0.01	0	0	0	0	0	0	0	0	0
Caledonia North												
1	0.03	0.03	0.03	0.08	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
Caledonia South												
1	0	0	0	0.03	0	0	0	0	0	0	0	0
2	0	0	0.03	0	0	0	0	0	0	0	0	0
Note, estimates calculated using design-based analysis. Data include “no-identification” birds apportioned to species level.												

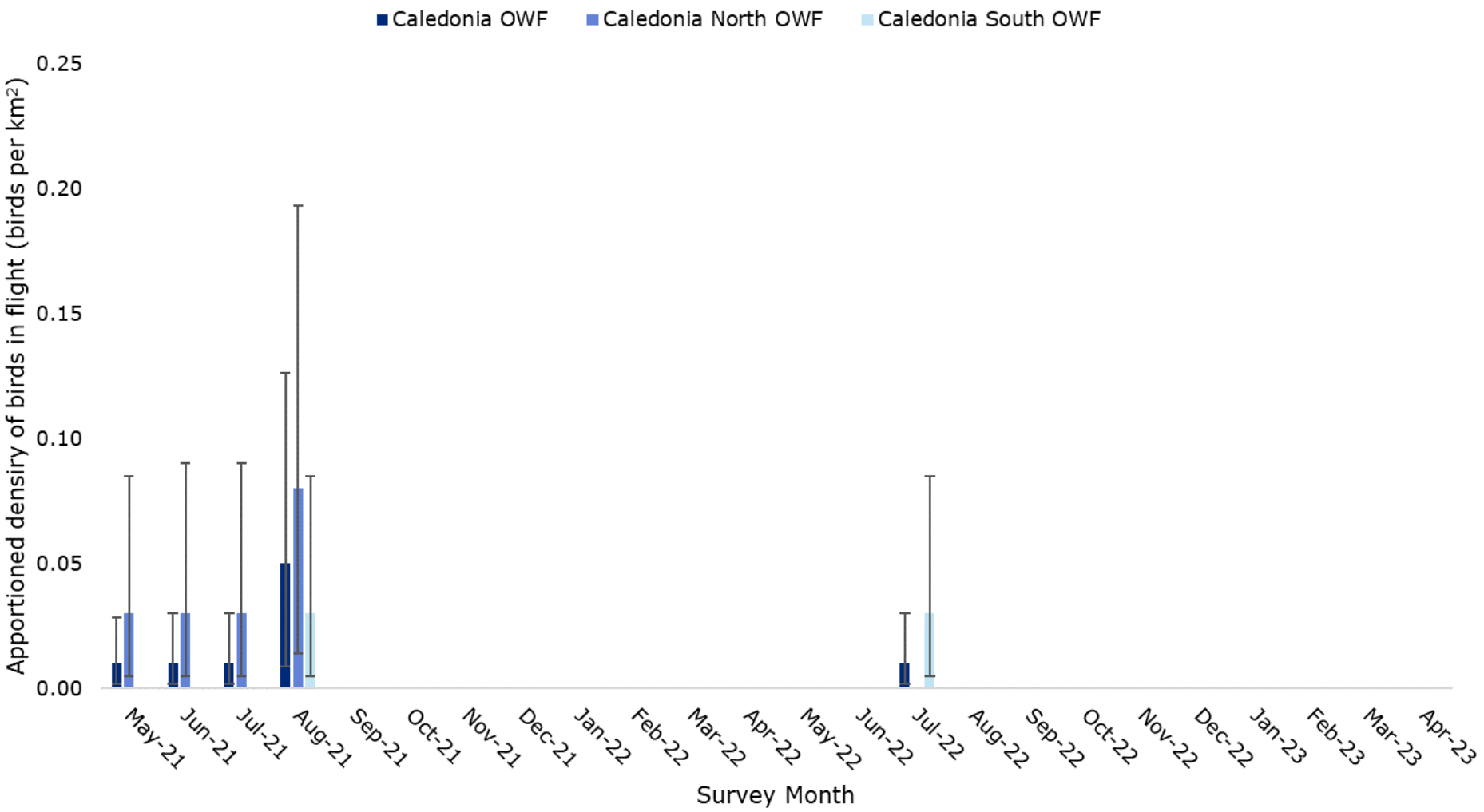


Figure 5-20: Bar plot of monthly apportioned densities (birds/km^2) of flying great skua (with 95% confidence intervals) recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period.

5.4 Alcidae

5.4.1 Guillemot

Defined Seasons

5.4.1.1 Guillemot seasonal definitions are presented in Table 5–19 as per the NatureScot (2020[71]) guidance. As there is only one non-breeding season for guillemot within Furness (2015[48]), no separate BDMPS seasons have been provided.

Table 5–19: Defined seasons in the Scottish Marine Environment used in the assessment for guillemot (NatureScot, 2020[71]).

Breeding Season	Post-breeding Migration Season	Non-breeding Season	Pre-breeding Migration Season
April to mid-August	Late-August to mid-October (flightless moult August to mid-October)	**Late August to March**	February to March
Time periods in **bold** are those used by the assessment.			

Overview

5.4.1.2 Common guillemot (hereafter guillemot) are the most abundant seabird in the northern hemisphere, forming large, high density breeding colonies consisting of up to tens of thousands of individuals on cliffs and stacks in the breeding season (defined as April to early August; NatureScot, 2020[71]).

5.4.1.3 Guillemot have a mean maximum foraging range of 73.2±80.5km or 55.5±39.7km (Woodward *et al.,* 2019[56]). The second foraging range excludes the Fair Isle due to reduced prey availability during the study year (Woodward *et al*., 2019[56]). Recent tracking data of 179 foraging trips recorded from 22 tagged guillemots breeding within the Buchan Ness to Collieston Coast SPA in 2023 were used to estimate a MMF±SD of 21.02±7.50km (Johnston *et al.,* 2024[60]), which is considerably lower than previously published estimates of this metric. Also of note during that study was the observation that guillemots tended to undertake a smaller number of longer foraging trips (in terms of trip length and duration) than razorbills, which could represent a species trait, or simply a preference of the tagged individuals from that study.

5.4.1.4 Guillemot are pursuit divers feeding on *Ammodytidae*, *Clupeidae* and *Gadidae* during the breeding season (Anderson *et al*., 2014[118]). In the North Sea, sandeel are an important prey source for guillemot during the breeding season (Anderson *et al*., 2014[118]). Reduced sandeel availability

caused a reduction in breeding productivity on the Isle of May in 2004, switching to foraging for sprat which increased foraging time increased and attendance at nests (Wanless *et al*., 2005[119]). This indicates the importance of sandeel to this particular colony, which might also be the case elsewhere.

5.4.1.5 Generally, winter distribution is dispersed around the whole of Britain and Ireland (Waggitt *et al*., 2019[37]), with the movements of many birds thought to be dispersive in nature rather than migratory. During the post-breeding moult guillemots are located across the west and north coast of Scotland, with hotspots in their northern distribution occurring around Fair Isle, Foula, East Caithness and the Isle of May (Buckingham *et al.*, 2022[120]). Mid-winter distribution is located off the north-west coast and the northern and central North Sea (Buckingham *et al*., 2022[120]). There is evidence to suggest that guillemot seasonal distribution is affected by the abundance of prey stocks (Furness, 2015[48]), though the drivers behind spatiotemporal distributional patterns are not fully understood.

Conservation Status

5.4.1.6 Guillemot are amber listed on the UK Birds of Conservation Concern List due to their restricted breeding and non-breeding ranges, and international importance (Stanbury *et al.,* 2021[81]).

Vulnerability to Climate Change

5.4.1.7 Guillemot are projected to decline considerably by 2050 in the east-coast of Scotland based on the Seabird 2000 estimates (Davies *et al*., 2021[39]). MarPAMM predict (with poor confidence) that guillemot have a moderate vulnerability to climate change, with an approximate 50% reduction in the breeding population in Britain and Ireland by 2050 (Davies *et al*., 2021[39]). Furthermore, the guillemot breeding population of the east coast of Scotland is predicted to decline under future climate projections (2070-2099) according to modelling presented by Searle *et al*. (2022[81]).

Regional and National Population Trends

5.4.1.8 The recent Seabirds Count (2015-2021) for guillemot estimated that there are approximately 810,645 breeding individuals in Scotland, a decline of approximately 31% since the Seabird 2000 count of 1,172,957 individuals (1998-2002) (Burnell *et al*., 2023[83]). These data contrast with indexed abundance data collated by Scottish Government (2020[99]), which indicates that between 2011 and 2018, the Scottish population showed an increasing trend on a national level, and that the Moray Firth population was stable during this time. Productivity rates at the Isle of May, from which a long term productivity dataset is available, were above average from 2011 to 2018 compared to the mean from 1986 to 2010 (Scottish Government,

2020[99]), which may have contributed to the apparent (relative) population stability during this time.

5.4.1.9 Around the Moray Firth, a relatively minor decrease (6%) in breeding guillemot numbers at the East Caithness Cliffs SPA (home to Scotland's largest breeding guillemot population) were observed between the Seabird 2000 census and Seabirds Count, and the population of the Buchan Ness to Collieston Cliffs SPA remained stable over the same period.

5.4.1.10 A contributory factor to the overall decline in breeding guillemot numbers since the Seabird 2000 census may have been the occurrence of three large non-breeding season 'wrecks' in the winters of 2013/14, 2018/19 and 2021/22 (Burnell *et al.,* 2023[83]). Whilst food resource during the non-breeding season is a key factor in the occurrence of these events, other drivers are not presently well understood.

5.4.1.11 An assessment of colony counts was undertaken by the RSPB following the first outbreak of HPAI in 2022. The total number of guillemots estimated to be breeding across all sites surveyed in 2023 (based on 52% of the UK breeding population being surveyed) decreased by 6% compared to the pre-HPAI baseline count for these colonies (from 694,261 to 650,375 individuals) (Tremlett *et al*., 2024[84]), with considerable variation in changes by colony. For example, the count undertaken at the Buchan Ness to Collieston Cliffs SPA in the Moray Firth recorded a 3% increase in the number of breeding adults when compared with the Seabirds Count, and at North Caithness Cliffs SPA, a 33% increase was recorded over the same period, with four other Scottish SPAs estimated to be supporting higher numbers of guillemots after the 2022 HPAI than before it. However, decreases of between 15% and 56% in breeding guillemot numbers were recorded at seven Scottish SPAs where guillemot is a qualifying feature. The surveys did not provide data for the East Caithness Cliffs SPA, which holds the largest guillemot population in Scotland. It is important to note that counts made by the RSPB in 2023 were undertaken prior to the further 2023 HPAI outbreak, and therefore any impacts occurring at guillemot colonies due to this outbreak are presently unknown.

5.4.1.12 The non-breeding season for guillemot is September to March (NatureScot, 2020[71]) with the UK North Sea population estimated during this season to consist of 1,617,306 individuals (Furness, 2015[48]). The total biogeographical population (UK and overseas breeding birds, with connectivity to the UK North Sea) was estimated to be 4,125,000 individuals (Furness, 2015[48]).

DAS Baseline Overview

5.4.1.13 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-31, Table 2-32 and Table 2-33;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-31 and Table 2-32; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-19, Table 2-20 and Table 2-21.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-30, Table 2-31 and Table 2-32;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-28 and Table 2-29; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-18, Table 2-19 and Table 2-20.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-30, Table 2-31 and Table 2-32;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-30 and Table 2-31; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-18, Table 2-19 and Table 2-20.

5.4.1.14 Figure 5-21 presents the abundance of guillemots (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km buffer and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.4.1.15 A total of 20,137 guillemots were recorded in the Survey Area during both years of baseline surveys. Guillemots were recorded in every survey. Highest abundances were recorded during the breeding season (April to mid-August), especially from May to July, with a peak of abundance recorded in May 2022:

- 1,511 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 8,755 [5,464; 12,277], an apportioned mean abundance estimate of 9,643 [6,067; 13,857] and an apportioned and availability bias-corrected mean abundance estimate of 12,547 [7,909; 18,015] individuals. These equated to mean density estimates of 20.49 (unapportioned), 22.55 (apportioned) and 29.34 (apportioned and availability bias-corrected) birds/km^2.
- 2,388 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 13,660 [8,735; 18,866], an apportioned mean abundance estimate of 14,995 [9,648; 20,305] and an apportioned and availability bias-corrected mean abundance estimate of 19,546 [12,599; 26,440] individuals. These equated to mean density estimates of 21.23 (unapportioned), 23.28 (apportioned) and 30.35 (apportioned and availability bias-corrected) birds/km^2.
- 3,127 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 18,156 [11,792; 24,548], an apportioned mean abundance estimate of 19,915 [12,794; 27,330] and an apportioned and availability bias-corrected mean abundance estimate of 25,952 [16,690; 35,597] individuals. These equated to mean density estimates of 20.55 (unapportioned), 22.52 (apportioned) and 29.35 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.16 In both breeding seasons covered by the baseline surveys, apportioned and availability bias-corrected mean guillemot abundances across the Survey Area were low at the beginning of the season (i.e., April), and rapidly increased thereafter. Peak abundances occurred either in July (2021) or May (2022), with mean abundances being consistently high throughout May to July in both survey years. Between July and August, apportioned and availability bias-corrected mean guillemot abundances dropped substantially in both breeding seasons covered by the baseline survey period, with low abundances observed in both August 2021 and August 2022. These temporal patterns are indicative of a rapid arrival and departure of birds from the Survey Area close to the start and end of the breeding season. The higher mean abundances in May to July indicate that the Survey Area is likely being used by breeding adults from nearby colonies. Apportioned and availability bias-corrected mean guillemot abundances across the breeding seasons of both 2021 and 2022 were relatively similar, with no obvious significant differences in apportioned and

availability bias-corrected mean guillemot abundances between the two seasons.

5.4.1.17 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month (May 2022) varied from 16% to 96%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.4.1.18 During both years of surveys, guillemots were also recorded during the non-breeding period (September to March), albeit in lower numbers than the breeding season, with a wintering peak of abundance in September 2022:

- 390 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 2,257 [1,302; 3,455], an apportioned mean abundance estimate of 2,701 [1,556; 4,119] and an apportioned and availability bias-corrected mean abundance estimate of 3,530 [2,037; 5,378] individuals. These equated to mean density estimates of 5.28 (apportioned), 6.32 (unapportioned) and 8.26 (apportioned and availability bias-corrected) birds/km^2.
- 1,303 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 7,520 [2,170; 17,222], an apportioned mean abundance estimate of 8,710 [2,608; 18,652] and an apportioned and availability bias-corrected mean abundance estimate of 11,408 [3,416; 24,432] individuals. These equated to mean density estimates of 11.69 (unapportioned), 13.52 (apportioned) and 17.71 (apportioned and availability bias-corrected) birds/km^2.
- 2,038 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 11,892 [4,476; 22,921], an apportioned mean abundance estimate of 13,436 [5,251; 26,308] and an apportioned and availability bias-corrected mean abundance estimate of 17,603 [6,882; 34,468] individuals. These equated to mean density estimates of 13.46 (unapportioned), 15.19 (apportioned) and 19.90 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.19 During the breeding site attendance period (February and March), guillemots were also recorded in low numbers (lower than the rest of the non-breeding period), with peak numbers in March 2023:

- 289 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 1,686 [1,143; 2,223], an apportioned mean abundance estimate of 1,821 [1,209; 2,479] and an apportioned and availability bias-corrected mean abundance estimate of 2,342 [1,570; 3,169] individuals. These equated to mean density

estimates of 3.95 (unapportioned), 4.26 (apportioned) and 5.48 (apportioned and availability bias-corrected) birds/km^2.

- 406 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 2,350 [1,528; 3,144], an apportioned mean abundance estimate of 2,568 [1,611; 3,511] and an apportioned and availability bias-corrected mean abundance estimate of 3,304 [2,093; 4,493] individuals. These equated to mean density estimates of 3.65 (unapportioned), 3.99 (apportioned) and 5.13 (apportioned and availability bias-corrected) birds/km^2.
- 503 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 2,953 [2,114; 3,840], an apportioned mean abundance estimate of 3,218 [2,131; 4,278] and an apportioned and availability bias-corrected mean abundance estimate of 4,146 [2,762; 5,487] individuals. These equated to mean density estimates of 3.34 (unapportioned), 3.64 (apportioned) and 4.69 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.20 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected guillemot abundances within the Survey Area occurred in September, with surveys in other non-breeding season months recording considerably lower equivalent abundances than the overall peak for the two years of surveys, in September 2022. The timing of the non-breeding season peak indicates that post-breeding aggregations of birds, likely from multiple colonies across the wider area, may occur in the Survey Area. Peak mean apportioned and availability bias-corrected guillemot abundances were generally low across the Survey Area during the winter months, with mean abundances increasing slightly from February in both survey years included in the baseline survey period. This indicates that birds attending nearby breeding colonies prior to the breeding season may be using the Survey Area.

5.4.1.21 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak for the non-breeding season were between 34% to 99%, with most surveys reporting reductions closer to the upper limit of the range. This indicates that the mean apportioned guillemot abundances were somewhat variable throughout the non-breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period, with many of the surveys recording mean abundances for this species that were considerably lower than the peak mean apportioned abundance for this seasonal period.

5.4.1.22 Very good measures of precisions were calculated for most survey months (CV ≤0.16). Within Caledonia OWF, four surveys out of 24 had precision values of CV >0.16, of which all were during the non-breeding season, when fewer records of this species were made. For Caledonia OWF plus buffer regions, CV values were generally lower than the corresponding CV

values for Caledonia OWF, indicating higher precision within these reporting regions.

Caledonia North

5.4.1.23 A total of 7,661 guillemots *were* recorded in Caledonia North Survey Area during both years of baseline surveys. Guillemots were recorded in every survey. Highest abundances were recorded during the breeding season (April to mid-August, with birds attending colonies from February onwards), especially from May to July, with a peak of abundance in May 2022:

- 852 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 4,944 [2,774; 7,515], an apportioned mean abundance estimate of 5,420 [2,764; 8,827] and an apportioned and availability bias-corrected mean abundance estimate of 7,019 [3,578; 11,441] individuals. These equated to mean density estimates of 22.64 (unapportioned), 24.81 (apportioned) and 32.12 (apportioned and availability bias-corrected) birds/km^2.
- 1,597 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 9,095 [5,888; 12,528], an apportioned mean abundance estimate of 9,965 [6,132; 14,072] and an apportioned and availability bias-corrected mean abundance estimate of 12,962 [7,988; 18,287] individuals. These equated to mean density estimates of 24.23 (unapportioned), 26.53 (apportioned) and 34.51 (apportioned and availability bias-corrected) birds/km^2.
- 2,284 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 13,280 [8,902; 18,176], an apportioned mean abundance estimate of 14,493 [9,513; 20,016] and an apportioned and availability bias-corrected mean abundance estimate of 18,859 [12,395; 26,032] individuals. These equated to mean density estimates of 23.84 (unapportioned), 26.00 (apportioned) and 33.83 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.24 In both breeding seasons covered by the baseline surveys, apportioned and availability bias-corrected mean guillemot abundances across Caledonia North Survey Area were low at the beginning of the season (i.e., April), and rapidly increased thereafter. Peak abundances occurred either in July (2021) or May (2022). In 2021, mean abundances were relatively similar between May and July, whilst in 2022, a large peak was observed in May 2022, with relatively stable mean abundances being recorded across much of Caledonia North Survey Area in June and July 2022. Between July and August in both years covered by the baseline surveys, apportioned and availability bias-corrected mean guillemot abundances dropped substantially, with low abundances observed in both August 2021 and August 2022. These temporal patterns are indicative of a rapid arrival and

departure of birds from Caledonia North Survey Area close to the start and end of the breeding season. The higher mean abundances in May to July indicate that Caledonia North Survey Area is likely being used by breeding adults from nearby colonies. Overall, excluding the overall peak for the breeding season apportioned and availability bias-corrected mean guillemot abundances in May 2022, abundances were relatively similar across the two breeding seasons covered by the baseline survey period.

5.4.1.25 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 55% to 99%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were somewhat variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.4.1.26 During both years of surveys, guillemots were recorded during the non-breeding period (September to March) in considerably lower numbers than the breeding season. Excluding the January to February period, where nest attendance commonly occurs in this species, the wintering peak abundance was recorded in November 2021:

- 62 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 362 [257; 479], an apportioned mean abundance estimate of 428 [268; 626] and an apportioned and availability bias-corrected mean abundance estimate of 552 [350; 797] individuals. These equated to mean density estimates of 1.66 (unapportioned), 1.96 (apportioned) and 2.53 (apportioned and availability bias-corrected) birds/km^2.
- 119 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 679 [411; 1,004], an apportioned mean abundance estimate of 752 [450; 1,169] and an apportioned and availability bias-corrected mean abundance estimate of 977 [588; 1,508] individuals. These equated to mean density estimates of 1.81 (unapportioned), 2.00 (apportioned) and 2.60 (apportioned and availability bias-corrected) birds/km^2.
- 180 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 1,051 [771; 1,390], an apportioned mean abundance estimate of 1,162 [796; 1,641] and an apportioned and availability bias-corrected mean abundance estimate of 1,509 [1,041; 2,117] individuals. These equated to mean density estimates of 1.89 (unapportioned), 2.08 (apportioned) and 2.71 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.27 During the breeding site attendance period (February and March), guillemots were recorded in low numbers (though in higher peak numbers than the rest of the non-breeding season, in contrast to the Survey Area), with peak numbers in March 2023:

- 132 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 774 [522; 1,031], an apportioned mean abundance estimate of 866 [552; 1,212] and an apportioned and availability bias-corrected mean abundance estimate of 1,110 [718; 1,532] individuals. These equated to mean density estimates of 3.55 (unapportioned), 3.97 (apportioned) and 5.08 (apportioned and availability bias-corrected) birds/km^2.
- 232 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,345 [957; 1,780], an apportioned mean abundance estimate of 1,489 [1,032; 2,054] and an apportioned and availability bias-corrected mean abundance estimate of 1,918 [1,346; 2,615] individuals. These equated to mean density estimates of 3.58 (unapportioned), 3.97 (apportioned) and 5.11 (apportioned and availability bias-corrected) birds/km^2.
- 316 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 1,856 [1,339; 2,408], an apportioned mean abundance estimate of 2,033 [1,355; 2,783] and an apportioned and availability bias-corrected mean abundance estimate of 2,620 [1,759; 3,561] individuals. These equated to mean density estimates of 3.33 (unapportioned), 3.65 (apportioned) and 4.70 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.28 During the two non-breeding seasons covered by the baseline surveys, mean apportioned and availability bias-corrected guillemot abundances were consistently low within Caledonia North Survey Area, with the overall peak for this period occurring in November 2021, excluding the pre-breeding season colony attendance period. The autumnal peaks in mean apportioned and availability bias-corrected guillemot abundances observed within the Survey Area and Caledonia South Survey Area were not recorded to the same extent within Caledonia North Survey Area, indicating a possible lower importance of Caledonia North Survey Area to this species during the autumn. Peak mean apportioned and availability bias-corrected guillemot abundances were generally low across Caledonia North Survey Area during the winter months, with mean abundances increasing slightly from February in both survey years included in the baseline survey period. This indicates that birds attending nearby breeding colonies prior to the breeding season may be using Caledonia North Survey Area.

5.4.1.29 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 14% to 95%, with most surveys reporting reductions in the middle of the extremes of the range. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.4.1.30 Good measures of precisions were calculated for most survey months (CV ≤0.16). Within Caledonia North, 12 surveys out of 24 had precision values of CV ≤0.16, and most surveys during the breeding season (seven of ten) had CV values of ≤0.16. CV values during the non-breeding season were higher (more often in the region of 0.2 to 0.5), indicating lower levels of precision when compared with breeding season surveys. For Caledonia North plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia North, indicating higher precision within these reporting regions.

Caledonia South

5.4.1.31 A total of 15,579 guillemots were recorded in Caledonia South Survey Area during both years of baseline surveys. Guillemots were recorded in every survey. Highest abundances were recorded during the breeding season (April to mid-August, with birds attending colonies from February onwards), especially from May to July, with a peak of abundance in July 2021 in Caledonia South and Caledonia South plus 2km buffer, and in July 2022 for Caledonia South Survey Area:

- 947 individuals were recorded in Caledonia South in July 2021, resulting in an unapportioned mean abundance estimate of 5,554 [1,771; 11,735], an apportioned mean abundance estimate of 5,748 [1,733; 12,403] and an apportioned and availability bias-corrected mean abundance estimate of 7,457 [2,224; 16,152] individuals. These equated to mean density estimates of 26.41 (unapportioned), 27.31 (apportioned) and 35.43 (apportioned and availability bias-corrected) birds/km^2.
- 1,563 individuals were recorded in Caledonia South plus 2km buffer in July 2021, resulting in an unapportioned mean abundance estimate of 9,094 [2,868; 19,305], an apportioned mean abundance estimate of 9,525 [3,142; 20,132] and an apportioned and availability bias-corrected mean abundance estimate of 12,351 [4,037; 26,194] individuals. These equated to mean density estimates of 25.30 (unapportioned), 26.48 (apportioned) and 34.33 (apportioned and availability bias-corrected) birds/km^2.
- 2,278 individuals were recorded in Caledonia South Survey Area in July 2022, resulting in an unapportioned mean abundance estimate of 13,189 [6,924; 20,611], an apportioned mean abundance estimate of 14,246 [6,710; 23,854] and an apportioned and availability bias-corrected mean abundance estimate of 18,392 [8,622; 30,838] individuals. These equated to mean density estimates of 24.73 (unapportioned), 26.69 (apportioned) and 34.46 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.32 In both breeding seasons covered by the baseline surveys, apportioned and availability bias-corrected mean guillemot abundances across Caledonia South Survey Area were low at the beginning of the season (i.e., April),

and rapidly increased thereafter. Peak abundances occurred in July in both the 2021 and 2022 breeding seasons, though apportioned and availability bias-corrected mean guillemot abundances were consistently high throughout May, June and July in both survey years. Between July and August in both years covered by the baseline surveys, apportioned and availability bias-corrected mean guillemot abundances dropped substantially, with low abundances observed in both August 2021 and August 2022. These temporal patterns are indicative of a rapid arrival and departure of birds from Caledonia South Survey Area close to the start and end of the breeding season. The higher mean abundances in May to July indicate that Caledonia South Survey Area is likely being used by breeding adults from nearby colonies. Apportioned and availability bias-corrected mean guillemot abundances across the breeding seasons of both 2021 and 2022 were relatively similar, with no obvious significant differences in apportioned and availability bias-corrected mean guillemot abundances between the two seasons.

5.4.1.33 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 4% to 95%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.4.1.34 During both years of surveys, guillemots were also recorded during the non-breeding period (September to March) in considerably lower numbers than during the breeding season. The wintering peak of abundance occurred in September 2022:

- 341 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 1,988 [1,084; 3,142], an apportioned mean abundance estimate of 2,282 [1,199; 3,515] and an apportioned and availability bias-corrected mean abundance estimate of 2,980 [1,567; 4,585] individuals. These equated to a mean density estimate of 9.45 (unapportioned), 10.85 (apportioned) and 14.16 (apportioned and availability bias-corrected) birds/km^2.
- 1,247 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 7,123 [1,868; 15,834], an apportioned mean abundance estimate of 8,150 [2,832; 17,259] and an apportioned and availability bias-corrected mean abundance estimate of 10,674 [3,709; 22,604] individuals. These equated to mean density estimates of 19.82 (unapportioned), 22.66 (apportioned) and 29.67 (apportioned and availability bias-corrected) birds/km^2.
- 1,982 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 11,565

[4,044; 22,092], an apportioned mean abundance estimate of 12,918 [4,500; 24,544] and an apportioned and availability bias-corrected mean abundance estimate of 16,924 [5,897; 32,156] individuals. These equated to mean density estimates of 21.68 (unapportioned), 24.20 (apportioned) and 31.71 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.35 During the breeding site attendance period (February and March), guillemots were also recorded in low numbers (lower than other periods of the non-breeding season), with peak numbers in March 2023:

- 157 individuals were recorded in Caledonia South in March 2023, resulting in an unapportioned mean abundance estimate of 910 [499; 1,461], an apportioned mean abundance estimate of 954 [531; 1,568] and an apportioned and availability bias-corrected mean abundance estimate of 1,231 [693; 2,011] individuals. These equated to mean density estimates of 4.33 (unapportioned), 4.53 (apportioned) and 5.85 (apportioned and availability bias-corrected) birds/km^2.
- 239 individuals were recorded in Caledonia South plus 2km buffer in March 2023, resulting in an unapportioned mean abundance estimate of 1,376 [916; 2,021], an apportioned mean abundance estimate of 1,497 [1,007; 2,246] and an apportioned and availability bias-corrected mean abundance estimate of 1,933 [1,312; 2,881] individuals. These equated to mean density estimates of 3.83 (unapportioned), 4.16 (apportioned) and 5.37 (apportioned and availability bias-corrected) birds/km^2.
- 357 individuals were recorded in Caledonia South Survey Area in March 2023, resulting in an unapportioned mean abundance estimate of 2,080 [1,434; 2,832], an apportioned mean abundance estimate of 2,251 [1,494; 3,151] and an apportioned and availability bias-corrected mean abundance estimate of 2,899 [1,940; 4,043] individuals. These equated to mean density estimates of 3.90 (unapportioned), 4.22 (apportioned) and 5.43 (apportioned and availability bias-corrected) birds/km^2.

5.4.1.36 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected guillemot abundances within Caledonia South Survey Area occurred in September, with surveys in other non-breeding season months recording considerably lower equivalent abundances than the overall peak for the two years of surveys, in September 2022. The timing of the non-breeding season peak indicates that post-breeding aggregations of birds, likely from multiple colonies across the wider area, may occur in Caledonia South Survey Area. Peak mean apportioned and availability bias-corrected guillemot abundances were generally low across Caledonia South Survey Area during the winter months, with mean abundances increasing from February in both survey years included in the baseline survey period. This indicates that birds attending nearby breeding colonies prior to the breeding season may be using Caledonia South Survey Area.

5.4.1.37 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak for the non-breeding season were between 55% to 99%, with most surveys reporting reductions closer to the upper limit of the range. This indicates that the mean apportioned guillemot abundances were somewhat variable throughout the non-breeding season surveys when compared with the peak mean apportioned abundance for the baseline survey period, with many of the surveys recording mean abundances for this species that were considerably lower than the peak mean apportioned abundance for this seasonal period.

5.4.1.38 Good measures of precisions were calculated for most survey months (CV ≤0.16). Within Caledonia South, 18 surveys out of 24 had precision values of CV ≤0.16, and most surveys during the breeding season (nine of ten) had CV values of ≤0.16. CV values during the non-breeding season were higher (more often in the region of 0.2 to 0.5), indicating lower levels of precision when compared with breeding season surveys. For Caledonia South plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia South, indicating higher precision within these reporting regions.

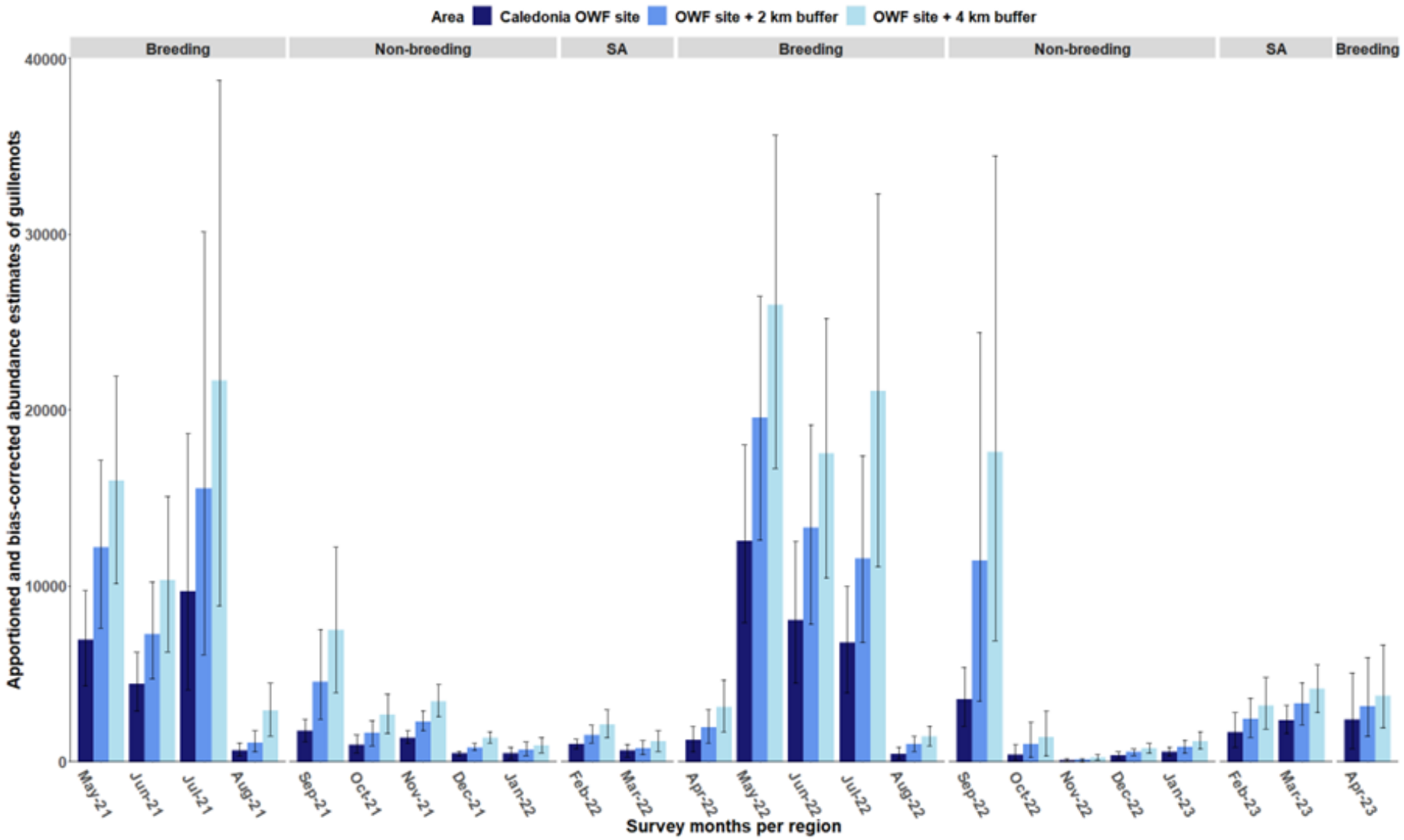


Figure 5-21: Bar plot of the monthly apportioned and availability bias-corrected abundance estimates (with 95% confidence intervals) of total guillemots recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Guillemot seasonal periods are also displayed. SA stands for breeding site attendance.

Spatial Distribution and Flight Direction

Spatial Distribution

5.4.1.39 In May to July 2021, November 2021, April to July 2022, December 2022, January 2023 and March 2023, guillemot were distributed throughout the Caledonia OWF (plus a 4km buffer) without any discernible distributional pattern. In August 2021, October 2021, and January 2022, largest concentrations of guillemot occurred in the east to south of the Caledonia OWF (plus a 4km buffer). In September 2021, February 2022, March 2022 and August to November 2022, February and April 2023, most birds were located towards the south of the Caledonia OWF (plus a 4km buffer).

5.4.1.40 The MRSea analysis (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) suggests that guillemot were widely distributed across the study area during the breeding season, with patchier distribution during the non-breeding season.

5.4.1.41 Higher numbers of birds to the south (and occasionally in the northwest) of the Caledonia OWF (plus a 4km buffer) may be linked to the proximity of these areas to breeding colonies (East Caithness Cliffs SPA to the west of the Caledonia OWF (plus a 4km buffer), and Troup, Pennan and Lion's Heads SPA to the south of the Caledonia OWF (plus a 4km buffer).

5.4.1.42 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

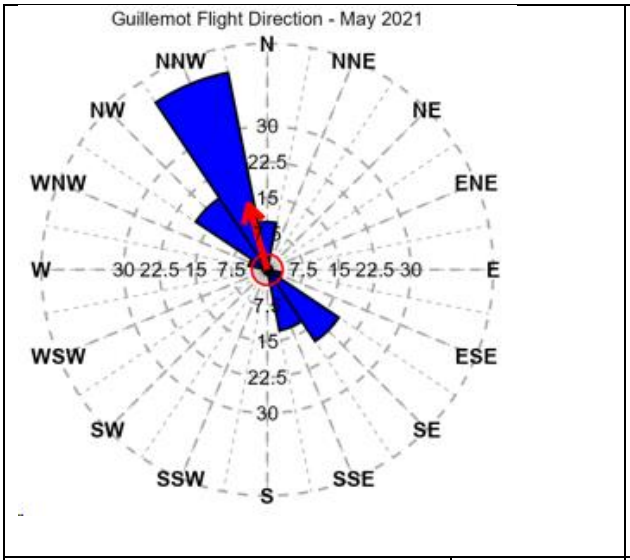
- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

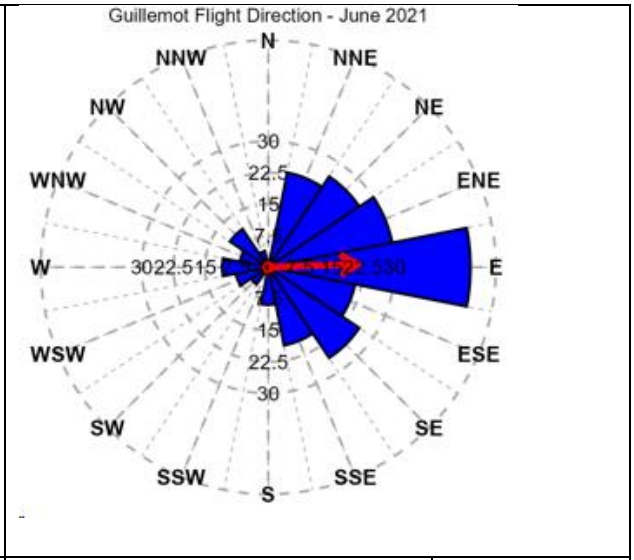
Flight Direction

5.4.1.43 Figure 5-22 presents the flight direction of guillemot within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

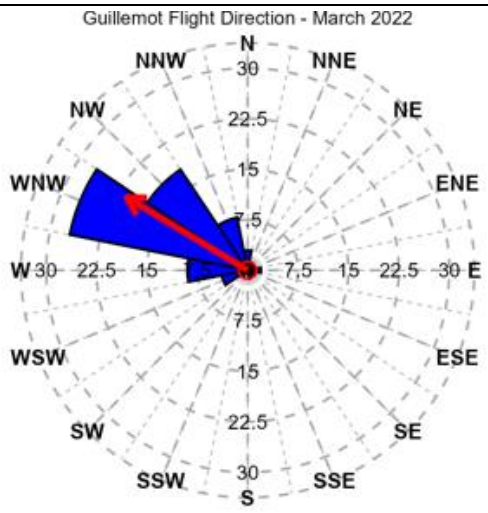
5.4.1.45 Significant predominant direction of flight was recorded in:

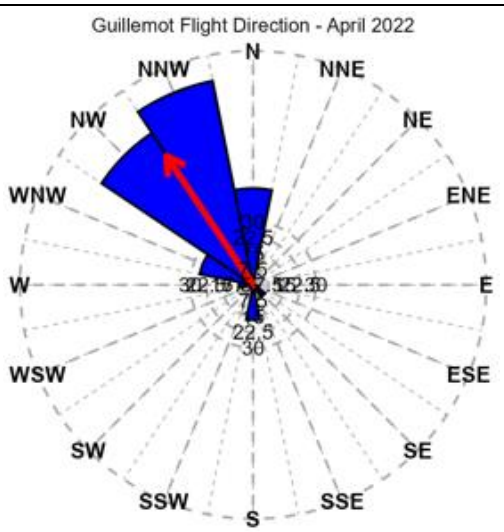
- May
  - 2021 north-northwest
- June
  - 2021 east
  - 2022 southeast
- July
  - 2022 southeast
- October
  - 2022 south-southeast
- February
  - 2023 northwest
- March
  - 2022 west-northwest
- April
  - 2022 northwest



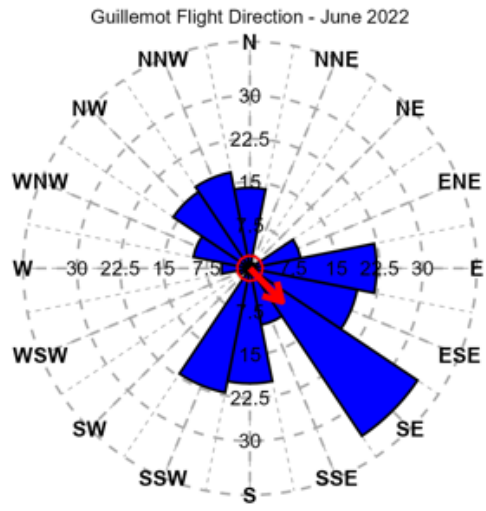


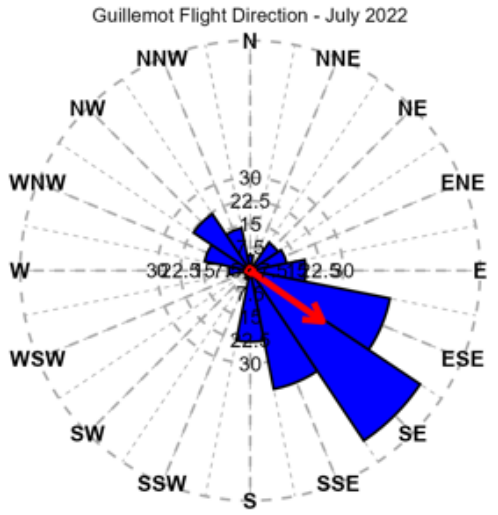
Number of Observations	114	Number of Observations	250
Mean Vector (μ)	344.331	Mean Vector (μ)	88.667
Length of Mean Vector (r)	0.334	Length of Mean Vector (r)	0.443
Rayleigh Test (Z)	12.752	Rayleigh Test (Z)	48.993
Rayleigh Test (p)	0.001	Rayleigh Test (p)	<0.001



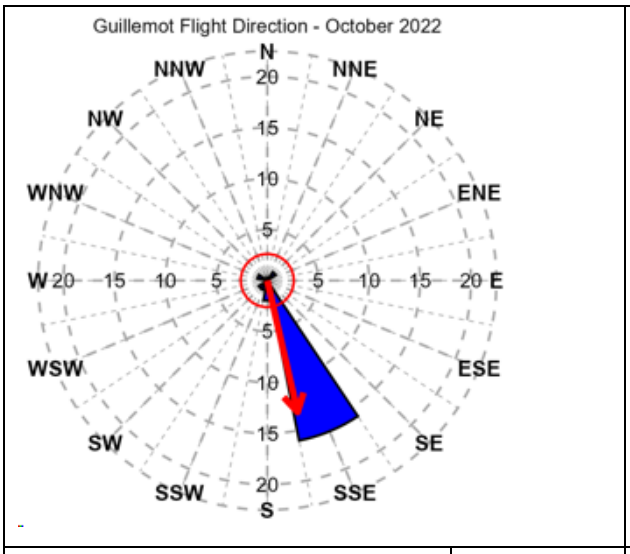


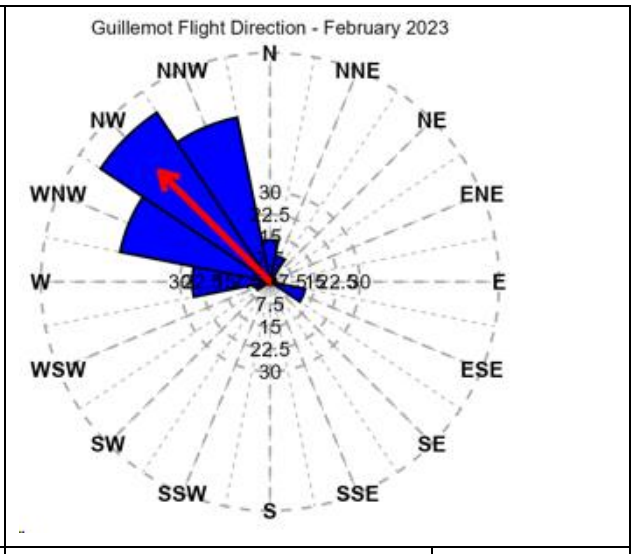
Number of Observations	76	Number of Observations	296
Mean Vector (μ)	301.781	Mean Vector (μ)	326.710
Length of Mean Vector (r)	0.777	Length of Mean Vector (r)	0.747
Rayleigh Test (Z)	45.871	Rayleigh Test (Z)	165.019
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001





Number of Observations	204	Number of Observations	285
Mean Vector (μ)	136.358	Mean Vector (μ)	125.997
Length of Mean Vector (r)	0.229	Length of Mean Vector (r)	0.432
Rayleigh Test (Z)	10.691	Rayleigh Test (Z)	53.283
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001

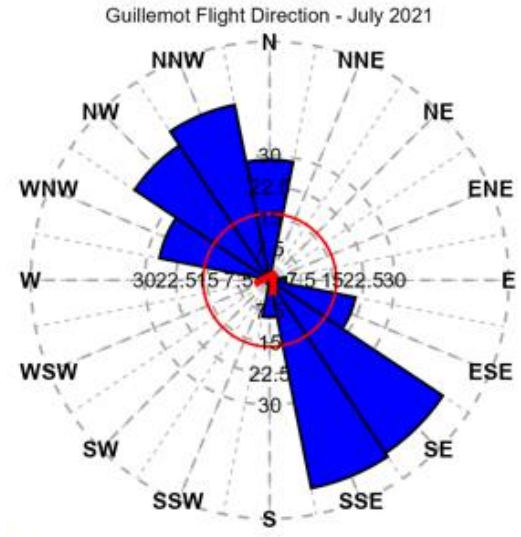


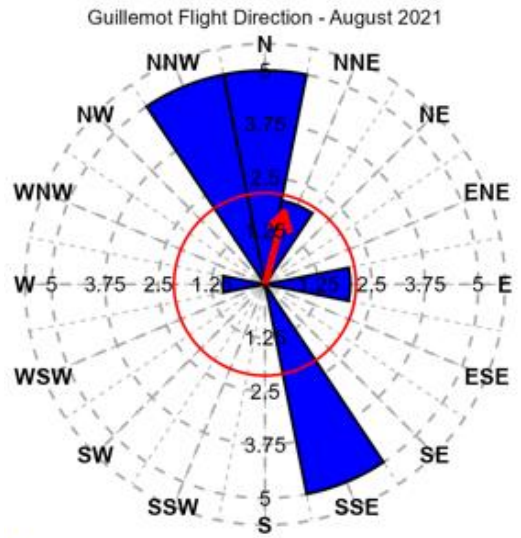


Number of Observations	22	Number of Observations	247
Mean Vector (μ)	167.081	Mean Vector (μ)	315.856
Length of Mean Vector (r)	0.828	Length of Mean Vector (r)	0.764
Rayleigh Test (Z)	15.072	Rayleigh Test (Z)	144.290
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001

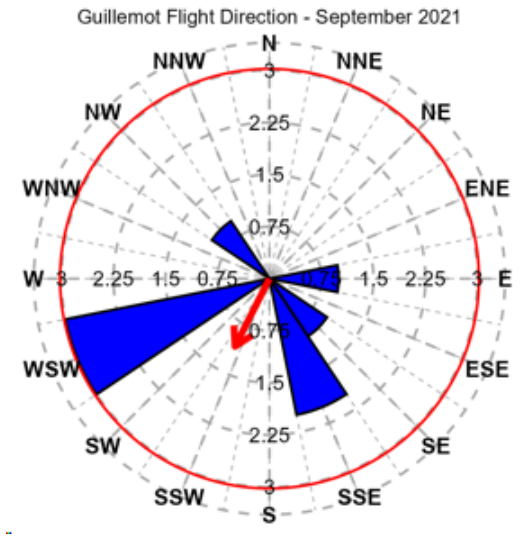
Figure 5-22: Summary of flight direction of guillemot within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

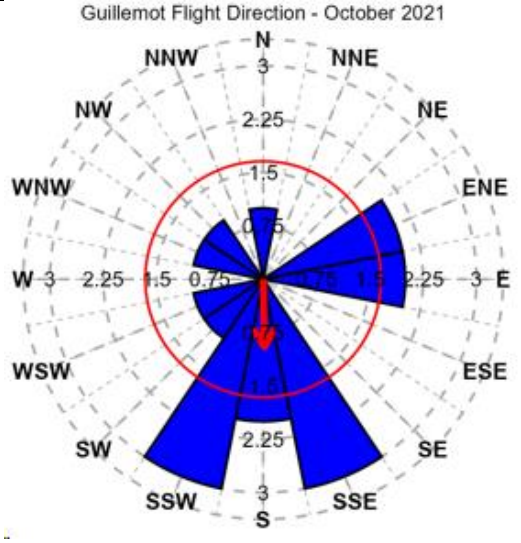
5.4.1.46 As very few birds were recorded in flight in other surveys, July, August, September, October, November 2022, January, February, May, August, September, November 2022, and January, March and April 2023, they were too infrequent to determine any preference in flight direction (Figure 5-23).



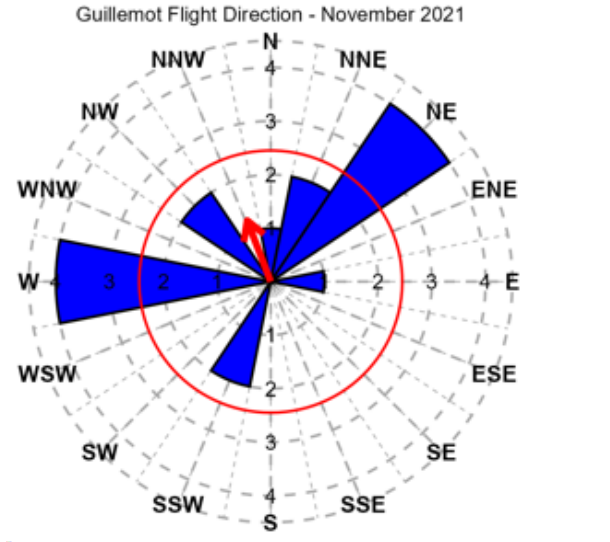


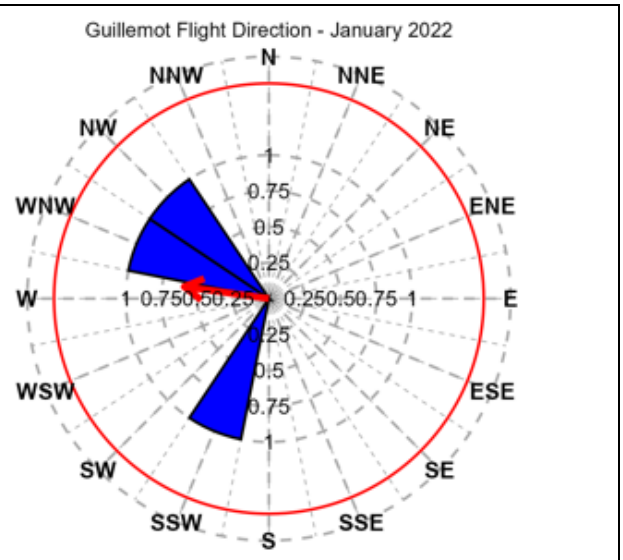
Number of Observations	282	Number of Observations	20
Mean Vector (μ)	27.189	Mean Vector (μ)	15.040
Length of Mean Vector (r)	0.035	Length of Mean Vector (r)	0.349
Rayleigh Test (Z)	0.348	Rayleigh Test (Z)	2.436
Rayleigh Test (p)	0.706	Rayleigh Test (p)	0.086



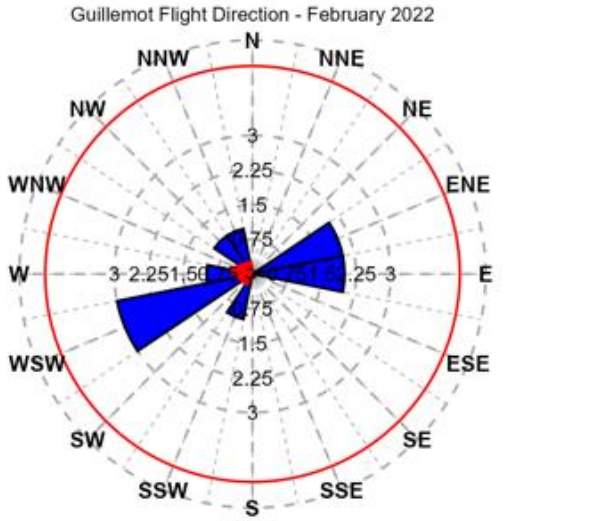


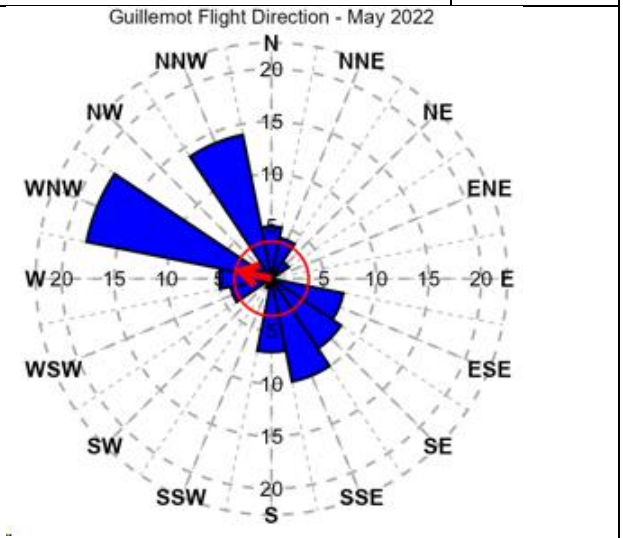
Number of Observations	8	Number of Observations	17
Mean Vector (μ)	207.633	Mean Vector (μ)	179.999
Length of Mean Vector (r)	0.365	Length Mean Vector (r)	0.317
Rayleigh Test (Z)	1.066	Rayleigh Test (Z)	1.710
Rayleigh Test (p)	0.356	Rayleigh Test (p)	0.182



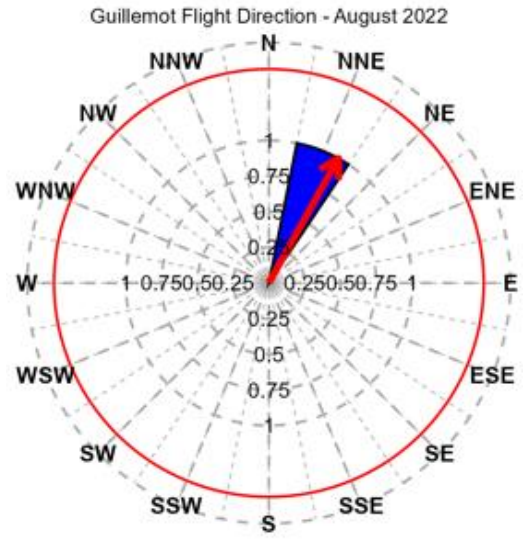


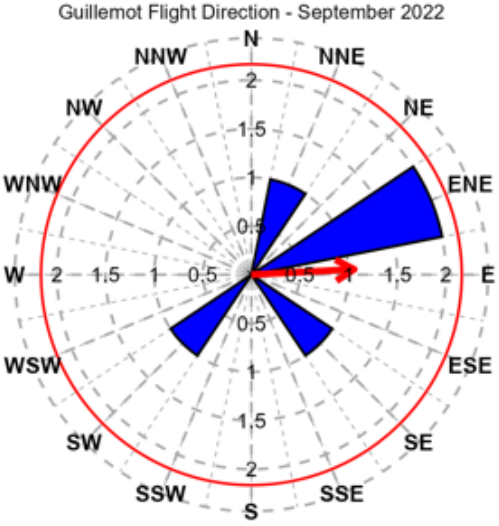
Number of Observations	16	Number of Observations	3
Mean Vector (μ)	339.394	Mean Vector (μ)	278.407
Length of Mean Vector (r)	0.305	Length of Mean Vector (r)	0.597
Rayleigh Test (Z)	1.490	Rayleigh Test (Z)	1.068
Rayleigh Test (p)	0.228	Rayleigh Test (p)	0.378



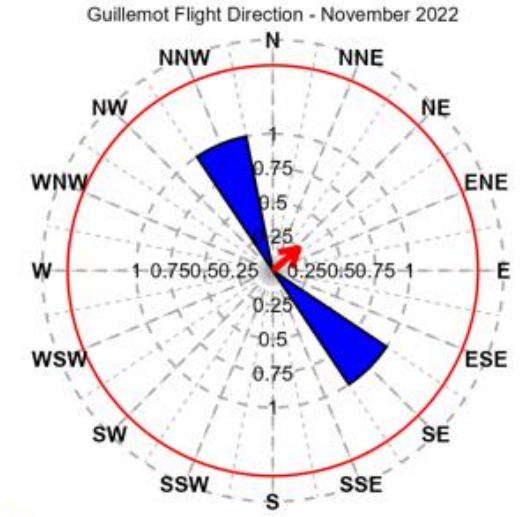


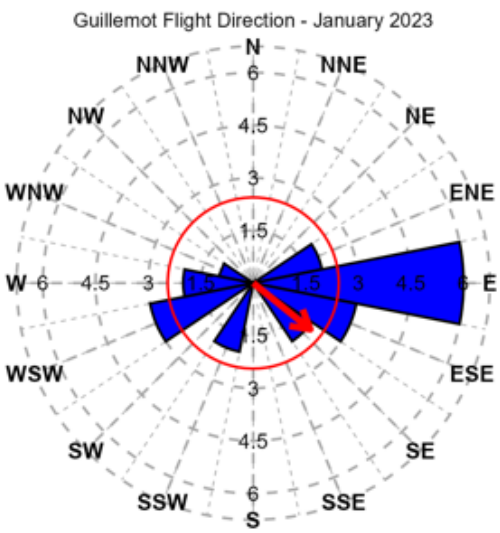
Number of Observations	11	Number of Observations	87
Mean Vector (μ)	282.578	Mean Vector (μ)	284.052
Length of Mean Vector (r)	0.144	Length of Mean Vector (r)	0.174
Rayleigh Test (Z)	0.229	Rayleigh Test (Z)	2.627
Rayleigh Test (p)	0.803	Rayleigh Test (p)	0.072



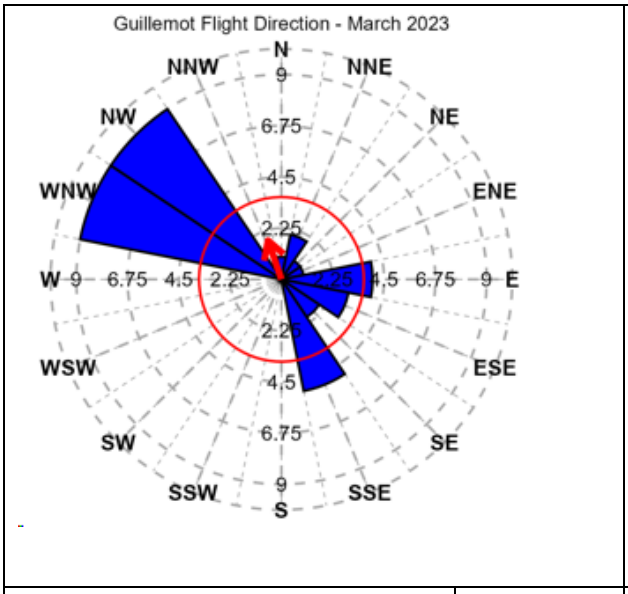


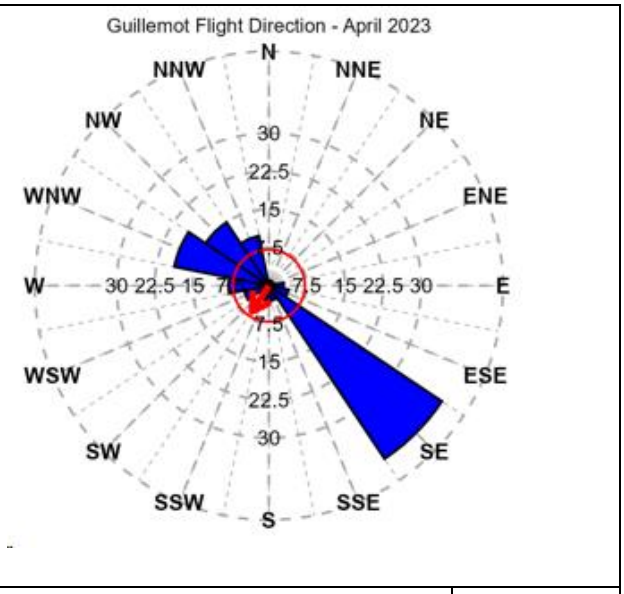
Number of Observations	1	Number of Observations	5
Mean Vector (μ)	29.346	Mean Vector (μ)	87.235
Length of Mean Vector (r)	1.000	Length of Mean Vector (r)	0.529
Rayleigh Test (Z)	1.000	Rayleigh Test (Z)	1.398
Rayleigh Test (p)	0.512	Rayleigh Test (p)	0.259





Number of Observations	2	Number of Observations	21
Mean Vector (μ)	49.300	Mean Vector (μ)	129.092
Length of Mean Vector (r)	0.247	Length of Mean Vector (r)	0.349
Rayleigh Test (Z)	0.122	Rayleigh Test (Z)	2.557
Rayleigh Test (p)	0.910	Rayleigh Test (p)	0.076





Number of Observations	37	Number of Observations	116
Mean Vector (μ)	341.517	Mean Vector (μ)	213.427
Length of Mean Vector (r)	0.201	Length of Mean Vector (r)	0.148
Rayleigh Test (Z)	1.488	Rayleigh Test (Z)	2.557
Rayleigh Test (p)	0.227	Rayleigh Test (p)	0.078

Figure 5-23: Summary of flight direction of guillemot within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.4.1.47 As recommended by the NatureScot (2023[1]) guidance, guillemot has been scoped into the assessment for:

- Potential operational phase displacement.

5.4.1.48 As a result, detailed consideration of mean seasonal peak abundance (all birds), is provided in the following sections.

Seasonal Peaks

5.4.1.49 The peaks used for the matrix-based distributional response assessment have been presented in Table 5–20. The offshore ornithology distributional responses assessment has been carried out separately for the Caledonia OWF, Caledonia North and Caledonia South. The peaks have been defined using the seasonal definitions presented in Table 5–19.

5.4.1.50 See Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates for the density and population estimate of all guillemot in the Caledonia OWF, Caledonia North and Caledonia South (plus a 2km buffer) used within assessments.

5.4.1.51 Guillemot were present in the greatest abundance during the breeding season (April to mid-August), with a peak abundance of 16,092 within Caledonia OWF (plus a 2km buffer); 7,220 birds within Caledonia North (plus a 2km buffer) and 11,323 birds within Caledonia South (plus a 2km buffer).

5.4.1.52 Outside the breeding season fewer guillemot were present with a peak estimate of 6,710 birds within Caledonia OWF (plus a 2km buffer); 1,432 birds within Caledonia North (plus a 2km buffer) and 5,788 within Caledonia South (plus a 2km buffer).

Table 5–20: Seasonal Peaks of Guillemot within Caledonia OWF (+2km buffer), Caldonia North (+2km buffer) and Caledonia South (+2km buffer), during the NatureScot defined seasons.

Defined Season	Breeding Season	Non-breeding Season
Caledonia OWF	16,092 (15,457 / 19,546)	6,710 (4,705 / 8,715)
Caledonia North	7,220 (3,959 / 10,481)	1,432 (1,593 / 1,217)
Caledonia South	11,323 (12,725 / 9,921)	5,788 (3,487 / 8,088)
Note, the seasonal peaks from Year 1 and Year 2 of DAS data used to calculate the mean seasonal peaks are provided within the brackets '()'. Note, the seasonal peaks have been calculated using model-based median abundances during both the breeding (April to mid-August) and non-breeding season (Late August to March).		

5.4.2 Razorbill

Defined Seasons

5.4.2.1 Razorbill seasonal definitions are presented in Table 5–21 as per the NatureScot (2020[71]) guidance. As the non-breeding season for razorbill is subdivided within Furness (2015[48]), separate BDMPS seasons have been provided in Table 5–22.

Table 5–21: Defined seasons in the Scottish Marine Environment used in the assessment for razorbill (NatureScot, 2020[71]).

Breeding Season	Post-breeding Migration Season	Non-breeding Season	Pre-breeding Migration Season
April to mid-August	Late-August to November (flightless moult August to November)	**Late August to March**	March
Time periods in **bold** are those used by the assessment.			

Table 5–22: Non-breeding season BDMPS periods based on Furness (2015[48]) used in the apportionment of razorbill to specific populations.

Autumn Migration	Winter Period	Spring Migration	Non-breeding
Late-August to October (August to October)	**November to December**	**January to March**	-
Seasonal definitions used for additional assessment are in **bold**. Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–21), with the original definitions as per Furness (2015[48]) provided in parentheses where different.			

Overview

5.4.2.2 Razorbill is a common seabird in the North Atlantic, breeding between April to mid-August (NatureScot, 2020[71]) around small ledges of rocky cliffs and often found breeding within mixed assemblages of guillemots and kittiwake (Mitchell *et al*., 2004[44]).

5.4.2.3 Razorbills occupy a similar ecological niche to guillemots; therefore, the reduction of prey availability is likely to be a concern for this species. Razorbill from the Isle of May were suggested to be influenced by reduction of 0-group sandeel size (Thaxter *et al*., 2013[121]). However, razorbills have relatively high foraging flexibility, and have been shown to be capable of switching foraging areas to catch high quality prey items in years of reduced prey availability (St John Glew *et al*., 2019[122]). Furthermore, climate change will increase the frequency of severe weather events (strong winds, high rainfall). For example, on the Isle of May, a severe storm event occurring in May 2011 lasted eight hours, causing high failure rates of razorbills compared to other seabirds (Newell *et al*., 2015[123]).

5.4.2.4 Razorbill, densities are concentrated around Northern Isles and the Hebrides in the summer, dispersing around Britain and Ireland and further afield in the winter (Waggitt *et al*., 2019[37]). Razorbill have an MMF±SD of 88.7±75.9km or 73.8±48.4km (Woodward *et al*., 2019[56]). The second MMF excludes the foraging range data collected from Fair Isle due to the reduction of prey availability during the study year (Woodward *et al*., 2019[56]). Recent tracking data of 481 foraging trips recorded from 23 tagged guillemots breeding within the Buchan Ness to Collieston Coast SPA in 2023 were used to estimate a MMF±SD of 17.01±7.38km (Johnston *et al.,* 2024[60]), which is considerably less than previously published estimates of this metric. Also of note during that study was the observation that guillemots tended to undertake a smaller number of longer foraging trips (in terms of trip length and duration) than razorbills, which could represent a species trait, or simply a preference of the tagged individuals from that study.

5.4.2.5 The North Sea is an important location for razorbills especially during the post-breeding moult period between July and September (Stone *et al*., 1995[32]). During the post-breeding moult razorbill fitted with geolocators were distributed around the coast of mainland Scotland, Orkney and the central North Sea, while in mid-winter, birds were found off the north coast of Scotland and the English Channel (Buckingham *et al*., 2022[120]).

Conservation Status

5.4.2.6 Razorbill is currently Amber-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]).

Vulnerability to Climate Change

5.4.2.7 The razorbill population is predicted to greatly decline across the whole of Britain and Ireland between 1998-2002 and 2050 (Davies *et al*., 2021[39]). Furthermore Searle *et al*. (2022[80]) has predicted that razorbill densities in the summer will decline in the southern sector of the North Sea under predicted future climatic conditions (2070-2099), though in the winter, abundance will increase in the northern North Sea. According to Davies *et al*. (2021[39]), razorbill is projected (with poor confidence) to have moderate vulnerability to climate change.

Regional and National Population Trends

5.4.2.8 According to the recent Seabird Count for razorbill, there are 138,828 individuals in Scotland, this is a decline of 2% since the Seabird 2000 count (Burnell *et al*., 2023[83]). Based on abundance estimates between 2011-2018, the Scottish population is showing an increasing trend in the Forth and Tay and Moray Firth, while a stable trend in Shetland and West Highlands (Scottish Government, 2020[99]). Productivity rates in Scotland are lower compared to England in recent years, with some colonies recording consistently low productivity rates between 2009-2019 (JNCC, 2021d[124]).

5.4.2.9 An assessment of colony counts was undertaken by the RSPB following the first outbreak of HPAI in 2022. Razorbill was not included in these surveys, since the species is thought to have incurred relatively low mortality due to HPAI (Tremlett *et al.,* 2024[84]). A continued campaign of counts is required to monitor this species, and others, for additional impacts due to HPAI.

5.4.2.10 The UK national population was estimated to be 357,000 individuals (adults and immatures), with the total biogeographical population with connectivity to UK waters (UK and overseas) of 1,707,000 individuals (Furness, 2015[48]). The seasonal definitions adapted from Furness (2015[48]) BDMPS to align with the NatureScot (2020[71]) seasonal period for razorbill are autumn migration (late August-October), spring migration (January-March) and migration free-winter (November-December) (Table 5–22). In the North

Sea and Channel population estimate for the spring and autumn migration seasons is 591,874 individuals while in the migration-free winter period, the population estimate is 218,622 individuals (Furness, 2015[48]).

DAS Baseline Overview

5.4.2.11 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-34, Table 2-35 and Table 2-36;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-33 and Table 2-34; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-22, Table 2-23 and Table 2-24.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-33, Table 2-34 and Table 2-35;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-30 and Table 2-31; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-21, Table 2-22 and Table 2-23.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-33, Table 2-34 and Table 2-35;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-32 and Table 2-33; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-21, Table 2-22 and Table 2-23.

5.4.2.12 Figure 5-24 presents the abundance of razorbill (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km buffer and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.4.2.13 A total of 2,542 razorbills were recorded in the Survey Area during both years of baseline surveys. Razorbills were recorded in every survey apart from November 2021. In contrast to guillemot, highest abundances of razorbills were recorded during the non-breeding period (September to February). Peak abundances were recorded in September 2022:

- 250 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 1,447 [619; 2,361], an apportioned mean abundance estimate of 1,731 [805; 2,821] and an apportioned and availability bias-corrected mean abundance estimate of 2,093 [974; 3,408] individuals. These equated to mean density estimates of 3.39 (unapportioned), 4.05 (apportioned) and 4.90 (apportioned and availability bias-corrected) birds/km^2.
- 401 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 2,314 [1,437; 3,342], an apportioned mean abundance estimate of 2,682 [1,707; 3,857] and an apportioned and availability bias-corrected mean abundance estimate of 3,232 [2,065; 4,636] individuals. These equated to mean density estimates of 3.60 (unapportioned), 4.16 (apportioned) and 5.02 (apportioned and availability bias-corrected) birds/km^2.
- 514 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 2,999 [1,844; 4,231], an apportioned mean abundance estimate of 3,395 [2,092; 4,797] and an apportioned and availability bias-corrected mean abundance estimate of 4,094 [2,531; 5,772] individuals. These equated to mean density estimates of 3.39 (unapportioned), 3.84 (apportioned) and 4.63 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.14 During the breeding site attendance period (March), razorbills were recorded in low numbers (considerably lower than the rest of the non-breeding season), with a peak abundance for the survey period recorded in March 2023:

- 48 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 280 [169; 379], an apportioned mean abundance estimate of 302 [166; 440] and an apportioned and availability bias-corrected mean abundance estimate of 360 [200; 521] individuals. These equated to mean density estimates of 0.66 (unapportioned), 0.71 (apportioned) and 0.84 (apportioned and availability bias-corrected) birds/km^2.

- 58 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 336 [191; 504], an apportioned mean abundance estimate of 366 [183; 590] and an apportioned and availability bias-corrected mean abundance estimate of 432 [220; 690] individuals. These equated to mean density estimates of 0.52 (unapportioned), 0.57 (apportioned) and 0.67 (apportioned and availability bias-corrected) birds/km^2.
- 84 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 493 [323; 646], an apportioned mean abundance estimate of 537 [307; 785] and an apportioned and availability bias-corrected mean abundance estimate of 634 [368; 919] individuals. These equated to mean density estimates of 0.56 (unapportioned), 0.61 (apportioned) and 0.72 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.15 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected abundances within the Survey Area occurred in September and February/March. The largest overall peak was in September 2022, when mean apportioned and availability bias-corrected abundances were considerably larger than in any other survey during the non-breeding season for this species. Based on the timing of this peak, this seems likely to be a post-breeding season peak as birds disperse from their breeding colonies. During the winter months, relatively low mean apportioned and availability bias-corrected abundances occurred in both non-breeding seasons, with slightly higher abundances recorded in February 2022, February 2023 and March 2023. The timing of the non-breeding season peaks indicates that the Survey Area may be relatively important to post-breeding aggregations of birds (likely from a number of breeding colonies in the wider area), and birds attending colonies in the pre-breeding period.

5.4.2.16 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 80% to >99.5%, reflecting the fact that the September 2022 peak was very large relative to the other mean apportioned and availability bias-corrected abundances recorded for razorbill in the Survey Area and reporting regions during the non-breeding season.

5.4.2.17 During the breeding season (April to mid-August), peak mean abundance was recorded in May 2022:

- 207 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 1,199 [591; 2,126], an apportioned mean abundance estimate of 1,323 [608; 2,417] and an apportioned and availability bias-corrected mean abundance estimate of 1,599 [735; 2,916] individuals. These equated to mean density estimates of 2.81 (unapportioned), 3.09 (apportioned) and 3.74 (apportioned and availability bias-corrected) birds/km^2.

- 290 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,659 [938; 2,626], an apportioned mean abundance estimate of 1,824 [1,002; 2,944] and an apportioned and availability bias-corrected mean abundance estimate of 2,205 [1,213; 3,355] individuals. These equated to mean density estimates of 2.58 (unapportioned), 2.83 (apportioned) and 3.42 (apportioned and availability bias-corrected) birds/km^2.
- 406 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 2,357 [1,260; 3,664], an apportioned mean abundance estimate of 2,590 [1,418; 4,061] and an apportioned and availability bias-corrected mean abundance estimate of 3,133 [1,716; 4,907] individuals. These equated to mean density estimates of 2.67 (unapportioned), 2.93 (apportioned) and 3.54 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.18 In both breeding seasons covered by the baseline surveys, apportioned and availability bias-corrected mean razorbill abundances across the Survey Area were slightly lower at the beginning of the season (i.e., April) than other months in the breeding season. During the 2021 breeding season, abundances between May and August 2021 were relatively consistent, with the peak apportioned and availability bias-corrected mean razorbill abundance occurring in July 2021. During the 2022 breeding season, a large peak in apportioned and availability bias-corrected mean razorbill abundances (which was the overall breeding season peak month) was recorded in May 2022. Abundances were very low in June 2022, and also low in August 2022, with a larger apportioned and availability bias-corrected mean abundance in July 2022 across the Survey Area. The reasons for the differences in temporal patterns between the 2021 and 2022 breeding seasons within the Survey Area are unclear.

5.4.2.19 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 28% to 92%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were somewhat variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.4.2.20 Precision values were quite variable for this species throughout the survey period. CV values of ≤0.16 were reported in nine of 23 baseline surveys across Caledonia OWF, with lower precision values (i.e., higher levels of precision) coinciding with surveys where higher numbers of razorbills were recorded. For Caledonia OWF plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia OWF, indicating higher precision within these reporting regions.

Caledonia North

5.4.2.21 A total of 1,395 razorbills were recorded in Caledonia North Survey Area during both years of baseline surveys. Razorbills were recorded in every survey apart from November 2021. Highest abundances were recorded during the non-breeding period (September to February). Peak of abundance were recorded in September 2022:

- 171 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 981 [419; 1,584], an apportioned mean abundance estimate of 1,256 [506; 2,086] and an apportioned and availability bias-corrected mean abundance estimate of 1,519 [612; 2,522] individuals. These equated to mean density estimates of 4.49 (unapportioned), 5.75 (apportioned) and 6.95 (apportioned and availability bias-corrected) birds/km^2.
- 276 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,603 [865; 2,434], an apportioned mean abundance estimate of 2,021 [1,043; 3,201] and an apportioned and availability bias-corrected mean abundance estimate of 2,438 [1,262; 3,850] individuals. These equated to mean density estimates of 4.27 (unapportioned), 5.38 (apportioned) and 6.49 (apportioned and availability bias-corrected) birds/km^2.
- 371 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 2,161 [1,089; 3,227], an apportioned mean abundance estimate of 2,665 [1,314; 4,158] and an apportioned and availability bias-corrected mean abundance estimate of 3,215 [1,589; 5,006] individuals. These equated to mean density estimates of 3.88 (unapportioned), 4.78 (apportioned) and 5.77 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.22 During the breeding site attendance period (March), razorbills were recorded in low numbers, with a peak number in March 2023:

- 18 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 105 [29; 199], an apportioned mean abundance estimate of 119 [34; 231] and an apportioned and availability bias-corrected mean abundance estimate of 141 [41; 273] individuals. These equated to mean density estimates of 0.48 (unapportioned), 0.54 (apportioned) and 0.65 (apportioned and availability bias-corrected) birds/km^2.
- 32 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 186 [70; 330], an apportioned mean abundance estimate of 204 [65; 372] and an apportioned and availability bias-corrected mean abundance estimate of 236 [77; 426] individuals. These equated to mean density estimates of 0.50 (unapportioned), 0.54 (apportioned) and 0.63 (apportioned and availability bias-corrected) birds/km^2.

- 53 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 311 [170; 458], an apportioned mean abundance estimate of 340 [157; 543] and an apportioned and availability bias-corrected mean abundance estimate of 399 [188; 630] individuals. These equated to mean density estimates of 0.56 (unapportioned), 0.61 (apportioned) and 0.72 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.23 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected abundances of razorbills within Caledonia North Survey Area occurred in September and February/March. The largest overall peak was recorded in September 2022, when mean apportioned and availability bias-corrected abundances were considerably larger than in any other survey during the non-breeding season for this species. During the late autumn and winter months, mean apportioned and availability bias-corrected abundances of razorbills was consistently low in Caledonia North Survey Area reporting regions, with higher mean apportioned and availability bias-corrected abundances of razorbills occurring in February 2022, and March 2023. The timing of the non-breeding season peaks indicates that the Survey Area may be relatively important to post-breeding aggregations of birds (likely from a number of breeding colonies in the wider area), and birds attending colonies in the pre-breeding period.

5.4.2.24 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 81% to >99.5%, with many of the surveys recording reductions in mean abundances at the upper end of this range when compared with the peak month. This is largely a reflection of the fact that the September 2022 peak was very large relative to the other mean apportioned and availability bias-corrected abundances recorded for razorbill in Caledonia North Survey Area and reporting regions during the non-breeding season.

5.4.2.25 During the breeding season (April to mid-August, with birds attending colonies from March onwards) Peak abundance was recorded in May 2022:

- 133 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 772 [395; 1,352], an apportioned mean abundance estimate of 850 [403; 1,548] and an apportioned and availability bias-corrected mean abundance estimate of 1,026 [488; 1,867] individuals. These equated to mean density estimates of 3.54 (unapportioned), 3.89 (apportioned) and 4.63 (apportioned and availability bias-corrected) birds/km^2.
- 214 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,219 [763; 1,822], an apportioned mean abundance estimate of 1,338 [804; 1,995] and an apportioned and availability bias-corrected mean abundance estimate of 1,618 [974; 2,409] individuals. These equated to mean

density estimates of 3.25 (unapportioned), 3.56 (apportioned) and 4.31 (apportioned and availability bias-corrected) birds/km^2.

- 314 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 1,826 [988; 2,797], an apportioned mean abundance estimate of 1,998 [1,036; 3,092] and an apportioned and availability bias-corrected mean abundance estimate of 2,417 [1,254; 3,737] individuals. These equated to mean density estimates of 3.28 (unapportioned), 3.58 (apportioned) and 4.33 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.26 During the 2021 breeding season, mean apportioned and availability bias-corrected razorbill abundance between May and August were relatively consistent, with Caledonia North Survey Area peak occurring in July 2021. During the 2022 breeding season, a large peak in apportioned and availability bias-corrected mean razorbill abundances (which was the overall breeding season peak month by a larger margin) was recorded in May 2022. Abundances were very low in June 2022 and in August 2022, with a larger apportioned and availability bias-corrected mean abundance in July 2022 across Caledonia North Survey Area. The reasons for the differences in temporal patterns between the 2021 and 2022 breeding seasons within Caledonia North Survey Area are unclear.

5.4.2.27 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 64% to 97%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were somewhat variable throughout the breeding season when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.4.2.28 Precision values were quite variable throughout the survey period. CV values of ≤0.16 were reported in two of 22 baseline surveys across Caledonia North, with lower precision values (i.e., higher levels of precision) coinciding with surveys where higher numbers of razorbills were recorded. For Caledonia North plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia North, indicating higher precision within these reporting regions.

Caledonia South

5.4.2.29 A total of 1,617 razorbills were recorded in Caledonia South Survey Area during both years of baseline surveys. Razorbills were recorded in every survey apart from November 2021. In contrast to Caledonia North and the Survey Area, highest abundances of razorbills were recorded during the breeding season (April to mid-August, with birds attending colonies from March onwards). Peak breeding season abundances were recorded during in July 2021:

- 100 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 586 [270; 1,003], an apportioned mean abundance estimate of 607 [288; 1,023] and an apportioned and availability bias-corrected mean abundance estimate of 735 [348; 1,239] individuals. These equated to mean density estimates of 2.79 (unapportioned), 2.88 (apportioned) and 3.49 (apportioned and availability bias-corrected) birds/km^2.
- 157 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 913 [425; 1,699], an apportioned mean abundance estimate of 958 [481; 1,645] and an apportioned and availability bias-corrected mean abundance estimate of 1,160 [582; 1,993] individuals. These equated to mean density estimates of 2.54 (unapportioned), 2.66 (apportioned) and 3.22 (apportioned and availability bias-corrected) birds/km^2.
- 244 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 1,465 [895; 2,210], an apportioned mean abundance estimate of 1,530 [960; 2,320] and an apportioned and availability bias-corrected mean abundance estimate of 1,853 [1,163; 2,809] individuals. These equated to mean density estimates of 2.75 (unapportioned), 2.87 (apportioned) and 3.47 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.30 During the 2021 breeding season, mean apportioned and availability bias-corrected razorbill abundance within Caledonia South Survey Area increased between May and July, with the breeding season peak for the baseline survey period occurring in July 2021. Razorbill mean apportioned and availability bias-corrected abundance declined between July 2021 and August 2021. During the 2022 breeding season, the temporal pattern observed was quite different to the 2021 breeding season, with low numbers of birds present in June 2022 and August 2022, and higher abundances recorded in April 2022, May 2022 and August 2022. The reasons for the differences in temporal patterns between the 2021 and 2022 breeding seasons within Caledonia South Survey Area are unclear.

5.4.2.31 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 22% to 93%, with most surveys falling somewhere in the middle of the two extremes of this range. This indicates that the mean apportioned abundances were somewhat variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.4.2.32 During the non-breeding period, peak numbers were recorded in September 2022:

- 79 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 461 [268; 665], an apportioned mean abundance estimate of 529 [288; 774] and an

apportioned and availability bias-corrected mean abundance estimate of 639 [348; 932] individuals. These equated to mean density estimates of 2.19 (unapportioned), 2.51 (apportioned) and 3.04 (apportioned and availability bias-corrected) birds/km^2.

- 163 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 931 [674; 1,171], an apportioned mean abundance estimate of 1,067 [803; 1,382] and an apportioned and availability bias-corrected mean abundance estimate of 1,286 [970; 1,659] individuals. These equated to mean density estimates of 2.59 (unapportioned), 2.96 (apportioned) and 3.57 (apportioned and availability bias-corrected) birds/km^2.
- 243 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 1,418 [1,120; 1,786], an apportioned mean abundance estimate of 1,586 [1,254; 1,983] and an apportioned and availability bias-corrected mean abundance estimate of 1,915 [1,517; 2,384] individuals. These equated to mean density estimates of 2.66 (unapportioned), 2.97 (apportioned) and 3.59 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.33 During the breeding site attendance period (March), razorbills were recorded in low numbers in Caledonia South Survey Area, with a peak abundance in March 2023:

- 30 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 174 [104; 255], an apportioned mean abundance estimate of 182 [92; 288] and an apportioned and availability bias-corrected mean abundance estimate of 217 [110; 340] individuals. These equated to mean density estimates of 0.83 (unapportioned), 0.87 (apportioned) and 1.03 (apportioned and availability bias-corrected) birds/km^2.
- 35 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 202 [98; 311], an apportioned mean abundance estimate of 219 [102; 367] and an apportioned and availability bias-corrected mean abundance estimate of 261 [122; 435] individuals. These equated to mean density estimates of 0.56 (unapportioned), 0.61 (apportioned) and 0.73 (apportioned and availability bias-corrected) birds/km^2.
- 57 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 332 [221; 449], an apportioned mean abundance estimate of 360 [185; 534] and an apportioned and availability bias-corrected mean abundance estimate of 425 [222; 627] individuals. These equated to mean density estimates of 0.62 (unapportioned), 0.67 (apportioned) and 0.8 (apportioned and availability bias-corrected) birds/km^2.

5.4.2.34 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected abundances of

razorbills occurred within Caledonia South Survey Area in September. The largest overall peak was in September 2022, when mean apportioned and availability bias-corrected abundances were considerably larger than in any other survey during the non-breeding season for this species. During the late autumn and winter months, mean apportioned and availability bias-corrected abundances of razorbills was generally low in Caledonia South Survey Area reporting regions (with the exception of December 2021), with higher mean apportioned and availability bias-corrected abundances of razorbills occurring in February 2022, February 2023, and March 2023.

5.4.2.35 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 66% to >99.5%, with many of the surveys recording reductions in mean abundances at the upper end of this range when compared with the peak month. This reflects the fact that the September 2022 peak was very large relative to the other peak mean apportioned and availability bias-corrected abundances recorded for razorbill during the non-breeding season.

5.4.2.36 Precision values were quite variable for this species throughout the survey period. CV values of ≤0.16 were reported in five of 22 baseline surveys across Caledonia South, with lower precision values (i.e., higher levels of precision) coinciding with surveys where higher numbers of birds were recorded. For Caledonia South plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia South, indicating higher precision within these reporting regions.

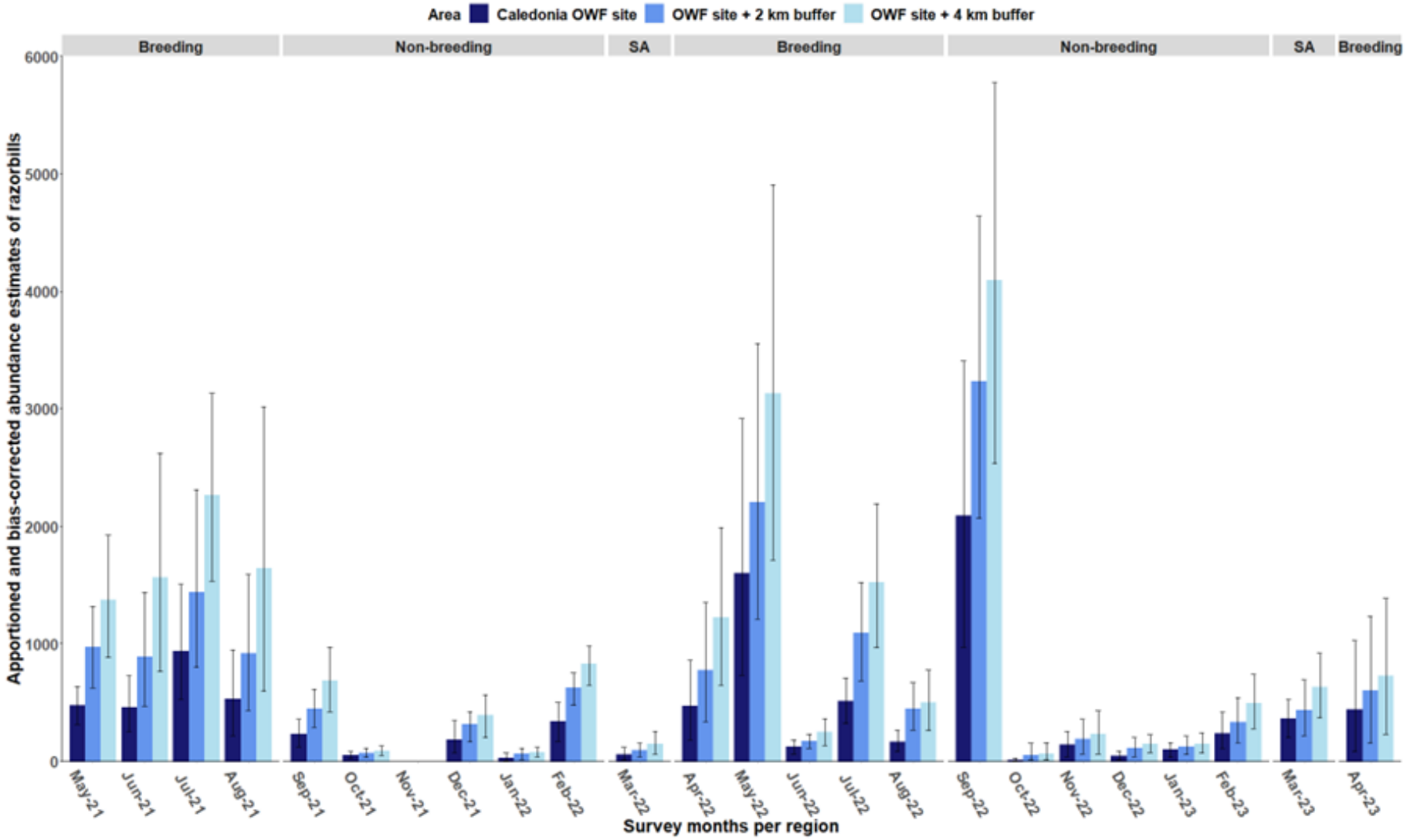


Figure 5-24: Bar plot of the monthly apportioned abundances estimates (with 95% confidence intervals) of total razorbills recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Razorbill seasonal periods are also displayed. SA stands for breeding site attendance.

Spatial Distribution and Flight Direction

Spatial Distribution

5.4.2.37 Razorbills were recorded throughout Caledonia OWF without any discernible distribution pattern in July to September and December 2021, March to April, June, August, November, and December 2022, and in January and March 2023. During May and June 2021, razorbills occurred throughout the majority of the Caledonia OWF (plus a 4km buffer) with lower numbers towards the northeast and highest numbers in the northwest and south. Razorbills appeared exclusively in Caledonia South and the Caledonia South 4km buffer in October 2021, and also displayed higher numbers therein during January, February and July 2022, and in February and April 2023. In contrast, May and September 2022 recorded the majority of birds in Caledonia North. Higher numbers of razorbills to the south (and to a lesser extent in the northwest) of the Caledonia OWF (plus a 4km buffer) indicate connectivity of these areas to breeding colonies within foraging range of these areas (East Caithness Cliffs SPA to the west of the Caledonia OWF (plus a 4km buffer), and Troup, Pennan and Lion's Heads SPA to the south of the Caledonia OWF (plus a 4km buffer)).

5.4.2.38 The MRSea analysis (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) suggest that the highest densities of all razorbill tend to be distributed throughout the southern region of the study area during the breeding season (01 April - 15 August). The highest densities occur during the non-breeding season, in September 2022, where birds are widely distributed across the entire region.

5.4.2.39 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

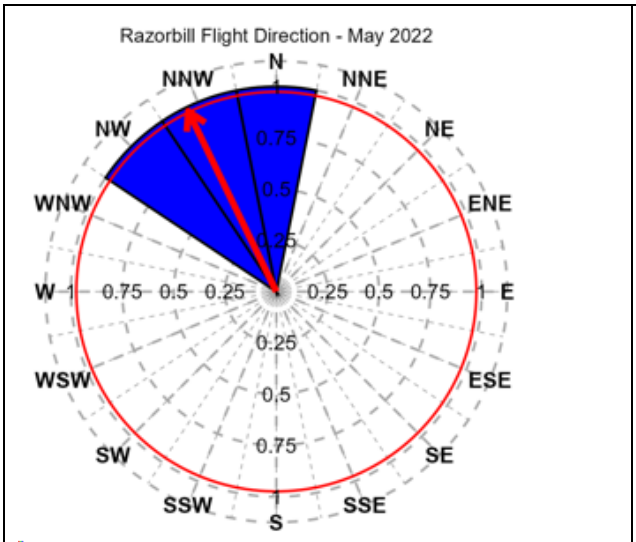
Flight Direction

5.4.2.40 Figure 5-25 presents the flight direction of razorbill within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

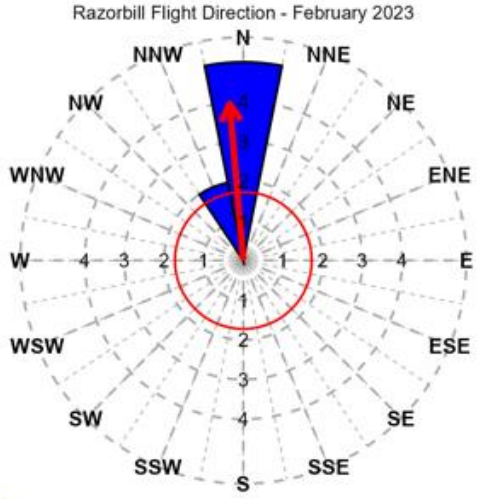
5.4.2.41 Significant predominant direction of flight was recorded in:

- May
  - 2022 north-northwest
- February
  - 2023 north
- March
  - 2023 east-southeast

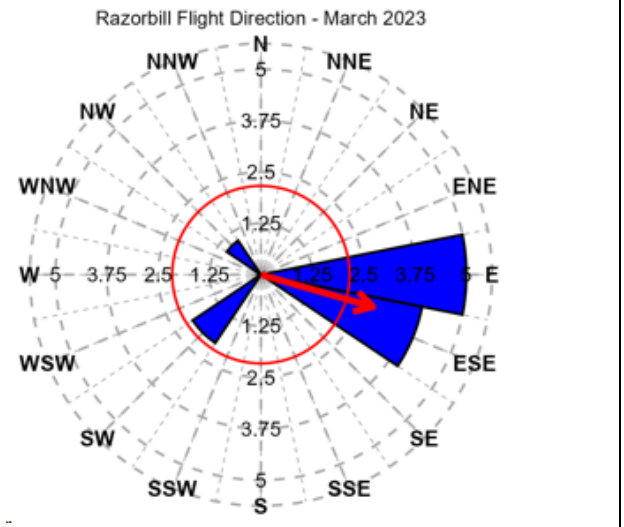
5.4.2.42 As very few birds were recorded in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-26).



Number of Observations	3
Mean Vector (μ)	334.718
Length of Mean Vector (r)	0.979
Rayleigh Test (Z)	2.874
Rayleigh Test (p)	0.041

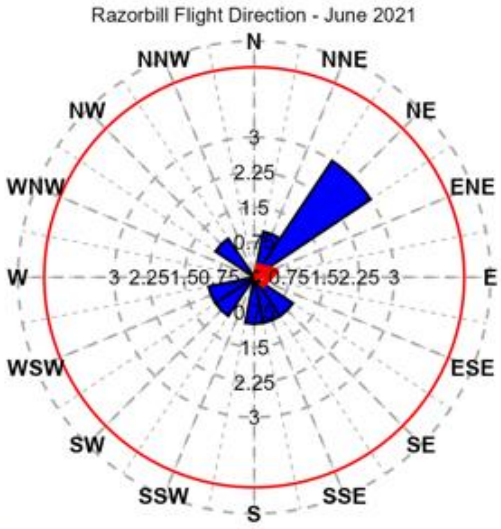


Number of Observations	7
Mean Vector (μ)	355.524
Length of Mean Vector (r)	0.991
Rayleigh Test (Z)	6.868
Rayleigh Test (p)	<0.001

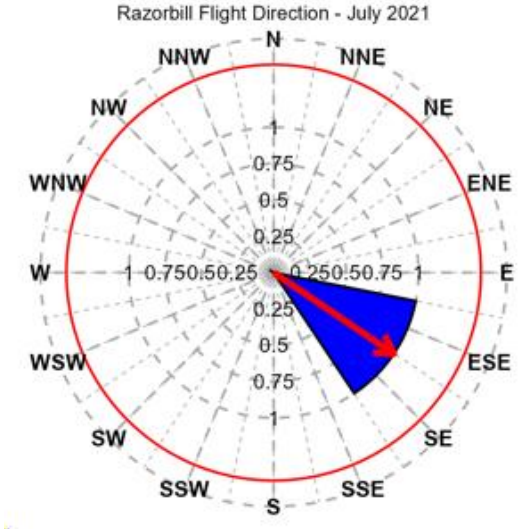


Number of Observations	12
Mean Vector (μ)	106.401
Length of Mean Vector (r)	0.567
Rayleigh Test (Z)	3.861
Rayleigh Test (p)	0.018

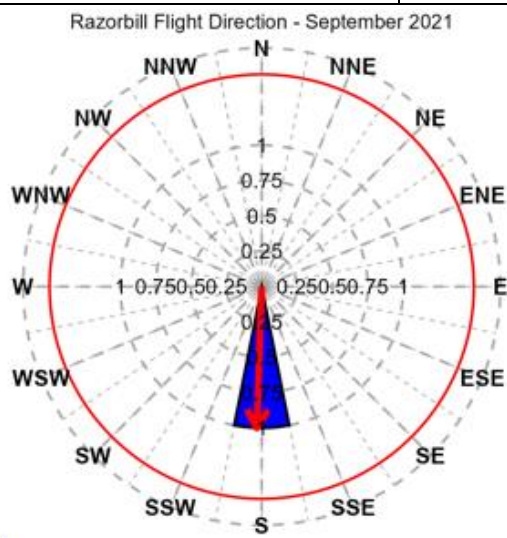
Figure 5-25: Summary of flight direction of guillemot within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.



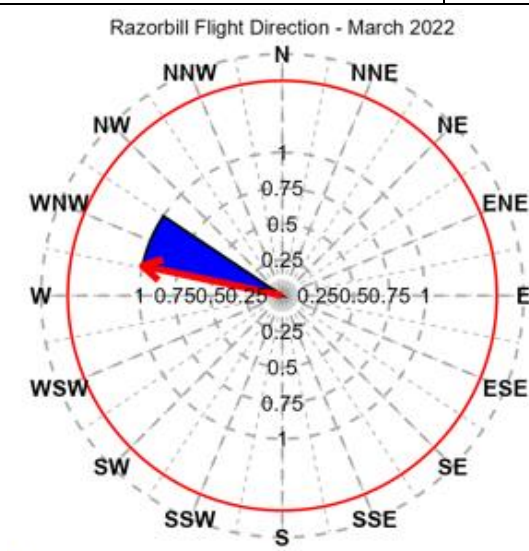
Number of Observations	10
Mean Vector (μ)	74.904
Length of Mean Vector (r)	0.157
Rayleigh Test (Z)	0.248
Rayleigh Test (p)	0.789



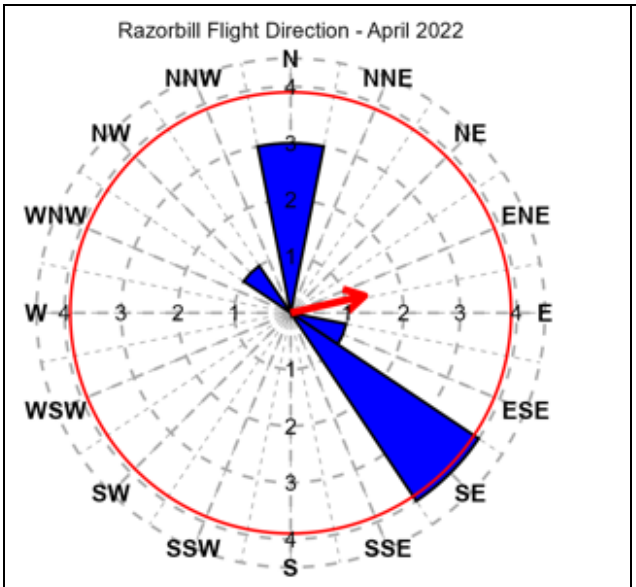
Number of Observations	2
Mean Vector (μ)	124.390
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.998
Rayleigh Test (p)	0.138

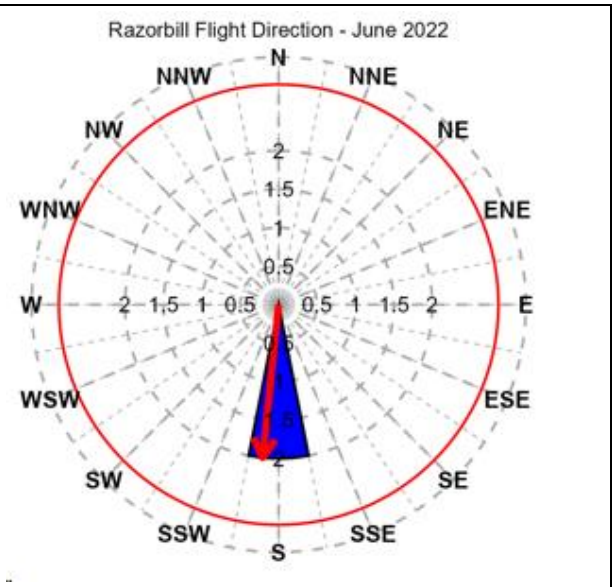


Number of Observations	1
Mean Vector (μ)	182.028
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512

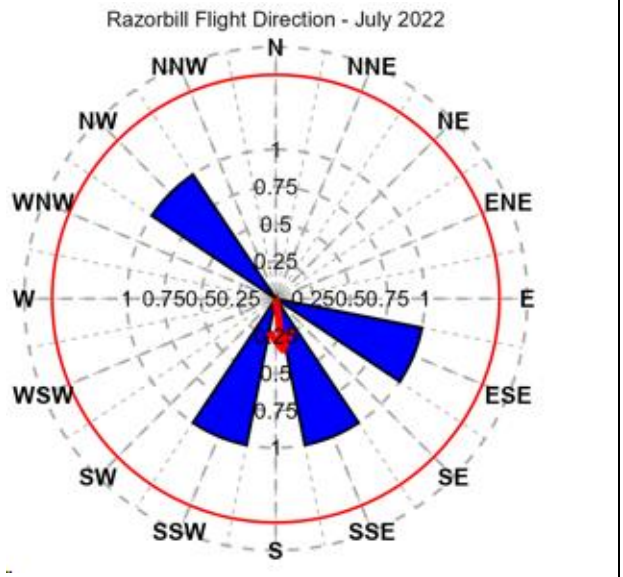


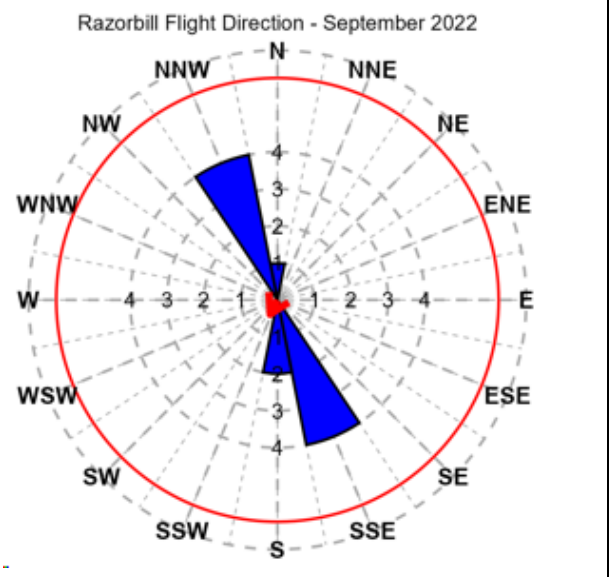
Number of Observations	1
Mean Vector (μ)	282.277
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512



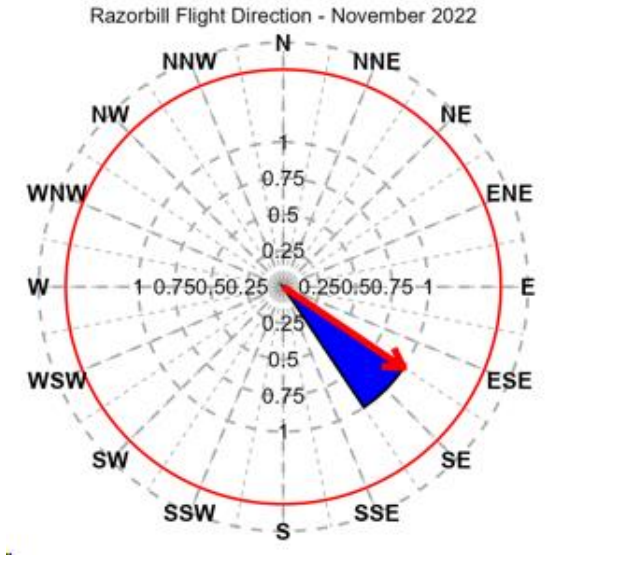


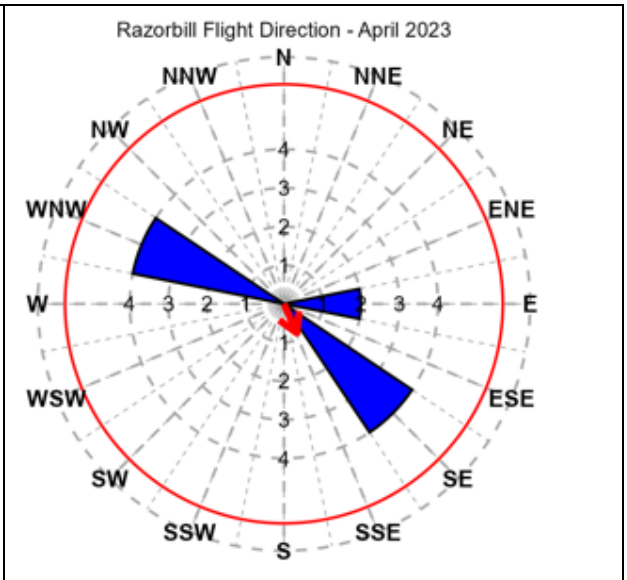
Number of Observations	9	Number of Observations	2
Mean Vector (μ)	77.947	Mean Vector (μ)	186.893
Length of Mean Vector (r)	0.335	Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.010	Rayleigh Test (Z)	1.999
Rayleigh Test (p)	0.375	Rayleigh Test (p)	0.127





Number of Observations	4	Number of Observations	11
Mean Vector (μ)	172.231	Mean Vector (μ)	207.993
Length of Mean Vector (r)	0.347	Length of Mean Vector (r)	0.111
Rayleigh Test (Z)	0.480	Rayleigh Test (Z)	0.134
Rayleigh Test (p)	0.648	Rayleigh Test (p)	0.879





Number of Observations	1	Number of Observations	10
Mean Vector (μ)	124.396	Mean Vector (μ)	156.623
Length of Mean Vector (r)	1.000	Length of Mean Vector (r)	0.207
Rayleigh Test (Z)	1.000	Rayleigh Test (Z)	0.429
Rayleigh Test (p)	0.512	Rayleigh Test (p)	0.663

Figure 5-26: Summary of flight direction of razorbill within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.4.2.43 As recommended by the NatureScot (2023[1]) guidance, razorbill has been scoped into the assessment for:

- Potential operational phase displacement.

5.4.2.44 As a result, detailed consideration of mean seasonal peak abundance (all birds), is provided in the following sections.

Seasonal Peak

5.4.2.45 The peaks used for the matrix-based distributional response assessment have been presented in Table 5–23. The offshore ornithology distributional responses assessment has been carried out separately for the Caledonia OWF, Caledonia North and Caledonia South. The peaks have been defined using the seasonal definitions presented in Table 5–21 and Table 5–22.

5.4.2.46 See Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates for the density and population estimate of all razorbill in the Caledonia OWF, Caledonia North and Caledonia South (plus a 2km buffer) used within assessments.

5.4.2.47 Razorbill were present in the greatest abundance during the non-breeding season (Late August to March) within Caledonia OWF (plus a 2km buffer) and Caledonia North with a peak abundance of 1,930 and 1,446 birds respectively. Whereas, fewer razorbill were present within Caledonia South (plus a 2km buffer) with a peak abundance of 803 birds.

5.4.2.48 During the breeding season (April to mid-August) fewer razorbill were present within Caledonia OWF (plus a 2km buffer) and Caledonia North with a peak abundance of 879 and 1,762 birds respectively. Whereas, within Caledonia South (plus a 2km buffer) razorbill were in the greatest abundance during the breeding season with a peak abundance of 1,089 birds.

Table 5–23: Seasonal Peaks of razorbill within Caledonia OWF (+2km buffer), Caldonia North (+2km buffer) and Caledonia South (+2km buffer), during the NatureScot defined seasons and the BDMPS Non-breeding Seasons as per Furness (2015[48]).

Defined Season	Breeding Season	Non-breeding Season	Autumn Migration	Winter Period	Spring Migration
Caledonia OWF	1,762 (1,510 / 2,014)	1,930 (627 / 3,232)	1,841 (449 / 3,232)	253 (314 / 191)	530 (627 / 432)
Caledonia North	879 (527 / 1,232)	1,446 (454 / 2,438)	1,315 (192 / 2,438)	126 (116 / 135)	345 (454 / 236)
Caledonia South	1,089 (1,156 / 1,022)	803 (320 / 1,286)	803 (320 / 1,286)	164 (233 / 95)	251 (241 / 261)
Note, the seasonal peaks from Year 1 and Year 2 of DAS data used to calculate the mean seasonal peaks are provided within the brackets '()'. Note, the seasonal peaks have been calculated using model-based median abundances for the breeding season (April to mid-August) and design-based mean abundances for the non-breeding season (Mid-August to March).					

5.4.3 Puffin

Defined Seasons

5.4.3.1 Puffin seasonal definitions are presented Table 5–24 as per the NatureScot (2020[71]) guidance. As there is only one non-breeding seasons for puffin within Furness (2015[48]), no separate BDMPS seasons have been provided.

Table 5–24: Defined seasons in the Scottish Marine Environment used in the assessment for puffin (NatureScot, 2020[71]).

Breeding Season	Post-breeding Migration Season	Non-breeding Season	Pre-breeding Migration Season
April to Mid-August	Late August	**Late August to March**	Late March (flightless moult February to mid-March)
Time periods in **bold** are those used by the assessment.			

Overview

5.4.3.2 Atlantic puffin (hereafter puffin) are colonial birds, nest in burrows during the breeding season (April-mid August) (NatureScot, 2020[71]), and are distributed across isolated offshore islands such as St Kilda and the Isle of May (Harris and Wanless, 2011[125]).

5.4.3.3 Puffins diet primarily consists of sandeel, gadoids and clupeids, with sandeel taking a higher proportion of their diet (Miles *et al*., 2015[126]). At Fair Isle, the mass of prey loads had been declining from 1987 to 2013 along with frequency of chick feeding and individual prey size which is a likely factor for the poor breeding success during some years (Miles *et al*., 2015[126]). The low productivity rate of north-east Atlantic puffin populations is driven by a combination of factors including adults forced to forage far from colonies due to reduced prey availability around colonies and a lack of suitable prey in their extended foraging range (Fayet *et al*., 2021[127]).

5.4.3.4 In the summer, puffin are found in greatest numbers in the north of Scotland and the Northern Isles (Mitchell *et al*., 2004[44]; Waggitt *et al*., 2019[37]; Burnell *et al*., 2023[83]).

5.4.3.5 Puffins have a relatively high MMF±SD of 137.1±128.3km or 119±131.2km, travelling further to forage during the breeding season than razorbill and guillemot (Woodward *et al*., 2019[56]). The second MMF excludes the foraging range from Fair Isle due to the reduction of prey availability during the study year (Woodward *et al*., 2019[56]). In the winter distribution is concentrated within the north-western North Sea, before birds depart for wintering areas in the North Atlantic (Stone *et al*., 1995[32]).

Conservation Status

5.4.3.6 Puffin are Red-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]), and are classified as vulnerable by the IUCN red list (BirdLife International, 2004[45]).

Vulnerability to Climate Change

5.4.3.7 Puffin are predicted (with low confidence) to have high vulnerability to climate change in the east of Scotland (Davies *et al*., 2021[39]). This species is projected to decline by 89% in Britain and Ireland and 93% in the Outer Hebrides between 1998-2002 and 2050 (Davies *et al*., 2021[39]). Searle *et al*. (2022[80]) predicted that puffin populations in north-east Scotland and the Northern Isles will severely decline towards the end of the century (2077-2099) under modelled scenarios.

Regional and National Population Trends

5.4.3.8 The annual monitoring of puffin colonies is limited due to difficulties collecting data (Harris and Wanless, 2011[125]). According to the Seabirds Count (2015-2021) there are approximately 369,279 individuals in Scotland, which represents a decline of 32% individuals since the Seabird 2000 Census (1998-2002) (Burnell *et al*., 2023[83]). Puffin productivity shows a long-term decline since the late 1980s (Scottish Government, 2020[99]). In the Forth and Tay region the population is declining but is still well above the population estimates in 1984, while in the Moray Firth and north coast populations are similarly declining, with a decline of 13% compared to 1986 population estimates, a 55% compared with the 1999 population estimates (Scottish Government, 2020[99]).

5.4.3.9 An assessment of colony counts was undertaken by the RSPB following the first outbreak of HPAI in 2022. Puffin was not included in these surveys, since the species is thought to have incurred relatively low mortality due to HPAI (Tremlett *et al.,* 2024[84]), and due to the difficultly in carrying out detailed censuses on this species. A continued campaign of counts is required to monitor this species, and others, for additional impacts due to HPAI.

5.4.3.10 The total biogeographical population estimate with connectivity to UK waters in 2015 was 11,840,000 individuals, with 2,370,000 individuals (adults and immatures) from the UK (Furness, 2015[48]). The non-breeding season for puffin is defined as late-August to March (NatureScot, 2020[71]), in which the total population in the UK North Sea is 231,957 individuals (Furness, 2015[48]).

DAS Baseline Overview

5.4.3.11 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:

- Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-37, Table 2-38 and Table 2-39;
- Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-35 and Table 2-36; and
- Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-25, Table 2-26 and Table 2-27.

- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-36, Table 2-37 and Table 2-38;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-32 and Table 2-33; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-24, Table 2-25 and Table 2-26.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-36, Table 2-37 and Table 2-38;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-34 and Table 2-35; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-24, Table 2-25 and Table 2-26.

5.4.3.12 Figure 5-27 presents the abundance of puffin (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.4.3.13 A total of 2,054 puffins were recorded in the Survey Area during both years of baseline surveys. Puffins were recorded in every survey except November 2021 to February 2022 and November to December 2022. Puffins were the most abundant during the breeding season (April to mid-August, with birds attending colonies from mid-March onwards). Peak of abundance was recorded in August 2021:

- 370 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 2,142 [1,042; 3,438], an

apportioned mean abundance estimate of 2,390 [1,099; 3,951] and an apportioned and availability bias-corrected mean abundance estimate of 2,784 [1,280; 4,603] individuals. These equated to mean density estimates of 5.01 (unapportioned), 5.59 (apportioned) and 6.51 (apportioned and availability bias-corrected) birds/km^2.

- 462 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 2,636 [1,381; 4,246], an apportioned mean abundance estimate of 3,076 [1,539; 4,976] and an apportioned and availability bias-corrected mean abundance estimate of 3,583 [1,793; 5,797] individuals. These equated to mean density estimates of 4.10 (unapportioned), 4.78 (apportioned) and 5.56 (apportioned and availability bias-corrected) birds/km^2.
- 562 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 3,260 [1,949; 4,891], an apportioned mean abundance estimate of 4,123 [2,188; 6,363] and an apportioned and availability bias-corrected mean abundance estimate of 4,803 [2,548; 7,413] individuals. These equated to mean density estimates of 3.69 (unapportioned), 4.66 (apportioned) and 5.43 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.14 During the 2021 breeding season, mean apportioned and availability bias-corrected puffin abundances in the Survey Area and reporting regions between May and July were very consistent. In August 2021, a large peak in mean abundance was observed, which was also the peak breeding season abundance for all reporting regions across the baseline survey period. It is anticipated that rather than a peak of breeding adult birds, the timing of this peak, and the size of the abundances recorded relative to other breeding season surveys, may indicate a post-breeding peak of birds, likely originating from multiple breeding colonies across the wider region. What could be considered to be an equivalent peak occurred in September 2022 (i.e., outside the breeding season). During the 2022 breeding season, mean abundances were consistent across April and May (and higher than the corresponding abundances recorded in the same months in 2021. In June and July 2022, abundances were considerably lower, with higher abundances reported during August 2022. The reason for the different temporal patterns in the 2021 and 2022 breeding seasons is unclear.

5.4.3.15 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 70% to 99%, with most surveys falling somewhere in the middle of the two extremes of this range. This is indicative of the overall breeding season peak for being considerably higher than the abundance estimates recorded for all other surveys during this season. This is perhaps related to the presence of a post-breeding season peak in August 2021, which happened to fall inside the breeding season.

5.4.3.16 During the non-breeding season (September to mid-March), puffins were only recorded in September to October 2021, September 2022 and January to March 2023, with a peak in September 2022:

- 213 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 1,233 [602; 1,921], an apportioned mean abundance estimate of 1,269 [627; 2,031] and an apportioned and availability bias-corrected mean abundance estimate of 1,477 [730; 2,360] individuals. These equated to mean density estimates of 2.89 (unapportioned), 2.97 (apportioned) and 3.45 (apportioned and availability bias-corrected) birds/km^2.
- 342 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,974 [1,281; 2,782], an apportioned mean abundance estimate of 2,084 [1,266; 2,990] and an apportioned and availability bias-corrected mean abundance estimate of 2,426 [1,475; 3,477] individuals. These equated to mean density estimates of 3.07 (unapportioned), 3.24 (apportioned) and 3.77 (apportioned and availability bias-corrected) birds/km^2.
- 495 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 2,888 [1,727; 4,277], an apportioned mean abundance estimate of 3,001 [1,745; 4,345] and an apportioned and availability bias-corrected mean abundance estimate of 3,492 [2,032; 5,051] individuals. These equated to mean density estimates of 3.27 (unapportioned), 3.39 (apportioned) and 3.95 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.17 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected abundances occurred within the Survey Area and reporting regions in September 2022. The timing of this peak is indicative of a post-breeding season aggregation of birds (likely consisting of birds from multiple breeding colonies across the region). A peak abundance estimate in August 2021 (i.e., within the breeding season) is also considered likely to be a post-breeding aggregation of birds, which arguably could be considered a non-breeding count, despite the earlier timing in 2021. The September 2022 mean apportioned and availability bias-corrected abundances were considerably larger than in any other survey during the non-breeding season for this species within the Survey Area and reporting regions. Puffin were absent from the surveys carried out between November 2021 and February 2022, and October to December 2022, in keeping with the general understand of the seasonal movements of this species. Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 86% to >99.5%, reflecting the fact that the September 2022 peak was very large relative to the other mean apportioned and availability bias-corrected abundances recorded for puffin during the non-breeding season.

5.4.3.18 During the breeding site attendance period (March), puffins were recorded in low numbers, with peak numbers in March 2023:

- Nine individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 53 [18; 88], an apportioned mean abundance estimate of 54 [18; 95] and an apportioned and availability bias-corrected mean abundance estimate of 63 [21; 111] individuals. These equated to mean density estimates of 0.12 (unapportioned), 0.13 (apportioned) and 0.15 (apportioned and availability bias-corrected) birds/km^2.
- 11 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 64 [23; 110], an apportioned mean abundance estimate of 65 [17; 112] and an apportioned and availability bias-corrected mean abundance estimate of 75 [20; 131] individuals. These equated to mean density estimates of 0.10 (unapportioned), 0.10 (apportioned) and 0.12 (apportioned and availability bias-corrected) birds/km^2.
- 14 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 82 [29; 141], an apportioned mean abundance estimate of 83 [35; 139] and an apportioned and availability bias-corrected mean abundance estimate of 97 [41; 161] individuals. These equated to mean density estimates of 0.09 (unapportioned), 0.09 (apportioned) and 0.11 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.19 Measures of precisions were variable for puffin across the survey period. During eight of 16 surveys in which the species was recorded within Caledonia OWF, CV values were ≤0.16, indicating higher levels of precision. Seven of these eight surveys were within the breeding season, which meant that seven of 10 breeding season surveys had a CV value of ≤0.16. Higher levels of precision coincided with higher numbers of puffins being recorded. Outside the breeding season, when lower numbers of puffins were recorded, CV values were typically calculated to be between 0.2 to 0.6, indicating lower levels of precision. For Caledonia OWF plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia OWF, indicating higher precision within these reporting regions.

Caledonia North

5.4.3.20 A total of 1,185 puffins were recorded in Caledonia North Survey Area during both years of baseline surveys. Puffins were recorded in every survey except November 2021 to March 2022 and November to December 2022. Puffin were the most abundant during the breeding season (April to mid-August, with birds attending colonies from mid-March onwards). Peak of abundance was recorded in August 2021:

- 195 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 1,130 [463; 1,796], an

apportioned mean abundance estimate of 1,156 [467; 1,811] and an apportioned and availability bias-corrected mean abundance estimate of 1,346 [545; 2,109] individuals. These equated to mean density estimates of 5.18 (unapportioned), 5.29 (apportioned) and 6.16 (apportioned and availability bias-corrected) birds/km^2.

- 345 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,957 [823; 3,211], an apportioned mean abundance estimate of 2,047 [856; 3,383] and an apportioned and availability bias-corrected mean abundance estimate of 2,385 [997; 3,942] individuals. These equated to mean density estimates of 5.21 (unapportioned), 5.45 (apportioned) and 6.35 (apportioned and availability bias-corrected) birds/km^2.
- 418 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 2,427 [1,115; 3,959], an apportioned mean abundance estimate of 2,532 [1,098; 4,231] and an apportioned and availability bias-corrected mean abundance estimate of 2,950 [1,279; 4,929] individuals. These equated to mean density estimates of 4.36 (unapportioned), 4.54 (apportioned) and 5.29 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.21 During the 2021 breeding season, mean apportioned and availability bias-corrected puffin abundances in Caledonia North Survey Area and reporting regions between May and July were relatively consistent, with the peak occurring in May 2021. In August 2021, a large peak in abundance was observed, which was also the peak breeding season mean apportioned and availability bias-corrected abundance for all reporting regions across the baseline survey period. It is anticipated that rather than a peak of breeding adult birds, the timing of this peak, and the size of the abundances recorded relative to other breeding season surveys, may indicate a post-breeding peak of birds, likely originating from multiple breeding colonies across the wider region. What could be considered to be an equivalent peak occurred in September 2022 (i.e., outside the breeding season). During the 2022 breeding season, abundances were consistent across April and May (and higher than the corresponding abundances recorded in the same months in 2021. In June and July 2022, abundances were considerably lower, with slightly higher mean abundances reported during August 2022. The reason for the different temporal patterns in the 2021 and 2022 breeding seasons is unclear.

5.4.3.22 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 75% to 99%, with most surveys falling somewhere in the middle of the two extremes of this range. This is indicative of the overall breeding season peak for the baseline survey period being considerably higher than the abundance estimates recorded for all other surveys during this season across both of the breeding seasons within the survey period. This is

perhaps related to the presence of a post-breeding season peak in August 2021 (i.e., inside the breeding season).

5.4.3.23 During the non-breeding season (September to mid-March), puffins were only recorded in September to October 2021, September 2022 and January to March 2023, with a peak recorded in September 2022:

- 107 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 614 [321; 930], an apportioned mean abundance estimate of 644 [327; 978] and an apportioned and availability bias-corrected mean abundance estimate of 750 [381; 1,139] individuals. These equated to mean density estimates of 2.81 (unapportioned), 2.95 (apportioned) and 3.43 (apportioned and availability bias-corrected) birds/km^2.
- 193 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,121 [691; 1,475], an apportioned mean abundance estimate of 1,178 [769; 1,620] and an apportioned and availability bias-corrected mean abundance estimate of 1,372 [896; 1,887] individuals. These equated to mean density estimates of 2.99 (unapportioned), 3.14 (apportioned) and 3.65 (apportioned and availability bias-corrected) birds/km^2.
- 302 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 1,759 [920; 2,673], an apportioned mean abundance estimate of 1,829 [978; 2,913] and an apportioned and availability bias-corrected mean abundance estimate of 2,128 [1,139; 3,385] individuals. These equated to mean density estimates of 3.16 (unapportioned), 3.28 (apportioned) and 3.82 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.24 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected abundances of puffin within Caledonia North Survey Area and reporting regions occurred in September 2022. The timing of this peak is indicative of a post-breeding season aggregation of birds (likely consisting of birds from multiple breeding colonies across the region). A peak abundance estimate in August 2021 (i.e., within the breeding season) is also considered likely to be a post-breeding aggregation of birds, which arguably could be considered a non-breeding count, despite the earlier timing in 2021. The September 2022 mean apportioned and availability bias-corrected abundances were considerably larger than in any other survey during the non-breeding season for this species within Caledonia North Survey Area and reporting regions. Puffin were absent from the surveys carried out between November 2021 and March 2022, and either absent or recorded in very low numbers between October 2022 to April 2023. Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 91% to 99%, reflecting the fact that the September 2022 peak was very large relative to the other mean apportioned and availability

bias-corrected abundances recorded for puffin during the non-breeding season.

5.4.3.25 During the breeding site attendance period (March), puffins were recorded absent in March 2022 and in low numbers in March 2023, which is when the peak was recorded:

- Six individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 35 [6; 70], an apportioned mean abundance estimate of 36 [6; 80] and an apportioned and availability bias-corrected mean abundance estimate of 42 [7; 93] individuals. These equated to mean density estimates of 0.16 (unapportioned), 0.16 (apportioned) and 0.19 (apportioned and availability bias-corrected) birds/km^2.
- Seven individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 41 [7; 87], an apportioned mean abundance estimate of 42 [7; 90] and an apportioned and availability bias-corrected mean abundance estimate of 49 [8; 105] individuals. These equated to mean density estimates of 0.11 (unapportioned), 0.11 (apportioned) and 0.153 (apportioned and availability bias-corrected) birds/km^2.
- Eight individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 47 [12; 94], an apportioned mean abundance estimate of 48 [12; 103] and an apportioned and availability bias-corrected mean abundance estimate of 56 [14; 120] individuals. These equated to mean density estimates of 0.08 (unapportioned), 0.09 (apportioned) and 0.10 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.26 Measures of precisions were variable for puffin across the survey period. During three of 16 surveys in which the species was recorded within Caledonia North, CV values were ≤0.16, indicating higher levels of precision. The three surveys were within the breeding season, which meant that three of 10 breeding season surveys had a CV value of ≤0.16. Higher levels of precision coincided with higher numbers of puffins being recorded. Outside the breeding season, when lower numbers of puffins were recorded, CV values were typically calculated to be between 0.2 to 0.6, indicating lower levels of precision. For Caledonia North plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia North, indicating higher precision within these reporting regions.

Caledonia South

5.4.3.27 A total of 1,329 puffins were recorded in Caledonia South Survey Area during both years of baseline surveys. Puffins were recorded in every survey except November 2021 to February 2022 and November 2022 to January 2023. During the breeding season (April to mid-August, with birds attending colonies from mid-March onwards). Puffin were the most

abundant during the breeding season (April to August), with a peak in August 2021:

- 175 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 1,010 [433; 1,605], an apportioned mean abundance estimate of 1,223 [494; 2,139] and an apportioned and availability bias-corrected mean abundance estimate of 1,424 [576; 2,491] individuals. These equated to mean density estimates of 4.80 (unapportioned), 5.81 (apportioned) and 6.77 (apportioned and availability bias-corrected) birds/km^2.
- 246 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,410 [803; 2,190], an apportioned mean abundance estimate of 1,796 [1,217; 2,935] and an apportioned and availability bias-corrected mean abundance estimate of 2,093 [1,418; 3,420] individuals. These equated to mean density estimates of 3.92 (unapportioned), 4.99 (apportioned) and 5.82 (apportioned and availability bias-corrected) birds/km^2.
- 309 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 1,777 [1,162; 2,537], an apportioned mean abundance estimate of 2,559 [1,441; 3,960] and an apportioned and availability bias-corrected mean abundance estimate of 2,981 [1,678; 4,614] individuals. These equated to mean density estimates of 3.33 (unapportioned), 4.79 (apportioned) and 5.59 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.28 During the 2021 breeding season, mean apportioned and availability bias-corrected puffin abundances within Caledonia South Survey Area and reporting regions between May and July were very consistent. In August 2021, a large peak in abundance was observed, which was also the peak breeding season mean apportioned and availability bias-corrected abundance for all reporting regions across the baseline survey period. It is anticipated that rather than a peak of breeding adult birds, the timing of this peak, and the size of the abundances recorded relative to other breeding season surveys, may indicate a post-breeding peak of birds, likely originating from multiple breeding colonies across the wider region. What could be considered to be an equivalent peak occurred in September 2022 (i.e., outside the breeding season). During the 2022 breeding season, abundances were consistent across April and May (and higher than the corresponding abundances recorded in the same months in 2021. In June and July 2022, abundances were considerably lower, with higher mean abundances comparable to April and May 2022 reported during August 2022. The reason for the different temporal patterns in the 2021 and 2022 breeding seasons is unclear.

5.4.3.29 Reductions in mean apportioned and availability bias-corrected abundance in the breeding season surveys outside the peak survey month varied from 66% to 99%, with most surveys falling somewhere in the middle of the two

extremes of this range. This is indicative of the overall breeding season peak for the baseline survey period being considerably higher than the abundance estimates recorded for all other surveys during this season across both of the breeding seasons within the survey period. This is perhaps related to the presence of a post-breeding season peak in August 2021 (i.e., inside the breeding season).

5.4.3.30 During the non-breeding season (September to mid-March), puffins were only recorded present in September to October 2021, September 2022 and January to March 2023, with a peak in September 2022:

- 106 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 618 [326; 985], an apportioned mean abundance estimate of 628 [336; 1,015] and an apportioned and availability bias-corrected mean abundance estimate of 730 [391; 1,177] individuals. These equated to mean density estimates of 2.94 (unapportioned), 2.99 (apportioned) and 3.47 (apportioned and availability bias-corrected) birds/km^2.
- 193 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,102 [777; 1,468], an apportioned mean abundance estimate of 1,372 [838; 1,591] and an apportioned and availability bias-corrected mean abundance estimate of 1,358 [976; 1,848] individuals. These equated to mean density estimates of 3.07 (unapportioned), 3.24 (apportioned) and 3.77 (apportioned and availability bias-corrected) birds/km^2.
- 283 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 1,651 [1,190; 2,101], an apportioned mean abundance estimate of 1,717 [1,216; 2,295] and an apportioned and availability bias-corrected mean abundance estimate of 1,996 [1,416; 2,662] individuals. These equated to mean density estimates of 3.1 (unapportioned), 3.22 (apportioned) and 3.74 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.31 During the two non-breeding seasons covered by the baseline surveys, peak mean apportioned and availability bias-corrected abundances of puffin within Caledonia South Survey Area and reporting regions occurred in September 2022. The timing of this peak is indicative of a post-breeding season aggregation of birds (likely consisting of birds from multiple breeding colonies across the region). A peak abundance estimate in August 2021 (i.e., within the breeding season) is also considered likely to be a post-breeding aggregation of birds, which arguably could be considered a non-breeding count, despite the earlier timing in 2021. The September 2022 mean apportioned and availability bias-corrected abundances were considerably larger than in any other survey during the non-breeding season for this species, and puffin were absent from the surveys carried out between November 2021 and February 2022, and either absent or recorded in very low numbers between October 2022 to April 2023.

Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 81% to >99.5%, reflecting the fact that the September 2022 peak was very large relative to the other peak mean apportioned and availability bias-corrected abundances recorded for puffin during the non-breeding season.

5.4.3.32 During the breeding site attendance period (March), puffins were recorded in low numbers, with peak numbers in March 2023:

- Three individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 17 [6; 35], an apportioned mean abundance estimate of 17 [3; 35] and an apportioned and availability bias-corrected mean abundance estimate of 20 [3; 41] individuals. These equated to mean density estimates of 0.08 (unapportioned), 0.08 (apportioned) and 0.09 (apportioned and availability bias-corrected) birds/km^2.
- Five individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned and apportioned mean abundance estimate of 29 [5; 58-64], and an apportioned and availability bias-corrected mean abundance estimate of 34 [6; 75] individuals. These equated to mean density estimates of 0.08 (unapportioned and apportioned) and 0.09 (apportioned and availability bias-corrected) birds/km^2.
- Nine individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 52 [23; 87], an apportioned mean abundance estimate of 53 [23; 89], and an apportioned and availability bias-corrected mean abundance estimate of 61 [27; 103] individuals. These equated to mean density estimates of 0.10 (unapportioned), 0.1 (apportioned) and 0.11 (apportioned and availability bias-corrected) birds/km^2.

5.4.3.33 Measures of precisions were variable for puffin across the survey period. During four of 15 surveys in which the species was recorded within Caledonia South, CV values were ≤0.16, indicating higher levels of precision. The four surveys were within the breeding season, which meant that four of 10 breeding season surveys had a CV value of ≤0.16. Higher levels of precision coincided with higher numbers of puffins being recorded. Outside the breeding season, when lower numbers of puffins were recorded, CV values were typically calculated to be between 0.2 to 0.7, indicating lower levels of precision. For Caledonia South plus buffer regions, CV values were generally lower than the corresponding CV values for Caledonia South, indicating higher precision within these reporting regions.

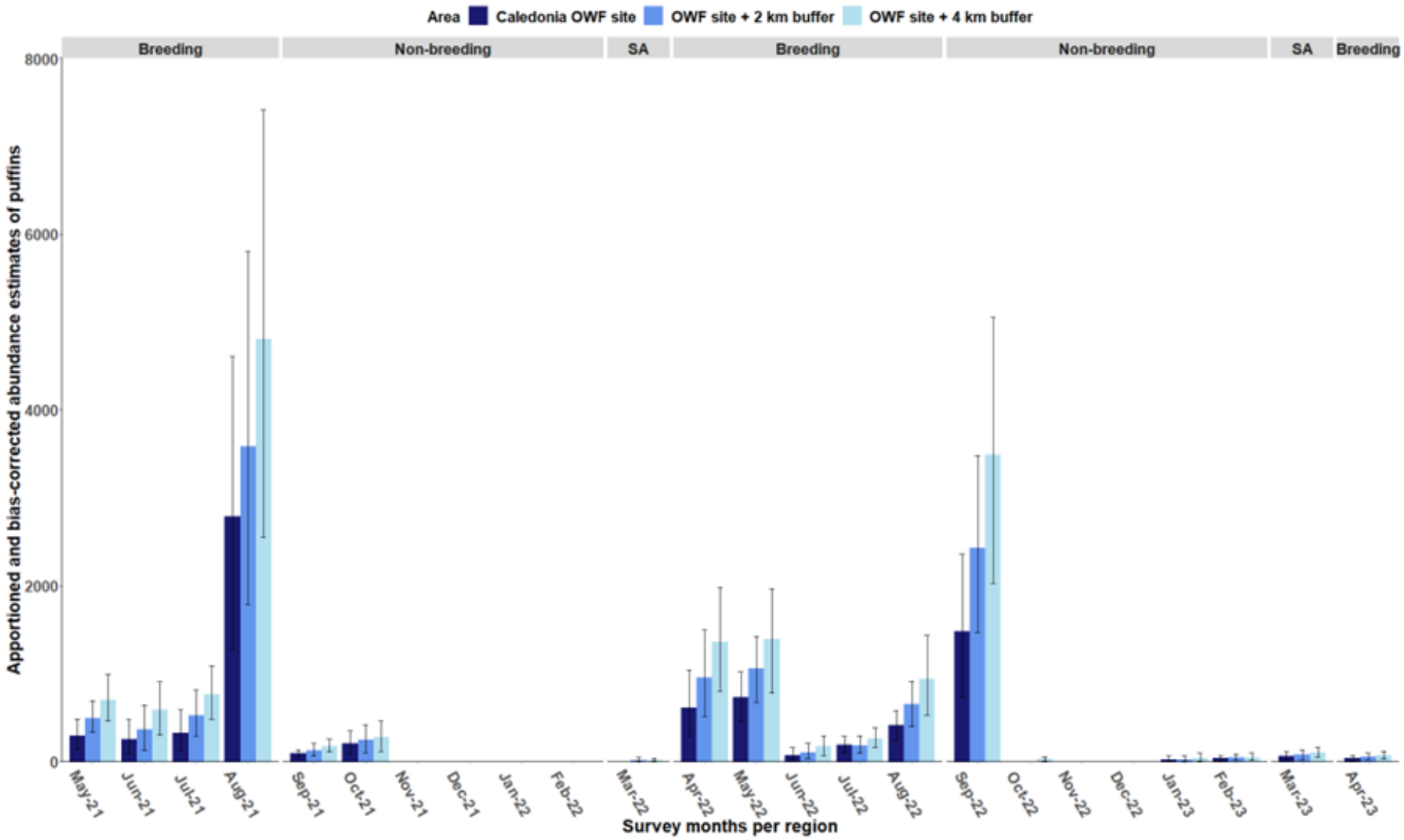


Figure 5-27: Bar plot of the monthly apportioned and availability bias-corrected abundances estimates (with 95% confidence intervals) of total puffins recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Puffin seasonal periods are also displayed. SA stands for breeding site attendance.

Spatial Distribution and Flight Direction

Spatial Distribution

5.4.3.34 While puffins were mostly loosely distributed across the Caledonia OWF (plus a 4km buffer), higher numbers of records were made in Caledonia South (plus a 4km buffer) in June, July, September, and October 2021 and in August 2022. In August 2021, October 2022 and January 2023, the opposite pattern was observed with individuals largely recorded in the north of the Caledonia OWF (plus a 4km buffer). The two individuals recorded in March 2022 were both located in the southwest of Caledonia South 4km Buffer Zone.

5.4.3.35 The MRSea analysis (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) suggest that puffin are distributed more generally towards the eastern half of the study area during the breeding season (01 April - 15 August). In the non-breeding season, with the exception of September - October 2021 and September 2022, puffins are mostly absent from the study area (less than 20 observations). The highest densities were observed in the centre and southern regions of the study area in August 2021.

5.4.3.36 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

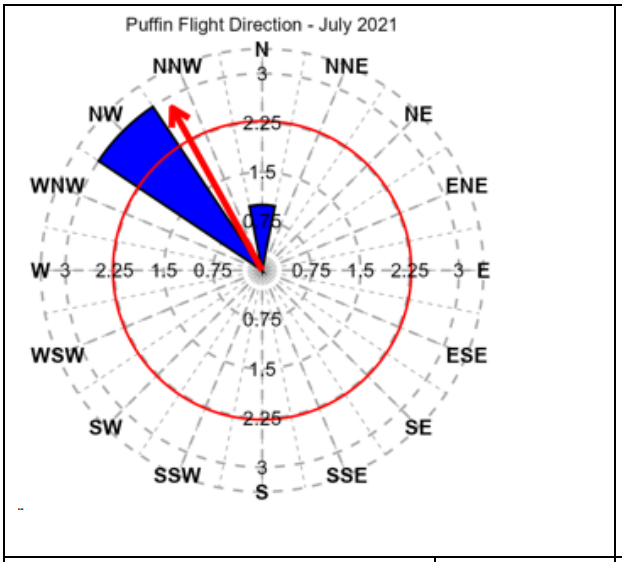
- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

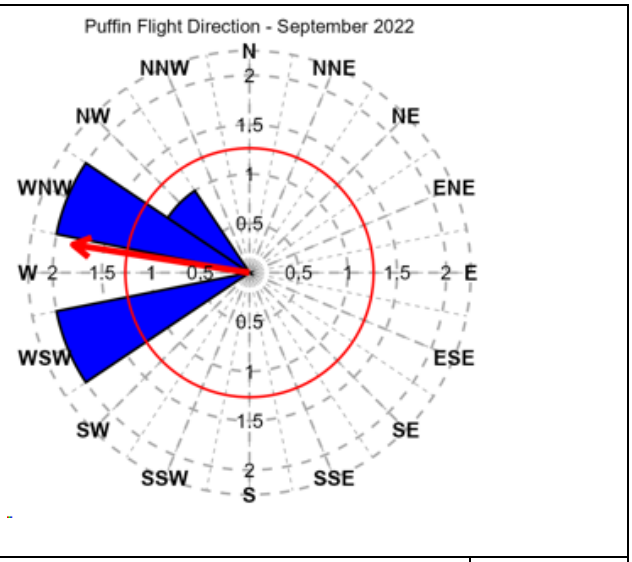
Flight Direction

5.4.3.37 Figure 5-28 presents the flight direction of puffin within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.4.3.38 Significant predominant direction of flight was recorded in:

- July
  - 2021 north-northwest
- September
  - 2022 west

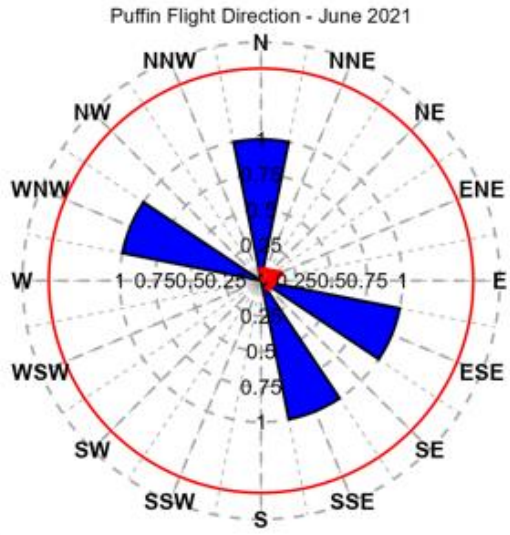




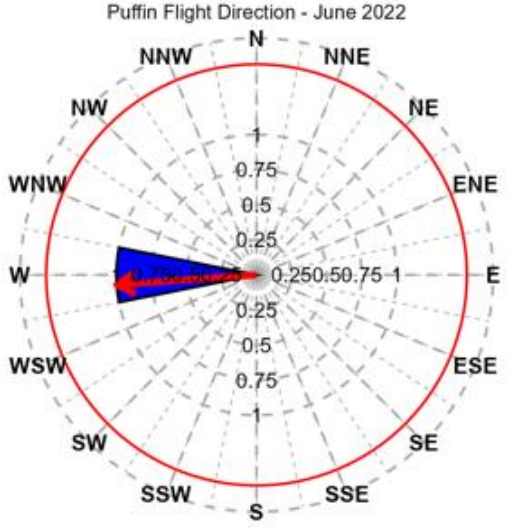
Number of Observations	4	Number of Observations	5
Mean Vector (μ)	331.121	Mean Vector (μ)	279.888
Length of Mean Vector (r)	0.943	Length of Mean Vector (r)	0.907
Rayleigh Test (Z)	3.558	Rayleigh Test (Z)	4.112
Rayleigh Test (p)	0.016	Rayleigh Test (p)	0.008

Figure 5-28: Summary of flight direction of puffin within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

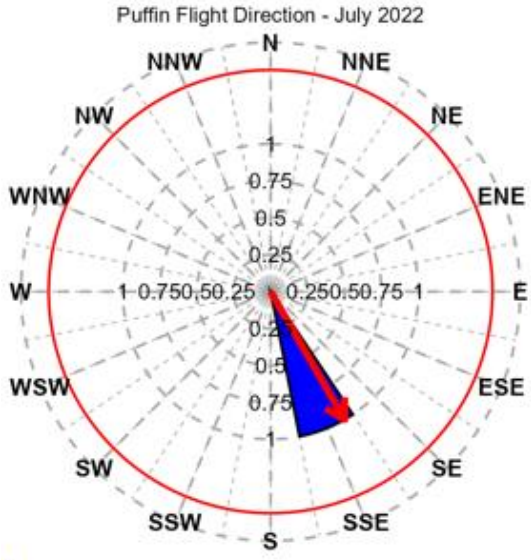
5.4.3.39 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-29).



Number of Observations	4
Mean Vector (μ)	69.758
Length of Mean Vector (r)	0.143
Rayleigh Test (Z)	0.081
Rayleigh Test (p)	0.931



Number of Observations	1
Mean Vector (μ)	266.650
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512



Number of Observations	1
Mean Vector (μ)	150.955
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512

Figure 5-29: Summary of flight direction of puffin within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.4.3.40 As recommended by the NatureScot (2023[1]) guidance, puffin has been scoped into the assessment for:

- Potential operational phase displacement.

5.4.3.41 As a result, detailed consideration of mean seasonal peak abundance (all birds), is provided in the following sections.

Seasonal Peaks

5.4.3.42 The peaks used for the matrix-based distributional response assessment have been presented in Table 5–25. The offshore ornithology distributional responses assessment has been carried out separately for the Caledonia OWF, Caledonia North and Caledonia South. The peaks have been defined using the seasonal definitions presented in Table 5–24.

5.4.3.43 It should be noted the Applicant has decided to include the August count in the non-breeding season rather than during the breeding season. This is due to the monthly abundance data suggesting the August abundance reflecting the potential migration rather than individuals present in the breeding season. The seasonal peaks for puffin have also been presented with the August count included in the breeding season as per the Guidance Approach (See Table 5–25)

5.4.3.44 As per the Guidance Approach, puffin were present in the greatest abundance during the breeding season (April to Mid- August, Table 5–24) with a peak abundance of 2,320 birds within Caledonia OWF (plus a 2km buffer); 1,461 birds within Caledonia North (plus a 2km buffer) and 1,364 birds within Caledonia South (plus a 2km buffer).

5.4.3.45 Whereas as per the Applicant Approach puffin were present in the greatest abundance outside of the breeding season with, a n peak estimate of 3,005 birds within Caledonia OWF (plus a 2km buffer); 1,879 birds within Caledonia North (plus a 2km buffer) and 1,726 within Caledonia South (plus a 2km buffer).

5.4.3.46 See Volume 7B, Appendix 6-1, Annex 11: MRSea-based and Design-based Abundance Estimates for the density and population estimate of all puffin in the Caledonia OWF, Caledonia North and Caledonia South (plus a 2km buffer) used within assessments.

Table 5–25: Seasonal Peaks of puffin within Caledonia OWF (+2km buffer), Caldonia North (+2km buffer) and Caledonia South (+2km buffer), during the NatureScot defined seasons.

Defined Season	Breeding Season		Non-breeding Season	
	Guidance Approach	Applicant Approach	Guidance Approach	Applicant Approach
Caledonia OWF	2,061 (3,583 / 896)	698 (500 / 896)	1,336 (245 / 2,426)	3,005 (3,583 / 2,426)
Caledonia North	1,309 (2,385 / 479)	367 (255 / 479)	739 (105 / 1,372)	1,879 (2,385 / 1,372)
Caledonia South	1,209 (2,093 / 644)	514 (384 / 644)	769 (179 / 1,358)	1,726 (2,093 / 1,358)
Note, the seasonal peaks from Year 1 and Year 2 of DAS data used to calculate the mean seasonal peaks are provided within the brackets '()'. Note, the seasonal peaks have been calculated using model-based median abundances for the breeding season (April to mid-August) and design-based mean abundances for the non-breeding season (Mid-August to March).				

5.5 Gaviidae

5.5.1 Red-throated Diver

Defined Seasons

5.5.1.1 Red-throated diver seasonal definitions are presented Table 5–26 as per the NatureScot (2020[71]) guidance. As different seasons for red-throated diver are included within Furness (2015[48]), separate BDMPS seasons have been provided in Table 5–27.

Table 5–26: Defined seasons in the Scottish Marine Environment used in the assessment for red-throated diver (NatureScot, 2020[71]).

Breeding Season	Post-breeding Migration Season	Non-breeding Season	Pre-breeding Migration Season
May to Mid-September	Flightless moult Late September to December	**Late-September to April**	April
Time periods in **bold** are those used by the assessment.			

Table 5–27: Non-breeding season BDMPS periods based on Furness (2015[48]) used in the apportionment of red-throated diver to specific populations.

Autumn Migration	Winter Period	Spring Migration	Non-breeding
September to November	**December to January**	**February to April**	-
Seasonal definitions used for additional assessment are in **bold**.			

Overview

5.5.1.2 Red-throated diver are high latitude breeders, with the UK breeding population restricted to northern areas, where they are found on oligotrophic lochs (Dillon *et al*., 2009[128]).

5.5.1.3 Threats to red-throated diver include reduced prey availability (Ball, 1994[129]), exposure to pollution, in terms of mercury (Eriksson *et al*., 1992[130]) and oil spill events (Foxton and Heubeck, 2011[131]). Human disturbance is also a threat to this species, since flushing from nests can last up to 30 minutes, leaving eggs or chicks exposed to predators (Sharrock, 1978[132]). Additionally, red-throated diver are greatly sensitive to collision with OWF (Garthe and Hüppop, 2004[13]).

5.5.1.4 The Shetland population is a key breeding area in the UK, being monitored more extensively compared to other areas (Dillon *et al*., 2009[128]; Gibbons *et al*., 1997[133]). This species has a short MMF of 9km (Woodward *et al*., 2019[56]). After the breeding season, birds disperse. Recent tracking work indicates that during the non-breeding season, red-throated diver breeding in Scotland remain around the Scottish coast before travelling into the southern North Sea in the early winter (Thompson *et al*., 2023[134]). However, variability among individual birds is not well understood.

Conservation Status

5.5.1.5 This species is currently Green-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]).

Vulnerability to Climate Change

5.5.1.6 Huntley (2006[135]) modelled red-throated diver distributions in Europe under the potential climate scenario for 2070-2099. This species breeding range is predicted to be restricted to the northwest of Europe, with no breeding predicted in the UK.

Regional and National Population Trends

5.5.1.7 The Scottish breeding population was estimated to be 1,225 individuals in 2006, which had increased by 33.7% from the last population estimate in 1994 (Dillon *et al*., 2009[128]). The most recent count of a red-throated diver population was at Kintyre, Scotland in 2016 to 2020, which reported 18-23 pairs and a lower productivity rate compared to UK average (Dewar and Lawrence, 2023[136]).

5.5.1.8 The total biogeographical population (UK and overseas) with connectivity to UK waters is estimated to be 27,000 individuals, with 4,400 individuals of this population estimated to be birds associated with the UK breeding population (Furness, 2015[48]). Biologically relevant seasons for red-throated diver are defined as spring migration (September-November), autumn migration (December-January) and migration-free winter (February-April) (Furness, 2015[48]). During the winter, the total population in the northwestern and southwestern North Sea is 1,523 and 10,177 individuals respectively, while in the migration BDMPS, the total North Sea population is 13,277 individuals (Furness, 2015[48]).

5.5.1.9 In the Moray Firth SPA, the density of red-throated diver was monitored between 2019 to 2020. The population was estimated to be 259 IND in the January 2020 and 880 individuals in March 2020 (Scott *et al*., 2023[137]).

DAS Baseline Overview

5.5.1.10 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-42 and Table 2-43; and
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-38 and Table 2-39.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-41 and Table 2-42; and
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-36 and Table 2-37

- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-41 and Table 2-42; and
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-38 and Table 2-39.

Caledonia OWF

5.5.1.11 A single red-throated diver was recorded in the Survey Area during the second year of the baseline surveys. The individual was recorded in October 2022 in Caledonia South. The abundance and density estimates were therefore very low.

5.5.1.12 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region (CV >0.16).

Caledonia North

5.5.1.13 No red-throated diver were recorded in Caledonia North.

Caledonia South

5.5.1.14 A single red-throated diver was recorded in the Caledonia South during the second year of the baseline surveys (October 2022). The abundance and density estimates were therefore very low.

5.5.1.15 Measures of precisions were high, which was likely related to the low numbers of individuals recorded in each region (CV >0.16).

Spatial Distribution and Flight Direction

Seasonal Distribution

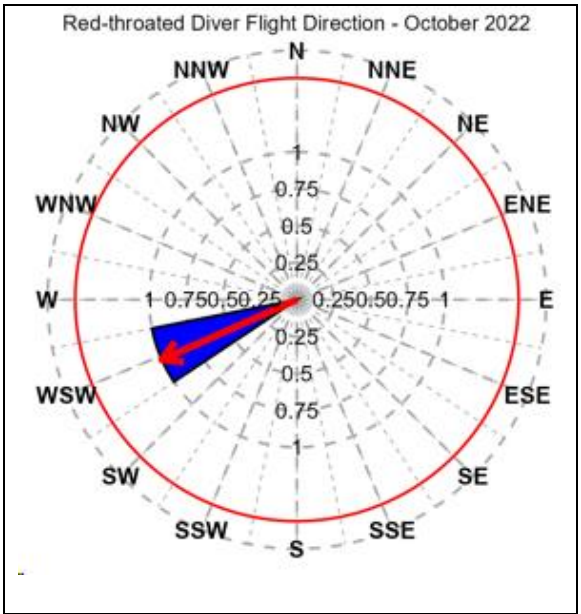
5.5.1.16 In October 2022, the single red-throated diver was recorded in the north of Caledonia South, near the border with Caledonia North.

5.5.1.17 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

Flight Direction

5.5.1.18 As only one bird was recorded in flight, they were too infrequent to determine any preference in flight direction (Figure 5-30).



Number of Observations	1
Mean Vector (μ)	246.841
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512

Figure 5-30: Summary of flight direction of red-throated diver within surveys where a non-significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.6 Procellariidae

5.6.1 Fulmar

Defined Seasons

5.6.1.1 Fulmar seasonal definitions are presented Table 5–28 as per the NatureScot (2020[71]) guidance. As the non-breeding season for fulmar is subdivided within Furness (2015[48]), separate BDMPS seasons have been provided in Table 5–29.

Table 5–28: Defined seasons in the Scottish Marine Environment used in the assessment for fulmar (NatureScot, 2020[71]).

Breeding Season	Post-breeding Season Migration	Non-breeding Season	Pre-breeding Migration Season
April to Mid-September	-	**Mid-September to March**	-
Note, time periods in **bold** are those used by the assessment.			

Table 5–29: Non-breeding season BDMPS periods based on Furness (2015[48]) used in the apportionment of fulmar to specific populations.

Autumn Migration	Winter Period	Spring Migration	Non-breeding
Mid-September to October (September to October)	**November**	**December to March**	-
Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–28) with the original definitions as per Furness (2015[48]) provided in parentheses where different. Species and seasonal definitions used for additional assessment are in **bold**.			

Overview

5.6.1.2 Northern fulmar (hereafter fulmar) are one of the most common seabird species of northern Britain, and can be found year-round. They can nest in a variety of habitat from cliffs to flat ground, and are confined to coastal locations (Mitchell *et al*., 2004[44]).

5.6.1.3 Fulmar occupy their nests sites throughout the breeding season and winter (Lack, 1986[138]) which explains their similar distribution between breeding and winter season throughout the British Isles (Waggitt *et al*., 2019[37]). Their distribution is highest around the northern North Sea and around Orkney and Shetland (Stone *et al*., 1995[32]; Waggitt *et al*., 2019[37]).

5.6.1.4 Fulmar have a large MMF±SD of 542± 657.9km (Woodward *et al*., 2019[56]), feeding pelagically around shelf edges (Lack, 1986[138]; Stone *et al*., 1995[32]).

5.6.1.5 Fulmar are generalist foragers, and are known to scavenge at fishing vessels in the North Sea (Camphuysen and Garthe, 1997[139]). Their natural diet consists of *Ammodytidae*, *Clupeidae* and *Gadidae*, while fish offal comprises of a high proportion of their diet in the breeding season (Ojowski *et al*., 2001[140]). Darby *et al*. (2021[141]) modelled fulmar distribution across Scottish, Irish and Scilly Island colonies and found that commercial fishing was a predictor of fulmar foraging behaviour, suggesting that discard is of

relatively high importance to this species. Fulmar are therefore likely to be negatively impacted by the European Union discard ban, but perhaps at a considerably lower level compared with large gulls and skua due to their preference for offal discards (Bicknell *et al.*, 2013[91]). Declines in the abundance of natural prey in the North Sea are also likely to be negatively impacting fulmar populations as prey location is known to determine fulmar distribution in the North Sea (Camphuysen and Garthe, 1997[139]).

Conservation Status

5.6.1.6 Fulmar are currently Amber-listed on the UK Birds of Conservation Concern List (Stanbury *et al.*, 2021[81]).

Vulnerability to Climate Change

5.6.1.7 MarPAMM predicted that fulmar have a high vulnerability (with poor confidence) to climate change, declining by 65% in east of Scotland and 73% in the whole of Britain and Ireland between 1998-2002 (Davies *et al.*, 2021[39]).

Regional and National Population Trends

5.6.1.8 The recent Seabirds Count for fulmar reported 309,545 apparently occupied sites (AOS) in Scotland, a decline of 36% since the Seabird 2000 census (Burnell *et al.*, 2023[83]). The fulmar population in Scotland has been gradually declining between 2011-2018 with a low productivity rate in this period (Scottish Government, 2020[99]).

5.6.1.9 An assessment of colony counts was undertaken by the RSPB following the first outbreak of HPAI in 2022. Fulmar was not included in these surveys, since the species is thought to have incurred relatively low mortality due to HPAI (Tremlett *et al.,* 2024[84]). A continued campaign of counts is required to monitor this species, and others, for additional impacts due to HPAI.

5.6.1.10 The fulmar breeding season is from April to mid-September and their BDMPS adjusted to NatureScot (2020[71]) seasonal periods are autumn migration (mid-September to October), spring migration (December to March) and migration-free winter (November). During the winter season the total number of birds in the UK North Sea is 568,736 individuals while in the migration season (autumn and spring) the population is estimated to be 957,502 individuals (Furness, 2015[48]).

5.6.1.11 The total biogeographic population (UK and overseas) with connectivity to UK waters is estimated to be 8,055,000 individuals with a total of 1,620,000 individuals (adults and immatures) in the UK (Furness, 2015[48]).

DAS Baseline Overview

5.6.1.12 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-50 and Table 2-51;
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-43 and Table 2-44; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-33 and Table 2-34.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-45 and Table 2-46; and
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-40 and Table 2-41.
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-30 and Table 2-31.
- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-49 and Table 2-50;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-43 and Table 2-44; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-33 and Table 2-34.

5.6.1.13 Figure 5-31 presents the abundance of fulmar (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km buffer and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.6.1.14 A total of 4,618 fulmars were recorded in the Survey Area during both years of baseline surveys. Fulmars were recorded in every survey. Fulmars were the most abundant during the breeding season (April to mid-September). A peak of abundance was recorded in July 2022:

- 705 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 4,124 [2,351; 6,147] and an apportioned abundance estimate of 4,123 [1,896; 6,732] individuals. These equated to mean density estimates of 9.65 (unapportioned) and 9.64 (apportioned) birds/km^2.
- 1,096 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 6,311 [3,783; 9,270] and an apportioned abundance estimate of 6,310 [3,484; 10,358] individuals. These equated to mean density estimates of 9.81 (unapportioned) and 9.80 (apportioned) birds/km^2.
- 1,631 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 9,532 [4,342; 15,617] and an apportioned abundance estimate of 9,533 [3,887; 16,136] individuals. These equated to mean density estimates of 10.79 (unapportioned) and 10.78 (apportioned) birds/km^2.

5.6.1.15 During the breeding seasons covered by the baseline surveys, very obvious peaks in fulmar abundance were recorded in July 2021 and 2022, with relatively consistent, and considerably lower numbers, recorded in other breeding season surveys. The peak mean abundance of fulmar within Caledonia OWF and its reporting regions was around 30% to 50% (depending on the reporting region considered) greater than the next highest mean abundance recorded, in July 2021. Mean abundances in the ten other surveys during the breeding seasons covered were 93% to 98% lower than the peak mean abundance. The data indicate that whilst larger numbers of fulmar were present within the Survey Area at a specific time within both breeding seasons covered by the baseline surveys (i.e., July), they were present in much lower numbers during the remainder of the breeding seasons covered by the baseline surveys.

5.6.1.16 During the non-breeding season (mid-September to March), fulmars were recorded in highest numbers in November, with a peak in November 2022:

- 125 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 735 [512; 1,000] and apportioned abundance estimate of 740 [480; 1,044] individuals. These equated to mean density estimates of 1.72 (unapportioned) and 1.73 (apportioned) birds/km^2.
- 196 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean unapportioned abundance estimate of 1,136 [840; 1,472] and apportioned abundance estimate of 1,141

[824; 1,510] individuals. Both equated to a mean density estimate of 1.77 birds/km^2.

- 252 individuals were recorded in the Survey Area, resulting in a mean unapportioned abundance estimate of 1,486 [1,032; 1,922] and apportioned abundance estimate of 1,497 [998; 1,988] individuals. These equated to mean density estimates of 1.68 (unapportioned) and 1.69 (apportioned) birds/km^2.

5.6.1.17 As with breeding season mean abundances, the data indicates that during a specific period within both non-breeding seasons covered by the surveys (i.e., November, which recorded similar abundances in both survey years), fulmar were present in larger numbers than the rest of the non-breeding season. In the ten other non-breeding season months covered by the baseline surveys, mean abundances in this were 76% to 98% lower, with mean abundances for most surveys being closer to the higher end of these reductions.

5.6.1.18 Very good measures of precisions were calculated for most survey months (CV ≤0.16), with 19 of the 24 baseline surveys for Caledonia OWF reporting CV values of ≤0.16. The five exceptions, all occurring during the winter months, coincided with lower numbers of birds being recorded.

Caledonia North

5.6.1.19 A total of 1,818 fulmars were recorded in Caledonia North Survey Area during both years of baseline surveys. Fulmar were recorded in every survey, except October 2022. Fulmars were the most abundant during the breeding season (April to mid-September). A peak of abundance was recorded in July 2022:

- 179 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 1,048 [427; 1,762] and an apportioned mean abundance estimate of 1,048 [409; 1,815] individuals. Both equated to a mean density estimate of 4.80 birds/km^2.
- 287 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,643 [876; 2,444] and an apportioned mean abundance estimate of 1,642 [807; 2,513] individuals. These equated to mean density estimates of 4.38 (unapportioned) and 4.37 (apportioned) birds/km^2.
- 405 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 2,370 [1,598; 3,260] and an apportioned mean abundance estimate of 2,370 [1,551; 3,289] individuals. Both equated to mean density estimate of 4.25 birds/km^2.

5.6.1.20 During the breeding seasons in Caledonia North Survey Area covered by the baseline surveys, relatively subtle peaks in fulmar abundance were recorded in July 2021 and 2022 (when the overall baseline survey seasonal peak was observed), with consistently low numbers recorded in most other breeding season surveys. Mean abundances in the other surveys during the

breeding seasons covered were 45% to 97% lower than the peak mean abundance, with the average reduction located towards the upper end of the range.

5.6.1.21 During the non-breeding season (mid-September to March), fulmars were only recorded in higher numbers in November, with a peak in November 2022:

- 70 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimate of 413 [230; 637] and apportioned abundance estimate of 412 [219; 636] individuals. Both equated to a mean density estimate of 1.89 birds/km^2.
- 119 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 686 [421; 980] individuals, which equated to a mean density estimate of 1.83 birds/km^2.
- 167 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 985 [655; 1,333] and apportioned abundance estimate of 990 [621; 1,384] individuals. Both equated to mean density estimates of 1.77 (unapportioned) and 1.78 (apportioned) birds/km^2.

5.6.1.22 The data indicates that during the non-breeding season, fulmar abundance in Caledonia North Survey Area was generally very low, with small peaks recorded In December 2021 and November 2022. In the other non-breeding season months covered by the baseline surveys, mean abundances in this were 45% to 99% lower than the peak mean abundance, with mean abundances for most surveys being closer to the higher end of these reductions.

5.6.1.23 Good measures of precisions were calculated for some, but not all, survey months (CV ≤0.16), with six of the 23 baseline surveys in which fulmar was recorded within Caledonia North reporting CV values of ≤0.16. The vast majority of other surveys reported CV values of ≤0.50, with higher values (i.e., lower precision) occurring in surveys where fewer birds were recorded. Corresponding values for Caledonia North plus buffer regions were generally lower (i.e., higher precision), which is anticipated to relate to the number of birds recorded.

Caledonia South

5.6.1.24 A total of 3,511 fulmars were recorded in Caledonia South Survey Area during both years of baseline surveys. Fulmar were recorded in all months. Fulmars were the most abundant during the breeding season (April to mid-September). Peak of abundance was recorded in July 2022:

- 526 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 3,068 [1,342; 5,191] and an apportioned mean abundance estimate of 3,068 [1,219; 5,640]

individuals. These equated to mean density estimates of 14.59 (unapportioned) and 14.58 (apportioned) birds/km^2.

- 888 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 5,138 [2,291; 8,615] and an apportioned abundance estimate of 5,138 [2,100; 8,713] individuals. These equated to mean density estimates of 14.29 (unapportioned) and 14.28 (apportioned) birds/km^2.
- 1,441 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 8,343 [3,300; 14,144] and an apportioned abundance estimate of 8,343 [2,976; 14,590] individuals. These equated to mean density estimates of 15.64 (unapportioned) and 15.63 (apportioned) birds/km^2.

5.6.1.25 During the breeding seasons covered by the baseline surveys, very obvious peaks in fulmar abundance were recorded in July 2021 and 2022, with relatively consistent, and considerably lower numbers, recorded in other breeding season surveys. The peak mean abundance of fulmar across Caledonia South Survey Area was around 30% to 50% (depending on the reporting region considered) greater than the next highest mean abundance recorded, in July 2021. Mean abundances in the ten other surveys during the breeding seasons covered were 86% to 99% lower than the peak mean abundance. The data indicate that whilst larger numbers of fulmar were present within the Caledonia South Survey Area at a specific time within both breeding seasons covered by the baseline surveys (i.e., July), they were present in much lower numbers during the remainder of the breeding seasons covered by the baseline surveys.

5.6.1.26 During the non-breeding season (mid-September to March), fulmars were only recorded in higher numbers in November, with a peak in November 2021 in Caledonia South and Caledonia South plus 2km buffer and in November 2022 in Caledonia South Survey Area:

- 112 individuals were recorded in Caledonia South in November 2021, resulting in an unapportioned mean abundance estimate of 645 [112; 1,722] and apportioned abundance estimate of 646 [112; 1,722] individuals. Both equated to a mean density estimate of 3.07 birds/km^2.
- 127 individuals were recorded in Caledonia South plus 2km buffer in November 2021, resulting in an unapportioned mean abundance estimate of 727 [127; 1,826] and apportioned abundance estimate of 727 [163; 1,849] individuals. Both equated to a mean density estimate of 2.02 birds/km^2.
- 140 individuals were recorded in Caledonia South Survey Area in November 2022, resulting in an unapportioned mean abundance estimate of 819 [602; 988] and apportioned abundance estimate of 824 [576; 1,044] individuals. Both equated to a mean density estimate of 1.54 birds/km^2.

5.6.1.27 As with breeding season mean abundances, the data indicates that during a specific period within both non-breeding seasons covered by the surveys (i.e., November, which recorded similar abundances in both survey years), fulmar were present in larger numbers than the rest of the non-breeding season, though the peaks were modest. Fulmar were present in most non-breeding season surveys in low numbers.

5.6.1.28 Good measures of precisions were calculated for most survey months (CV ≤0.16), with eight of the 23 baseline surveys in which fulmar was recorded within Caledonia South reporting CV values of ≤0.16. The other surveys reported CV values of ≤0.50, with higher values (i.e., lower precision) occurring in surveys where fewer birds were recorded. Corresponding values for Caledonia South plus buffer regions were generally lower (i.e., higher precision), which is anticipated to relate to the number of birds recorded.

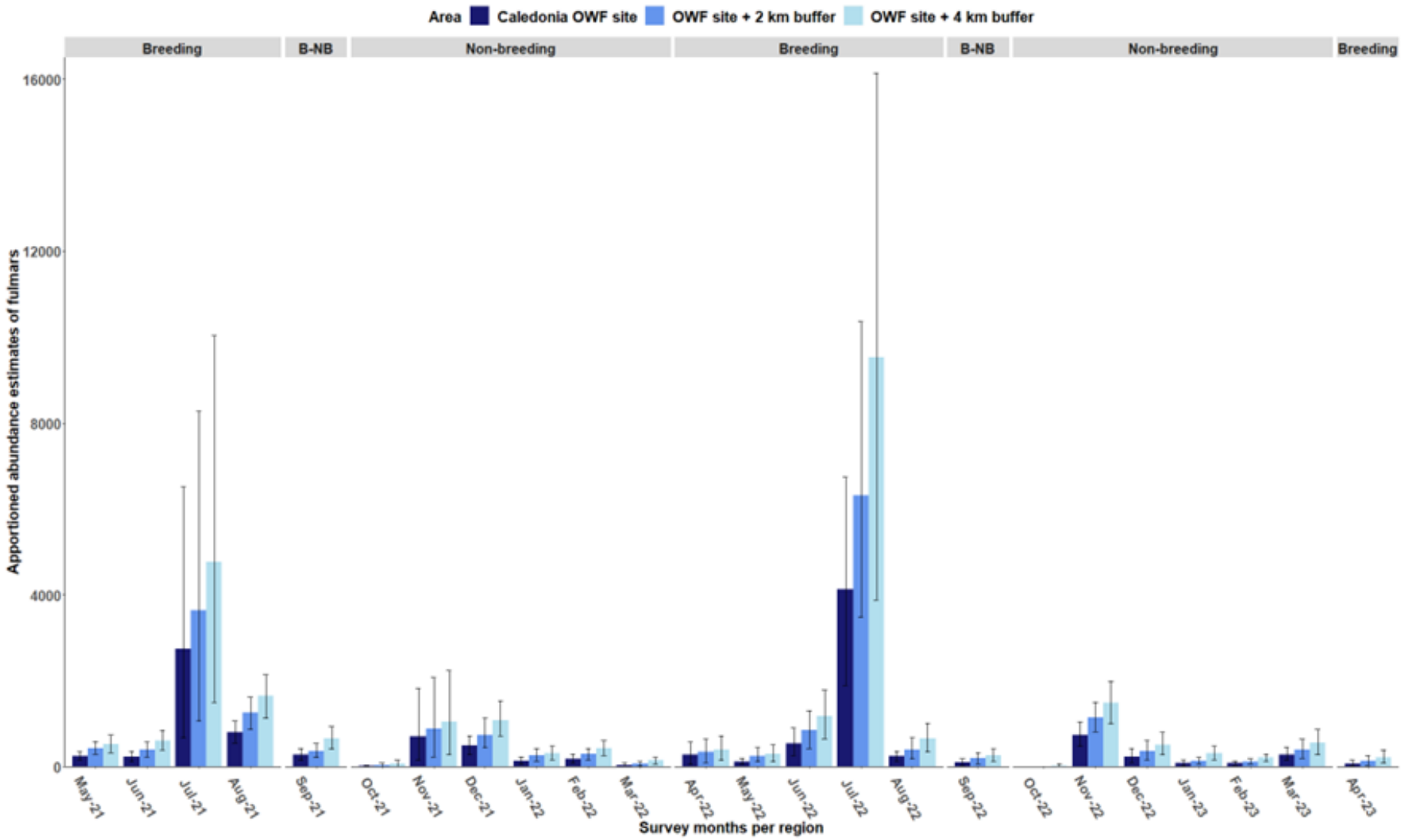


Figure 5-31: Bar plot of monthly apportioned abundance estimates (with 95% confidence intervals) of the total fulmars recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Fulmar seasonal periods are also displayed. B-NB corresponds to month split between breeding (B) and non-breeding (NB).

Spatial Distribution and Flight Direction

Spatial Distribution

5.6.1.29 Overall, fulmars displayed no discernible distribution pattern. However, slightly higher abundances were recorded in the southeast of the Caledonia OWF (plus a 4km buffer) in October 2021 and displayed hotspots in the north and the southeast of the Caledonia OWF (plus a 4km buffer) in November 2021. Only two individuals were recorded in October 2022, both in the southeast of Caledonia South 4km Buffer Zone towards its outer boundary.

5.6.1.30 Distribution maps generated using MRSea (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) suggest that all fulmar are distributed in higher densities in the southern and western areas of the study area during the breeding season (01 April - 15 September). In the non-breeding season, fulmar tend to be distributed in higher densities along the south edge of the study area. The highest densities were observed around the southern tip of the study area during July 2022.

5.6.1.31 Distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

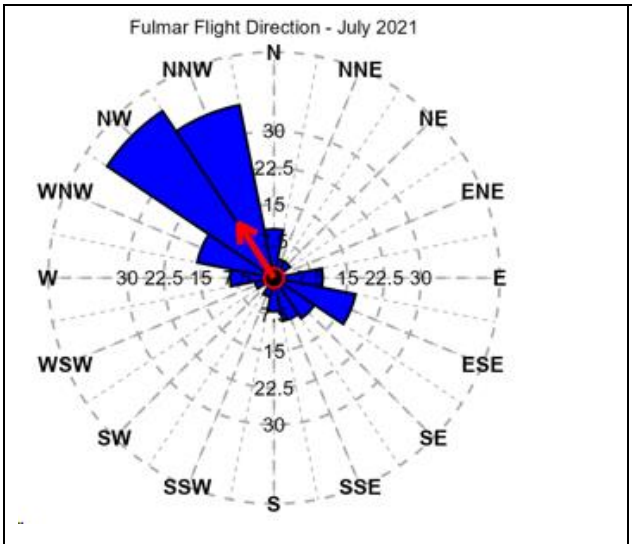
Flight Direction

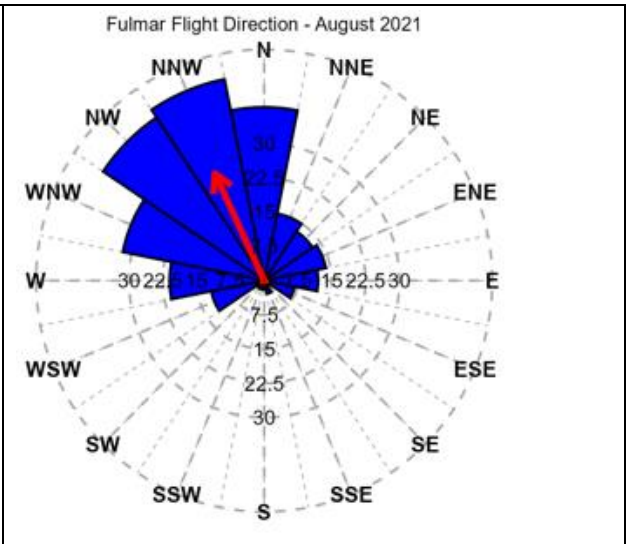
5.6.1.32 Figure 5-32 presents the flight direction of fulmar within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.6.1.33 Significant predominant direction of flight was recorded in:

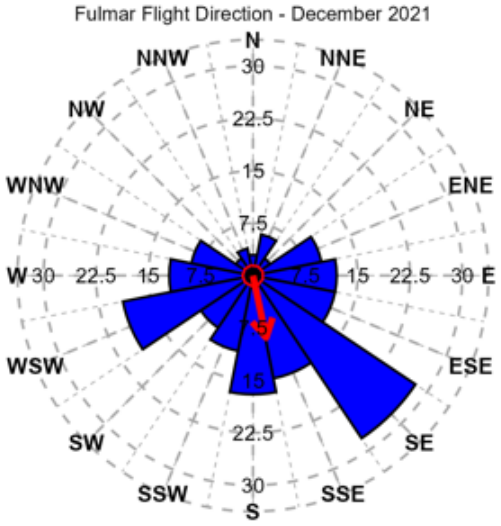
- June
  - 2022 north-northeast
- July
  - 2021 northwest
  - 2022 south-southeast
- August
  - 2021 north-northwest
  - 2022 south

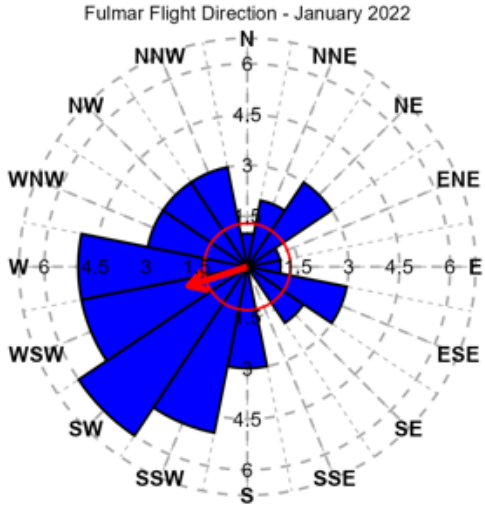
- November
  - 2022 southeast
- December
  - 2021 south
  - 2022 south
- January
  - 2022 west-southwest
  - 2023 south-southeast
- February
  - 2022 southeast
  - 2023 east
- March
  - 2022 east-northeast
  - 2023 north-northeast
- April
  - 2022 northeast
  - 2023 east-southeast



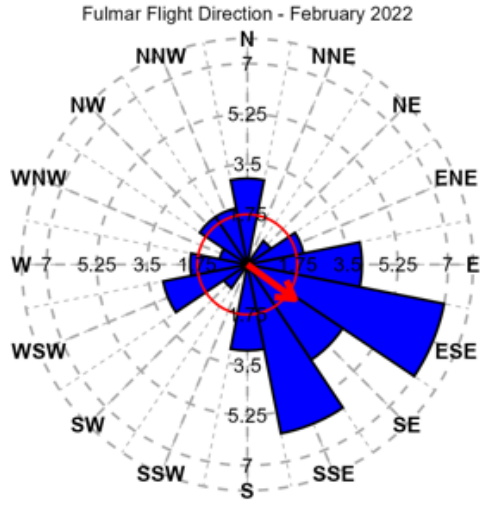


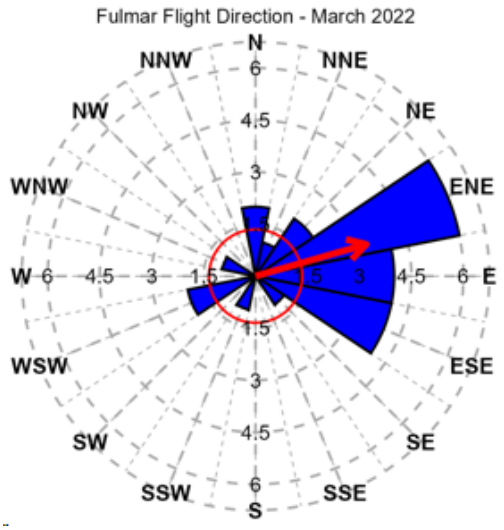
Number of Observations	185	Number of Observations	262
Mean Vector (μ)	327.768	Mean Vector (μ)	335.478
Length of Mean Vector (r)	0.319	Length of Mean Vector (r)	0.574
Rayleigh Test (Z)	18.823	Rayleigh Test (Z)	86.434
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001



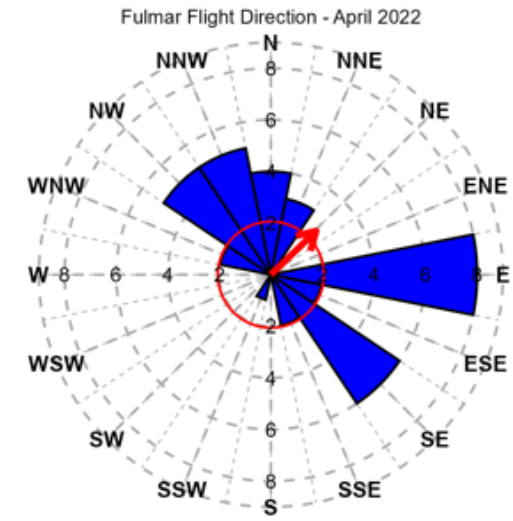


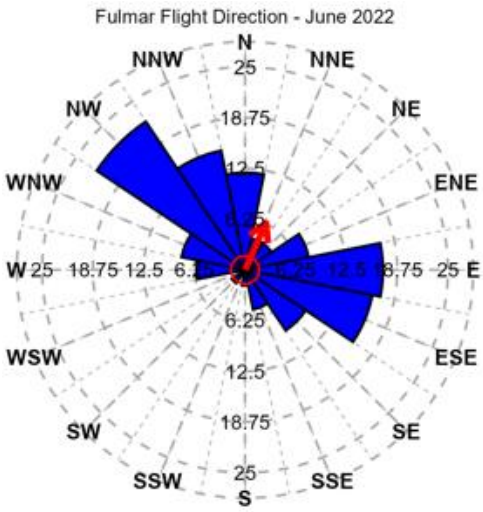
Number of Observations	173	Number of Observations	46
Mean Vector (μ)	168.743	Mean Vector (μ)	252.731
Length of Mean Vector (r)	0.324	Length of Mean Vector (r)	0.303
Rayleigh Test (Z)	18.139	Rayleigh Test (Z)	4.224
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	0.014



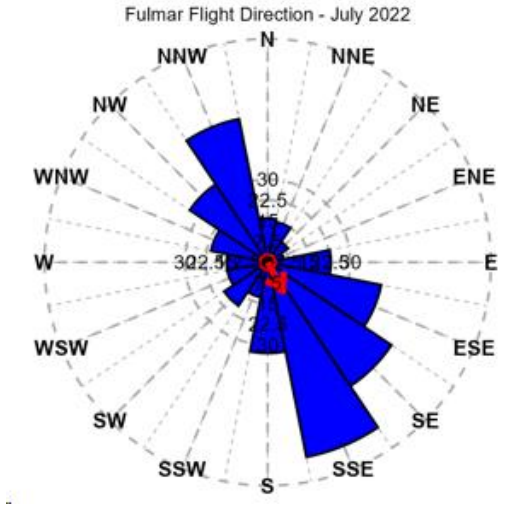


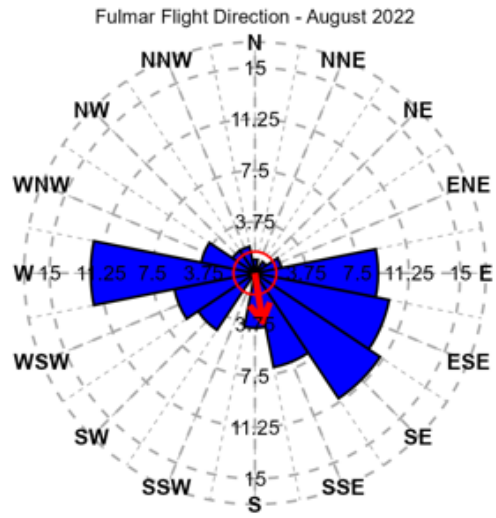
Number of Observations	41	Number of Observations	24
Mean Vector (μ)	126.390	Mean Vector (μ)	74.892
Length of Mean Vector (r)	0.291	Length of Mean Vector (r)	0.554
Rayleigh Test (Z)	3.480	Rayleigh Test (Z)	7.353
Rayleigh Test (p)	0.030	Rayleigh Test (p)	<0.001



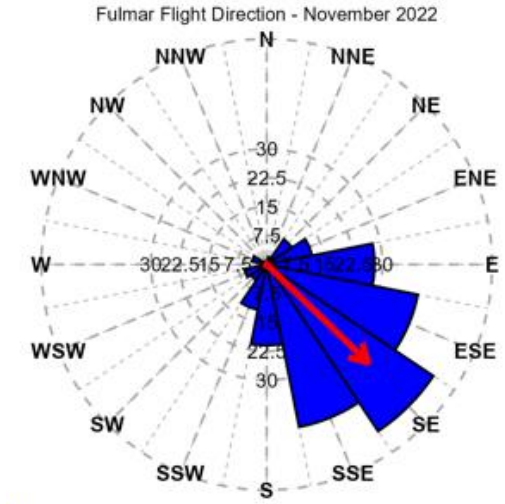


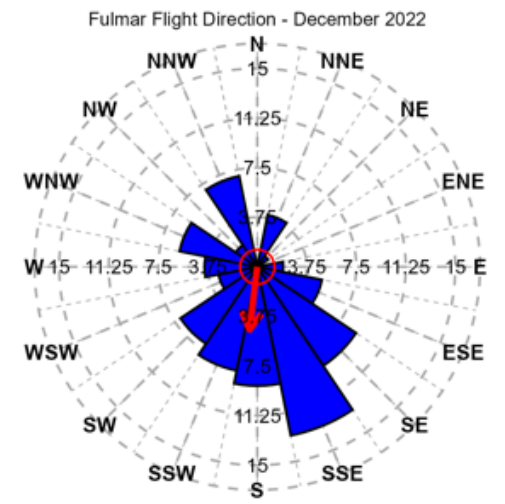
Number of Observations	38	Number of Observations	130
Mean Vector (μ)	46.196	Mean Vector (μ)	24.238
Length of Mean Vector (r)	0.305	Length of Mean Vector (r)	0.287
Rayleigh Test (Z)	3.530	Rayleigh Test (Z)	10.740
Rayleigh Test (p)	0.028	Rayleigh Test (p)	<0.001



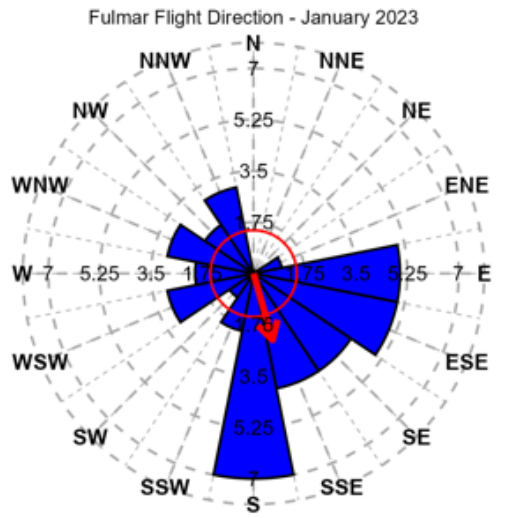


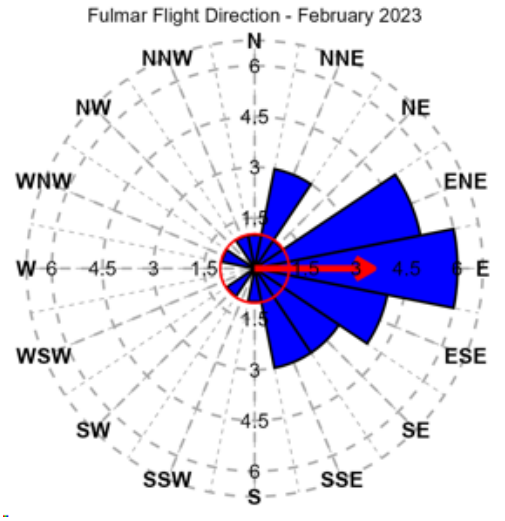
Number of Observations	440	Number of Observations	76
Mean Vector (μ)	152.648	Mean Vector (μ)	171.359
Length of Mean Vector (r)	0.165	Length of Mean Vector (r)	0.298
Rayleigh Test (Z)	11.968	Rayleigh Test (Z)	6.765
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	0.001



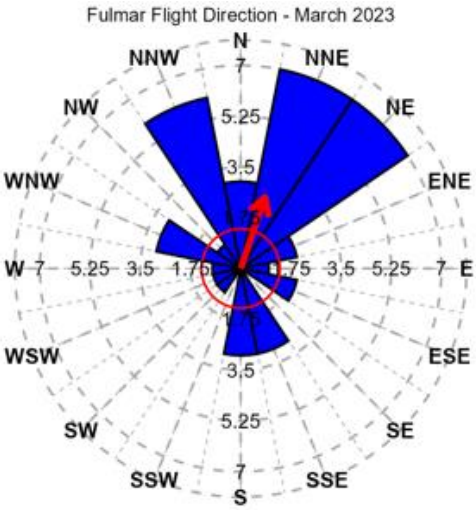


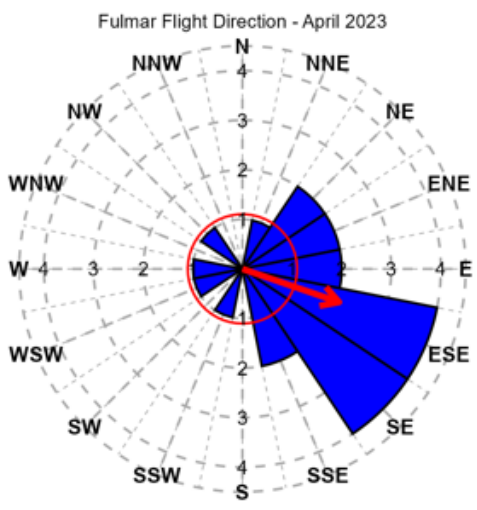
Number of Observations	234	Number of Observations	80
Mean Vector (μ)	134.555	Mean Vector (μ)	187.842
Length of Mean Vector (r)	0.702	Length of Mean Vector (r)	0.368
Rayleigh Test (Z)	115.160	Rayleigh Test (Z)	10.814
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001





Number of Observations	42	Number of Observations	30
Mean Vector (μ)	164.798	Mean Vector (μ)	90.965
Length of Mean Vector (r)	0.336	Length of Mean Vector (r)	0.584
Rayleigh Test (Z)	4.752	Rayleigh Test (Z)	10.239
Rayleigh Test (p)	0.008	Rayleigh Test (p)	<0.001

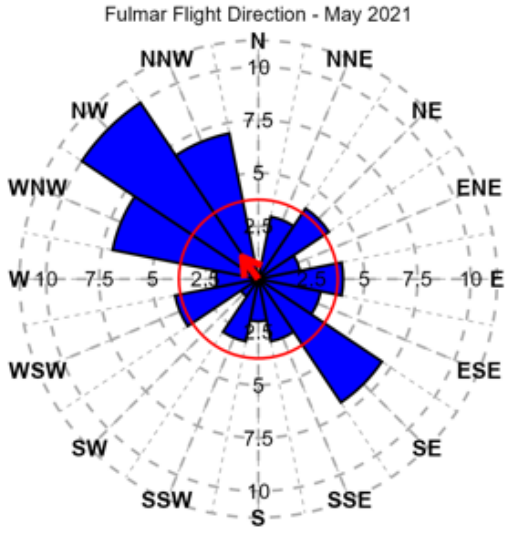


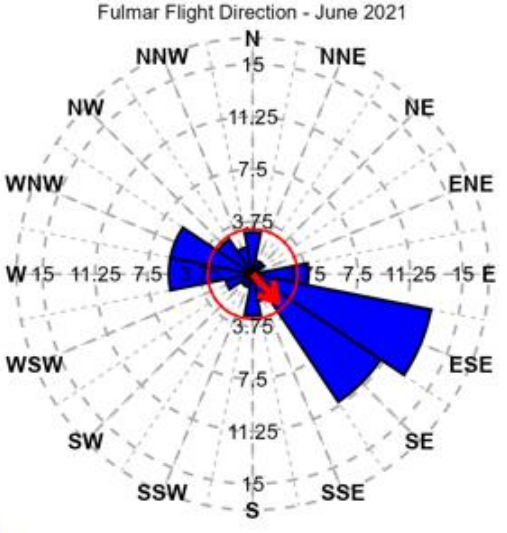


Number of Observations	41	Number of Observations	21
Mean Vector (μ)	19.539	Mean Vector (μ)	109.590
Length of Mean Vector (r)	0.372	Length of Mean Vector (r)	0.515
Rayleigh Test (Z)	5.674	Rayleigh Test (Z)	5.560
Rayleigh Test (p)	0.003	Rayleigh Test (p)	0.003

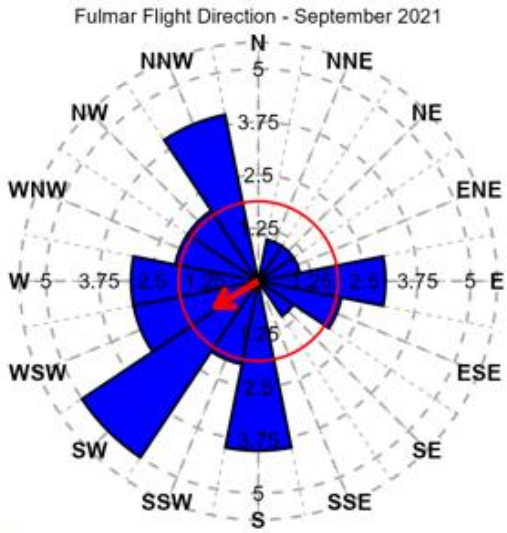
Figure 5-32: Summary of flight direction of fulmar within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

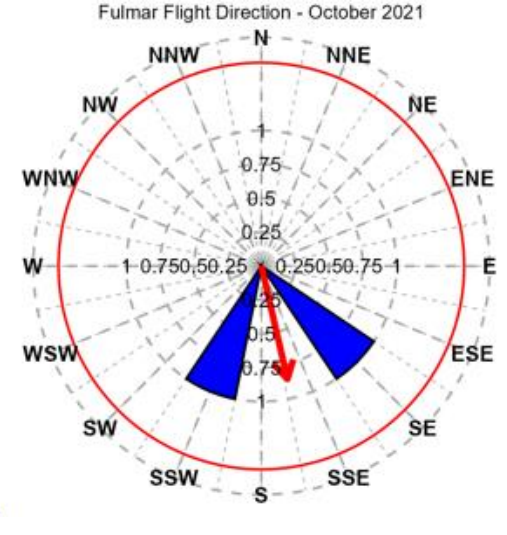
5.6.1.34 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-33).



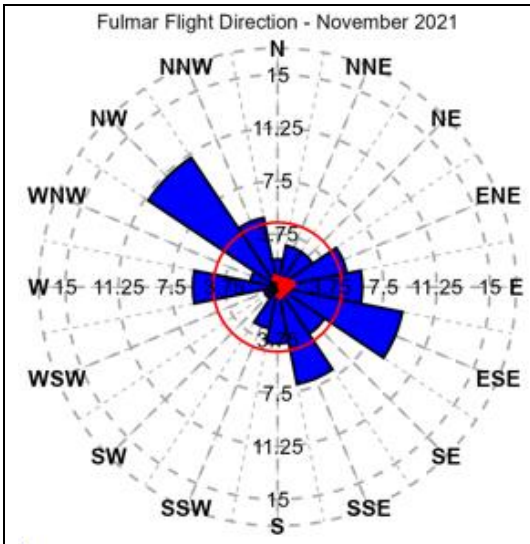


Number of Observations	62	Number of Observations	59
Mean Vector (μ)	324.076	Mean Vector (μ)	138.992
Length of Mean Vector (r)	0.129	Length of Mean Vector (r)	0.205
Rayleigh Test (Z)	1.030	Rayleigh Test (Z)	2.477
Rayleigh Test (p)	0.357	Rayleigh Test (p)	0.084

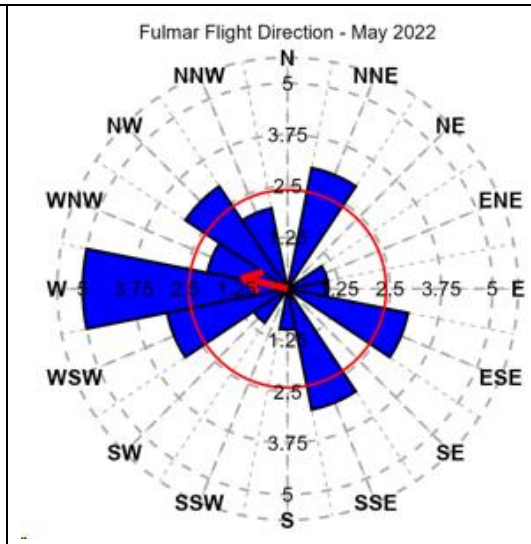




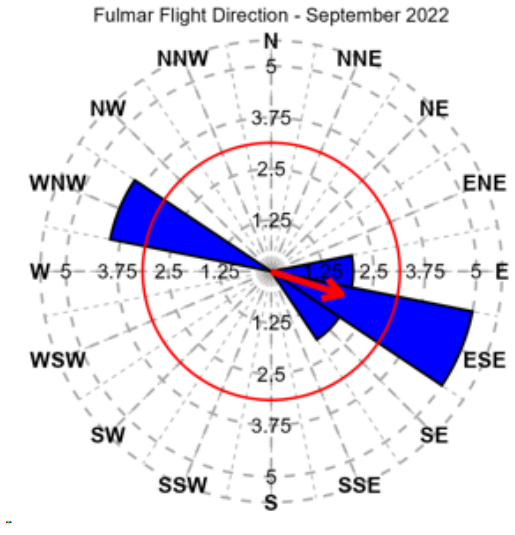
Number of Observations	34	Number of Observations	2
Mean Vector (μ)	239.508	Mean Vector (μ)	167.714
Length of Mean Vector (r)	0.233	Length of Mean Vector (r)	0.855
Rayleigh Test (Z)	1.846	Rayleigh Test (Z)	1.462
Rayleigh Test (p)	0.158	Rayleigh Test (p)	0.265



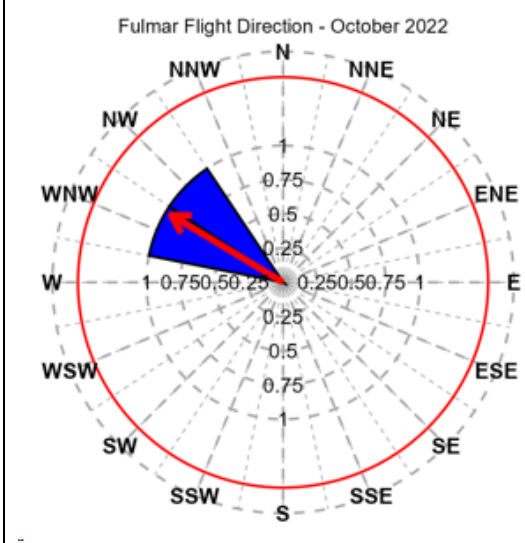
Number of Observations	72
Mean Vector (μ)	77.905
Length of Mean Vector (r)	0.100
Rayleigh Test (Z)	0.723
Rayleigh Test (p)	0.485



Number of Observations	28
Mean Vector (μ)	284.858
Length of Mean Vector (r)	0.221
Rayleigh Test (Z)	1.370
Rayleigh Test (p)	0.256



Number of Observations	13
Mean Vector (μ)	108.158
Length of Mean Vector (r)	0.361
Rayleigh Test (Z)	1.694
Rayleigh Test (p)	0.186



Number of Observations	2
Mean Vector (μ)	301.874
Length of Mean Vector (r)	0.954
Rayleigh Test (Z)	1.819
Rayleigh Test (p)	0.174

Figure 5-33: Summary of flight direction of fulmar within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.6.1.35 As recommended by the NatureScot (2023[1]) guidance, fulmar has been scoped into the assessment for:

- Potential operational phase displacement.

5.6.1.36 As a result, detailed consideration of mean seasonal peak abundance (all birds), is provided in the following sections.

Mean Seasonal Peaks

5.6.1.37 The mean peaks used for this assessment have been presented in Table 5–30. The offshore ornithology distributional responses assessment has been carried out separately for the Caledonia OWF, Caledonia North and Caledonia South. The peaks have been defined using the seasonal definitions presented in Table 5–28 and Table 5–29.

5.6.1.38 Fulmar were present in the greatest abundance during the breeding season (April to August), with a mean peak abundance of 4,977 within Caledonia OWF (plus a 2km buffer); 1,228 birds within Caledonia North (plus a 2km buffer) and 4,125 birds within Caledonia South (plus a 2km buffer).

5.6.1.39 Outside the breeding season fewer fulmar were present with a mean peak estimate of 1,014 birds within Caledonia OWF (plus a 2km buffer); 517 birds within Caledonia North (plus a 2km buffer) and 669 within Caledonia South (plus a 2km buffer).

Table 5–30: Mean Seasonal Peaks of fulmar within Caledonia OWF (+2km buffer), Caldonia North (+2km buffer) and Caledonia South (+2km buffer), during the NatureScot defined seasons and the BDMPS Non-breeding Seasons as per Furness (2015[48]).

Defined Season	Breeding Season	Non-breeding Season	Autumn Migration	Winter Period	Spring Migration
Caledonia OWF	4,977 (3,643 / 6,310)	1,014 (886 / 1,141)	285 (374 / 196)	1,014 (886 / 1,141)	566 (739 / 393)
Caledonia North	1,228 (813 / 1,642)	517 (347 / 686)	126 (165 / 87)	423 (159 / 686)	280 (347 / 212)
Caledonia South	4,125 (3,112 / 5,138)	669 (727 / 611)	199 (249 / 148)	669 (727 / 611)	346 (444 / 247)
Note, the seasonal peaks from Year 1 and Year 2 of DAS data used to calculate the mean seasonal peaks are provided within the brackets '()'.					

5.6.2 Gannet

Defined Seasons

5.6.2.1 Northern gannet (hereafter gannet) seasonal definitions are presented in Table 5–31 as per the NatureScot (2020[71]) guidance. Separate BDMPS seasons have been provided as per Furness (2015[48]) (Table 5–32).

Table 5–31: Defined seasons in the Scottish Marine Environment used in the assessment for gannet (NatureScot, 2020[71]).

Species	Breeding Season	Post-breeding Migration Season	Non-breeding Season	Pre-breeding Migration Season
Gannet	**Mid-March to September**	-	**October to early March**	Mid-February to early-March
Time periods in **bold** are those used by the assessment.				

Table 5–32: Non-breeding season BDMPS periods based on Furness (2015[48]) used in the apportionment of razorbill to specific populations.

Species	Autumn Migration	Winter Period	Spring Migration	Non-breeding
Gannet	**October to November** (September to November)	-	**December to mid-March** (December to March)	-
Species and seasonal definitions used for additional assessment are in **bold**. Seasonal definitions have been modified to align with the NatureScot breeding season periods (see Table 5–31), with the original definitions as per Furness (2015[48]) provided in parentheses where different. Seasonal definitions used for additional assessment are in bold.				

Overview

5.6.2.2 Gannet are the largest pelagic seabird in the North Atlantic, forming large colonies during the breeding season (mid-March to September) and wintering in Western Europe (North Sea, English Channel, and Bay of Biscay) and Africa in October-February (Kubetzki *et al.*, 2009[142]; NatureScot, 2020[71]). These plunge diving birds are able to exploit a variety of fish species and sizes such as sandeels, mackerel and herring (Hamer *et al.*, 2000[143]). There are records of commercial fisheries discards composing 10% of their diet in the North Sea (Garthe *et al.*, 1994[144]). However, they are relatively flexible with respect to prey selection.

5.6.2.3 Gannet at their southernmost limit in Canda have shown low reproductive success following a decline in prey availability from rising SST and fishery over-exploitation over four decades (d'Entremont *et al*., 2022[145]). Northern gannet have a generalist diet which can act as a buffer from indirect impacts of climate warming (Burthe *et al*., 2014[114]). Discards appear to be a higher proportion of gannet diet during the non-breeding season (Garthe *et al*., 1996[146]). Therefore, it is unclear whether the European Union discard ban and the UK Fisheries Act 2020 (HM Government, 2020[93]) has an impact on the future growth rate of gannets compared to gulls and skuas (Bicknell *et al*., 2013[91]). Recent increases in the population in the UK indicate that this may not be the case.

5.6.2.4 Gannet densities are greatest during the breeding season throughout the North Sea, eastern Scotland and the Northern Isles (Searle *et al*., 2022[80]; Waggitt *et al*., 2019[37]). Breeding adults can range widely during the breeding season, reflected by their MMF±SD of 315.2±194.2km (Woodward *et al*., 2019[56]).

Conservation Status

5.6.2.5 Gannet are currently Amber-listed on the UK Birds of Conservation Concern List (Stanbury *et al*., 2021[81]).

Vulnerability to Climate Change

5.6.2.6 Searle *et al*. (2022[80]) predicted that under future climate projections (2077-2099), gannet breeding success will have a widespread increase in the northern North Sea, particularly in eastern Scotland (Searle *et al*., 2022[80]). This study also shows that gannet breeding success is suggested to be less likely to be negatively impacted by climate warming than many other seabird species, for which negative effects are anticipated.

Regional and National Population Trends

5.6.2.7 The total biogeographic population (UK and overseas) estimate for gannet is 1,180,000 individuals, with 923,000 individuals estimated in the UK (Furness, 2015) [48]. Their BDMPS adjusted to NatureScot (2020[71]) seasonal period are defined as autumn migration (October to November) and spring migration (December to mid-March). The UK North Sea and Channel estimates for autumn migration are 465,298 individuals and in the spring the population estimate is 248,385 individuals (Furness, 2015[48]). Gannet flexibility in diet, foraging behaviour and trip duration has allowed them to maintain a high reproductive success when prey availability is low in the North Sea (Hamer *et al*., 2007[147]). The Seabird count (2015-2021) for gannet reports approximately 254,773 AON in Scotland, an increase of 40% AON since the gannet census (1998-2002) (Burnell *et al*., 2023[83]).

5.6.2.8 In the Shetland Islands, the mean breeding success is 0.71 chicks raised per nests (Scottish Government, 2020[99]). Scotland's most important gannetry is the Bass rock in the Firth of Forth, which is the world's largest colony with 75,259 AOS and was increasing as of the 2013-2014 census (Murray *et al*., 2014[148]).

5.6.2.9 Gannet were severely impacted by the 2021-2022 HPAI outbreak, with a significant decline in population numbers, breeding success and survival on the Bass Rock (Lane *et al*., 2023[149]). Colony counts undertaken by the RSPB following the 2021-2022 outbreak reported that the total number of gannet across all sites surveyed in 2023 (75% of the UK population of breeding gannet) declined by 25% compared to the pre-HPAI baseline count for these colonies (Tremlett *et al*., 2024[84]). The counts made by the RSPB in 2023 were undertaken prior to the further 2023 HPAI outbreak. Therefore, it is extremely likely that updated counts are required for this species to fully understand the ongoing effects of HPAI.

DAS Baseline Overview

5.6.2.10 The following sections present information on seasonal peaks, temporal patterns of abundance, and the precision values of abundance estimates, derived from the design-based abundance estimates of all birds (i.e., flying and on the sea) for this species. The data tables presenting the information referred to can be found in the following locations:

- Caledonia OWF:
  - Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF), Table 2-56
  - Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF), Table 2-49; and
  - Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF), Table 2-37.
- Caledonia North:
  - Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North), Table 2-49;
  - Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North), Table 2-44; and
  - Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North), Table 2-34.

- Caledonia South:
  - Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South), Table 2-55;
  - Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South), Table 2-49; and
  - Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South), Table 2-37.

5.6.2.11 Figure 5-34 presents the abundance of gannet (all behaviours), by survey, over the 24-month survey period, for the Caledonia OWF, Caledonia OWF plus 2km buffer and Caledonia OWF plus 4km buffer reporting regions.

Caledonia OWF

5.6.2.12 A total of 1,093 gannets were recorded in the Survey Area during both years of baseline surveys. Gannets were recorded throughout the year, being recorded in Caledonia OWF in 23 of 24 baseline surveys, and Caledonia OWF plus buffers in every survey. Gannets were the most abundant during the breeding season (mid-March to September). Peak of abundance was recorded in June 2022:

- 173 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 994 [224; 1,977] individuals, which equated to a mean density estimate of 2.33 birds/km^2.
- 225 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,289 [487; 2,212] individuals, which equated to a mean density estimate of 2.00 birds/km^2.
- 258 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 1,493 [666; 2,448] individuals, which equated to a mean density estimate of 1.69 birds/km^2.

5.6.2.13 The two breeding seasons covered by the baseline survey period displayed some similarities in temporal variation in mean unapportioned gannet abundance within the Survey Area. Abundances were relatively low in the early breeding season months (April and May), with peak mean unapportioned gannet abundance occurring in June for both breeding seasons. A key difference between the 2021 and 2022 breeding seasons was the size of the June mean unapportioned abundance peak, which was considerably larger in 2022 than 2021. The following two months (July and August) recorded lower mean unapportioned gannet abundances in both 2021 and 2022, though higher than the early breeding season. In 2021, the August mean unapportioned gannet abundances were higher than July,

and vice versa in 2022. Both September 2021 and September 2022 saw increases in mean unapportioned gannet abundance compared with previous months. The timing of this increased mean unapportioned abundance peak, and its continuation into the early part of the non-breeding season, suggests that the Survey Area may be a location used by post-breeding aggregations of this species, before birds leave the wider area for the non-breeding season.

5.6.2.14 The peak abundance of gannets during the breeding season (June 2022) was considerably higher than other months, with over twice the number of birds recorded in Caledonia OWF reporting regions when compared with the next most abundant month. Reductions in mean unapportioned abundance relative to the peak were between 55% to >99.5%.

5.6.2.15 During the non-breeding season (October to mid-February), gannets were particularly abundant in October 2021, which is when the peak was recorded:

- 66 individuals were recorded in Caledonia OWF, resulting in an unapportioned mean abundance estimate of 386 [252; 527] individuals, which equated to a mean density estimate of 0.90 birds/km^2.
- 91 individuals were recorded in Caledonia OWF plus 2km buffer, resulting in an unapportioned mean abundance estimate of 525 [375; 692] individuals, which equated to a mean density estimate of 0.82 birds/km^2.
- 125 individuals were recorded in the Survey Area, resulting in an unapportioned mean abundance estimate of 732 [486; 977] individuals, which equated to a mean density estimate of 0.83 birds/km^2.

5.6.2.16 In both non-breeding seasons covered by the baseline survey period, the only month where substantial numbers of gannets were recorded in the Survey Area was October. It is considered a reasonable assumption, based on the timing of this peak, and its relative size compared with unapportioned mean abundances in other non-breeding season surveys, that these peak mean unapportioned abundances represent post-breeding aggregations of birds (likely from multiple breeding colonies across the region). Low abundances of birds were recorded in all reporting regions for the remainder of the non-breeding season surveys. It is noteworthy that the October 2021 peak was considerably larger than the October 2022 peak.

5.6.2.17 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 62% to 99%, with many of the surveys recording reductions in mean abundances at the upper end of this range when compared with the peak month. This reflects the fact that the October 2021 peak (which was the overall peak mean unapportioned abundance for gannet in the non-breeding season across the baseline survey period) was very large relative to the other mean unapportioned

abundances recorded for gannet during the non-breeding season in the Survey Area and reporting regions. Relatively good measures of precisions (CV ≤0.16) were calculated for survey month where raw counts of individuals where higher, and measures of precisions were high when raw counts of individual were low (CV >0.16).

5.6.2.18 This means that CV values were lowest during the middle part of the breeding season, and the late breeding season and autumn dispersal periods. CV values were >0.16 for the most part, with only five, seven and eight surveys of Caledonia OWF, Caledonia OWF plus 2km buffer and the Survey Area respectively having CV values of ≤0.16. This indicates lower precision for the abundance and densities calculated for this species compared to some of the more numerous species recorded during the baseline surveys. This is reflected by the relatively large 95% confidence intervals around the mean abundance estimates for this species.

Caledonia North

5.6.2.19 A total of 435 gannets were recorded in Caledonia North Survey Area during both years of baseline surveys. Gannets were recorded throughout the year, except January to March 2022, November 2022, and March 2023. Within Caledonia North, Caledonia North plus 2km buffer, and Caledonia North Survey Area, they were recorded in 16, 18 and 19 of the 24 baseline surveys respectively. Gannets were the most abundant during the non-breeding season (October to mid-March) across Caledonia North Survey Area, except in Caledonia North, where they were the most abundant during the breeding season (mid-March to September).

5.6.2.20 During the non-breeding season, peak abundance was recorded in October 2021:

- 37 individuals were recorded in Caledonia North, resulting in an unapportioned mean abundance estimates of 216 [99; 333] individuals, which equated to a mean density estimate of 0.99 birds/km^2.
- 61 individuals were recorded in Caledonia North plus 2km buffer, resulting in an unapportioned mean abundance estimate of 349 [206; 497] individuals, which equated to a mean density estimate of 0.93 birds/km^2.
- 89 individuals were recorded in Caledonia North Survey Area, resulting in an unapportioned mean abundance estimate of 520 [316; 754] individuals, which equated to a mean density estimate of 0.93 birds/km^2.

5.6.2.21 In both non-breeding seasons covered by the baseline survey period, the only month where substantial numbers of gannets were recorded in Caledonia North Survey Area was October. It is considered a reasonable assumption, based on the timing of this peak, and its relative size compared with unapportioned mean abundances in other non-breeding season surveys, that these peak mean unapportioned abundances

represent post-breeding aggregations of birds (likely from multiple breeding colonies across the region). Low abundances of birds were recorded in all reporting regions for the remainder of the non-breeding season surveys. It is noteworthy that the October 2021 peak was considerably larger than the October 2022 peak.

5.6.2.22 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 84% to 99%, with many of the surveys recording reductions in mean abundances at the upper end of this range when compared with the peak month. This reflects the fact that the October 2021 peak (which was the overall peak mean unapportioned abundance for gannet in the non-breeding season across the baseline survey period) was very large relative to the other mean unapportioned abundances recorded for gannet during the non-breeding season in Caledonia North Survey Area and reporting regions.

5.6.2.23 During the breeding season (mid-March to September), gannet peak abundances were recorded in June 2021 in Caledonia North and Caledonia North plus 2km buffer, and June 2022 in Caledonia North Survey Area:

- 42 individuals were recorded in Caledonia North in June 2021, resulting in an unapportioned mean abundance estimate of 248 [89; 497] individuals, which equated to a mean density estimate of 1.14 birds/km^2.
- 47 individuals were recorded in Caledonia North plus 2km buffer in June 2021, resulting in an unapportioned mean abundance estimate of 272 [81; 521] individuals, which equated to a mean density estimate of 0.72 birds/km^2.
- 74 individuals were recorded in Caledonia North Survey Area in June 2022, resulting in an unapportioned mean abundance estimate of 428 [260; 630] individuals, which equated to a mean density estimate of 0.77 birds/km^2.

5.6.2.24 The two breeding seasons covered by the baseline survey period displayed some similarities in temporal variation in mean unapportioned gannet abundance within Caledonia North Survey Area. Abundances were relatively low in the early breeding season months (April and May), with peak mean unapportioned gannet abundance occurring in June for both breeding seasons. The following two months (July and August) recorded lower mean unapportioned gannet abundances, though higher than the early breeding season. In 2021, the August mean unapportioned gannet abundances were higher than July, and vice versa in 2022. Both September 2021 and September 2022 saw increases in mean unapportioned gannet abundance compared with previous months. The timing of this increased mean unapportioned abundance peak, and its continuation into the early part of the non-breeding season (in the 2021 breeding season in particular), suggests that Caledonia North Survey Area

may be a location used by post-breeding aggregations of this species, before birds leave the wider area for the non-breeding season.

5.6.2.25 Reductions in mean unapportioned abundance relative to the peak were between 14% to 99%, with many of the surveys recording reductions in mean abundances at the upper end of this range when compared with the peak month. This indicates that the mean apportioned abundances were highly variable throughout the breeding season surveys when compared with the peak mean apportioned abundance for this season during the baseline survey period.

5.6.2.26 CV values were high, which is likely related to the relatively low numbers of individuals recorded in each region (CV >0.16). CV values were generally lowest during the middle part of the breeding season, and the late breeding season and autumn dispersal periods. CV values were >0.16 for the most part, with two of 16, three of 18, and five of 19 surveys in Caledonia North, Caledonia North plus 2km buffer, and Caledonia North Survey Area respectively falling below this value. This indicates lower precision for the abundance and densities calculated for this species compared to some of the more numerous species recorded during the baseline surveys. This is reflected by the relatively large 95% confidence intervals around the mean abundance estimates for this species.

Caledonia South

5.6.2.27 A total of 807 gannets were recorded in Caledonia South Survey Area during both years of baseline surveys. Gannets were recorded throughout the year, being recorded in Caledonia South in 23 of 24 baseline surveys, and Caledonia South plus buffers in every survey. Gannets were the most abundant during the breeding season (mid-March to September). Peak of abundance was recorded in June 2022:

- 152 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 880 [185; 1,807] individuals, which equated to a mean density estimate of 4.18 birds/km^2.
- 196 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 1,113 [324; 2,066] individuals, which equated to a mean density estimate of 3.10 birds/km^2.
- 222 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 1,286 [492; 2,253] individuals, which equated to a mean density estimate of 2.41 birds/km^2.

5.6.2.28 The two breeding seasons covered by the baseline survey period displayed some similarities in temporal variation in mean unapportioned gannet abundance. Abundances were relatively low in the early breeding season months (April and May), with peak mean unapportioned gannet abundance

occurring in June for both breeding seasons. The most striking difference between unapportioned mean abundances in the 2021 and 2022 breeding seasons is the size of the peak in June, with the 2022 peak being very large relative to other months around it (as well as other months in the 2021 breeding season). The peak abundance of gannets during the breeding season (June 2022) was considerably higher than other months, with over twice the number of birds recorded in Caledonia South reporting regions when compared with the next most abundant month across the baseline survey period.

5.6.2.29 The following two months of each breeding season (July and August) recorded lower mean unapportioned gannet abundances than June. In 2021, the August mean unapportioned gannet abundances were higher than July, and vice versa in 2022 (when mean unapportioned abundances were particularly low). Abundances remained at a similar level in September 2021 compared with the previous month, and actually increased substantially between August 2021 and September 2022. This, coupled with the continued use of the area into October in both years, suggests that Caledonia South Survey Area may be a location used by post-breeding aggregations of this species.

5.6.2.30 During the non-breeding season (October to mid-March), gannets were particularly abundant in October 2021, which is when the peak was recorded:

- 29 individuals were recorded in Caledonia South, resulting in an unapportioned mean abundance estimate of 170 [105; 228] individuals, which equated to a mean density estimate of 0.81 birds/km^2.
- 46 individuals were recorded in Caledonia South plus 2km buffer, resulting in an unapportioned mean abundance estimate of 267 [186; 354] individuals, which equated to a mean density estimate of 0.74 birds/km^2.
- 82 individuals were recorded in Caledonia South Survey Area, resulting in an unapportioned mean abundance estimate of 476 [366; 598] individuals, which equated to a mean density estimate of 0.89 birds/km^2.

5.6.2.31 In both non-breeding seasons covered by the baseline survey period, the only month where substantial numbers of gannets were recorded in Caledonia South Survey Area was October. It is considered a reasonable assumption, based on the timing of this peak, and its relative size compared with unapportioned mean abundances in other non-breeding season surveys, that these peak mean unapportioned abundances represent post-breeding aggregations of birds (likely from multiple breeding colonies across the region). Low abundances of birds were recorded in all reporting regions for the remainder of the non-breeding season surveys. It is noteworthy that the October 2021 peak was considerably larger than the October 2022 peak.

5.6.2.32 Reductions in mean apportioned and availability bias-corrected abundance relative to the peak were between 63% to 98%, with many of the surveys recording reductions in mean abundances at the upper end of this range when compared with the peak month. This reflects the fact that the October 2021 peak (which was the overall peak mean unapportioned abundance for gannet in the non-breeding season across the baseline survey period) was very large relative to the other mean unapportioned abundances recorded for gannet during the non-breeding season in Caledonia South Survey Area and reporting regions.

5.6.2.33 Relatively good measures of precisions (CV ≤0.16) were calculated for survey month where raw counts of individuals where higher, and measures of precisions were high when raw counts of individual were low (CV >0.16). CV values were generally lowest during the middle part of the breeding season, and the late breeding season and autumn dispersal periods. CV values were >0.16 for the most part, with two of 23, six of 24, and eight of 24 surveys in Caledonia South, Caledonia South plus 2km buffer, and Caledonia South Survey Area respectively falling below this value. This indicates lower precision for the abundance and densities calculated for this species compared to some of the more numerous species recorded during the baseline surveys. This is reflected by the relatively large 95% confidence intervals around the mean abundance estimates for this species.

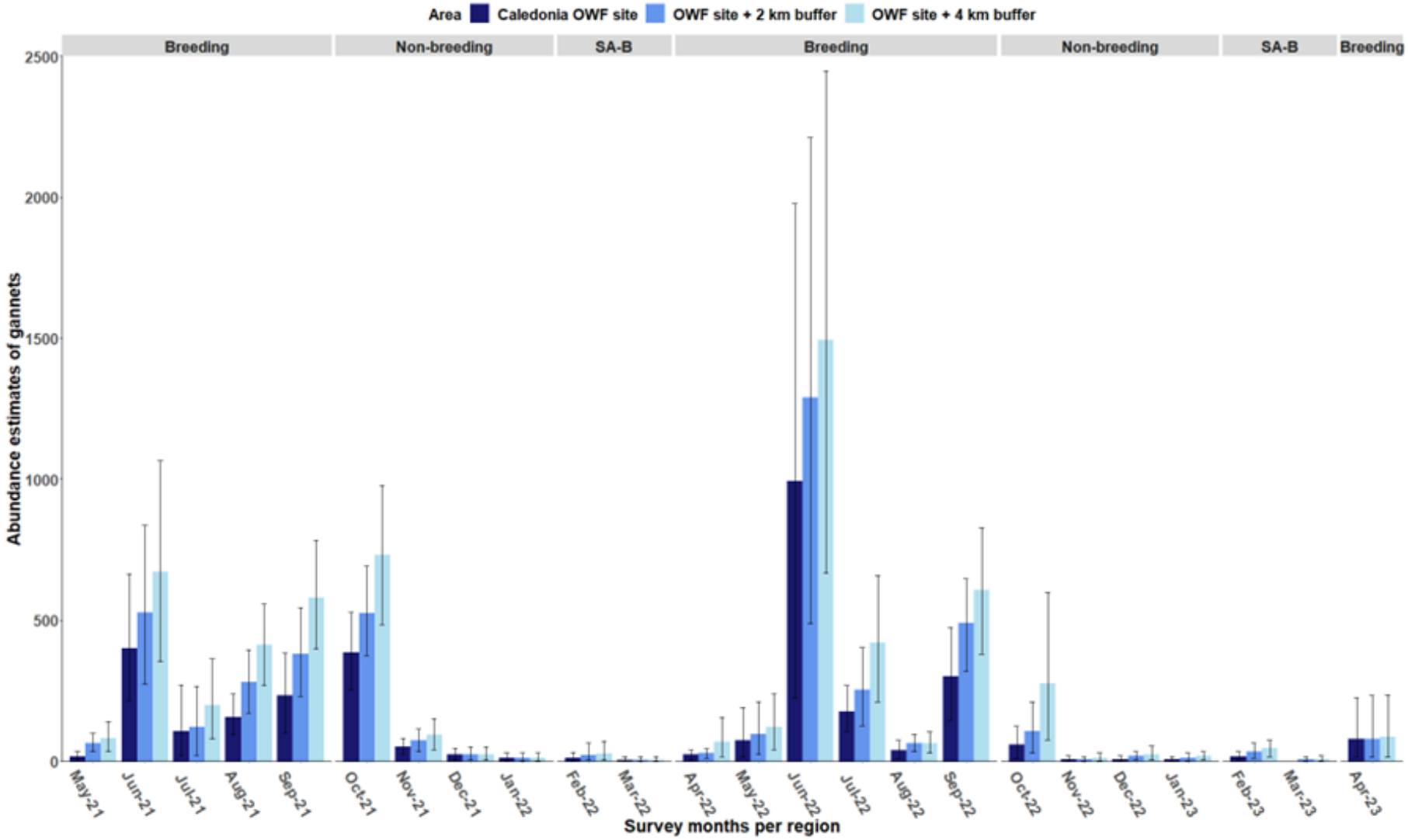


Figure 5-34: Bar plot of the monthly abundance estimates (with 95% confidence intervals) of total gannets recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period. Gannet seasonal periods are also displayed. SA stands for breeding site attendance and SA-B corresponds to month split between SA and breeding (B).

Spatial Distribution and Flight Direction

Spatial Distribution

5.6.2.34 Overall, gannets were recorded throughout the Caledonia OWF (plus a 4km buffer). In July and August 2021, they were mostly in the south of the Caledonia OWF (plus a 4km buffer), while most individuals in September 2021 were in the northwest and the south. Between January and March 2022, a small number of gannets were recorded in Caledonia South and its 4km Buffer Zone. In June 2002, the highest numbers of gannets were recorded in the western half of the Caledonia OWF (plus a 4km buffer). Between July 2022 and January 2023, gannets occurred throughout the Caledonia OWF (plus a 4km buffer), although the highest numbers were seen in Caledonia South. In other months, they were more loosely distributed across the Caledonia OWF (plus a 4km buffer). Distribution during the breeding season appeared more skewed towards the southern half of the Caledonia OWF (plus a 4km buffer), indicating that birds could have originated from the Troup, Pennan and Lion's Heads SPA, which supports a breeding colony of gannets (though the species is not a qualifying feature of the SPA).

5.6.2.35 Distribution maps generated using MRSea (Volume 7B, Appendix 6-1, Annex 16: MRSea Modelling Report) suggest that gannets are distributed mostly across the southern half of the study area during the breeding season (15 March – 30 September). In the non-breeding season, gannets were largely absent from the study area. The highest densities were observed along the south east border of the study area in July 2022.

5.6.2.36 Distribution maps generated using design-based estaimtes for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

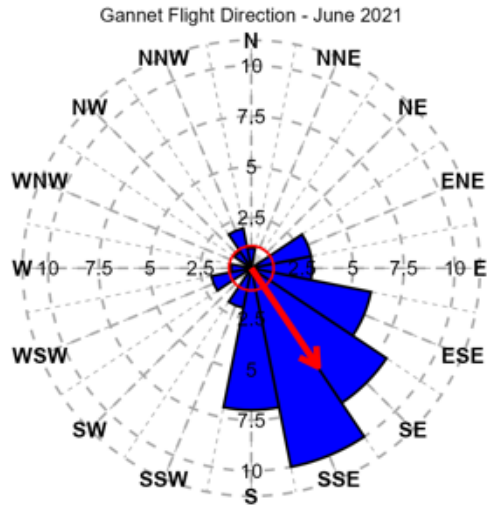
- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

Flight Direction

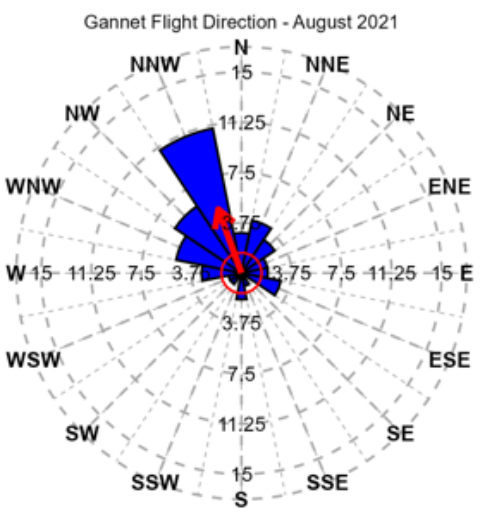
5.6.2.37 Figure 5-35 presents the flight direction of gannet within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.6.2.39 Significant predominant direction of flight was recorded in:

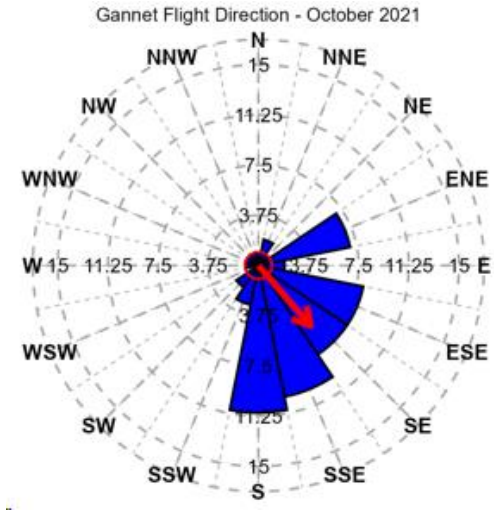
- June
  - 2021 southeast
  - 2022 east-northeast
- July
  - 2022 east-southeast
- August
  - 2021 north-northwest
- September
  - 2022 southeast
- October
  - 2021 southeast
  - 2022 south-southwest
- November
  - 2021 east-southeast
- February
  - 2023 east



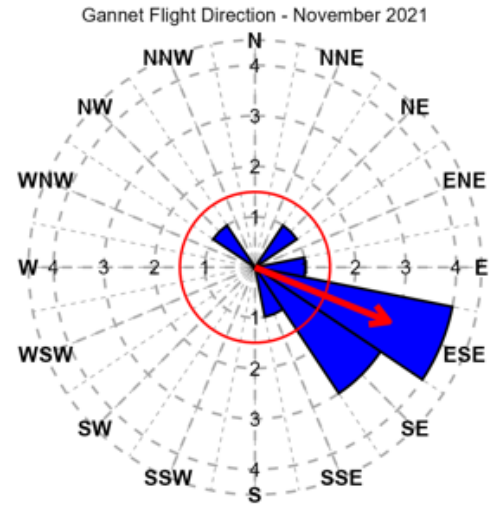
Number of Observations	46
Mean Vector (μ)	146.023
Length of Mean Vector (r)	0.585
Rayleigh Test (Z)	15.733
Rayleigh Test (p)	<0.001



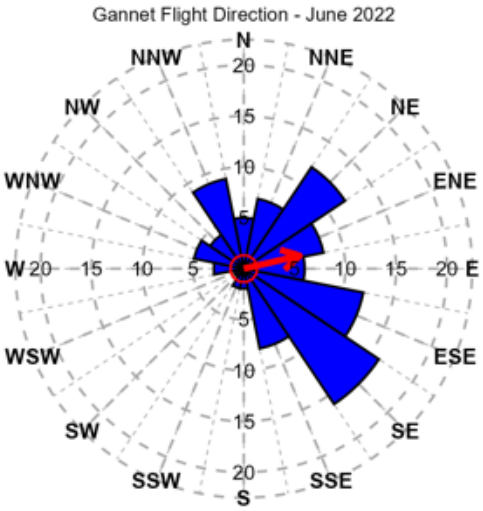
Number of Observations	47
Mean Vector (μ)	340.832
Length of Mean Vector (r)	0.459
Rayleigh Test (Z)	9.892
Rayleigh Test (p)	<0.001

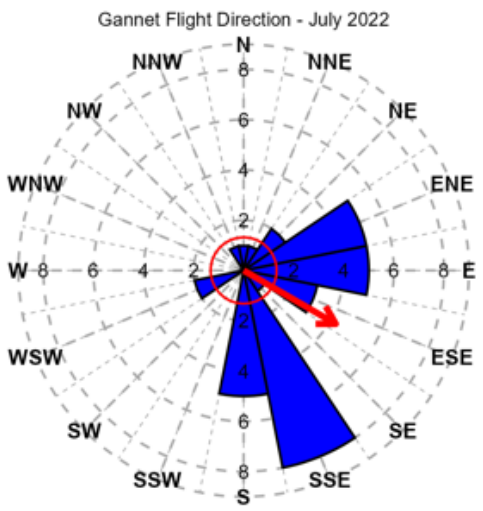


Number of Observations	59
Mean Vector (μ)	139.938
Length of Mean Vector (r)	0.541
Rayleigh Test (Z)	17.261
Rayleigh Test (p)	<0.001

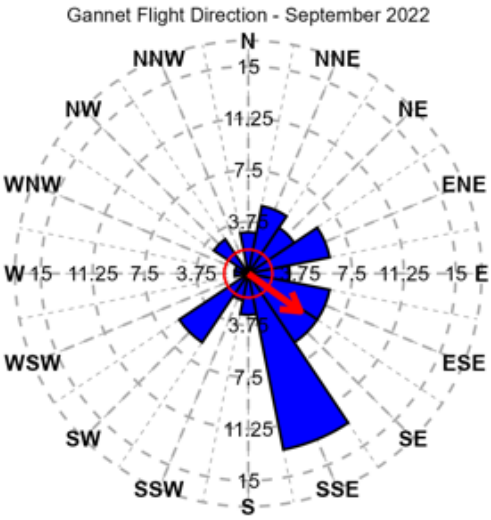


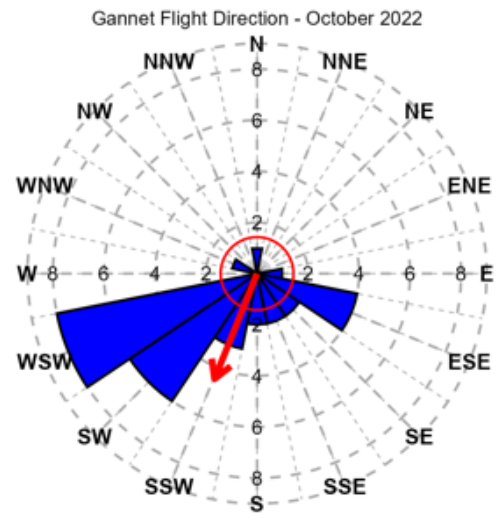
Number of Observations	11
Mean Vector (μ)	112.987
Length of Mean Vector (r)	0.717
Rayleigh Test (Z)	5.648
Rayleigh Test (p)	0.002



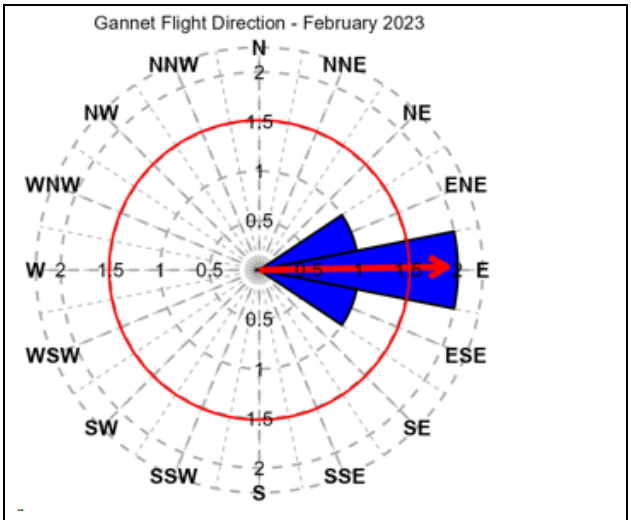


Number of Observations	101	Number of Observations	34
Mean Vector (μ)	77.505	Mean Vector (μ)	120.057
Length of Mean Vector (r)	0.353	Length of Mean Vector (r)	0.531
Rayleigh Test (Z)	12.553	Rayleigh Test (Z)	9.575
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001





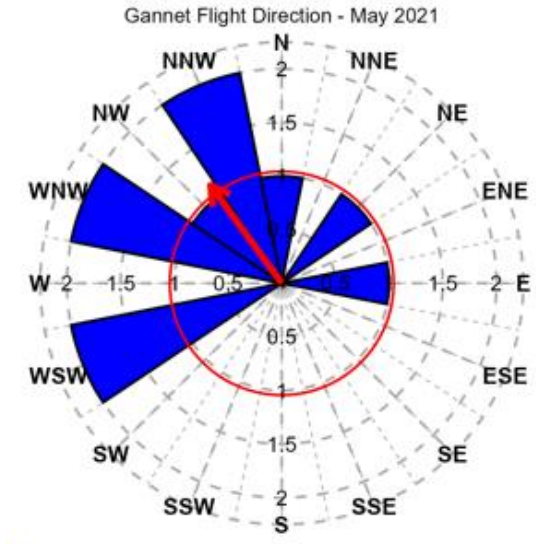
Number of Observations	62	Number of Observations	30
Mean Vector (μ)	126.594	Mean Vector (μ)	202.354
Length of Mean Vector (r)	0.358	Length of Mean Vector (r)	0.555
Rayleigh Test (Z)	7.947	Rayleigh Test (Z)	9.250
Rayleigh Test (p)	<0.001	Rayleigh Test (p)	<0.001



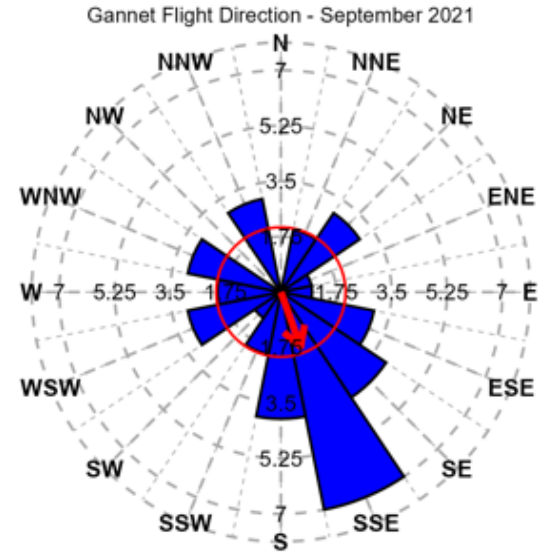
Number of Observations	4
Mean Vector (μ)	89.122
Length of Mean Vector (r)	0.945
Rayleigh Test (Z)	3.574
Rayleigh Test (p)	0.016

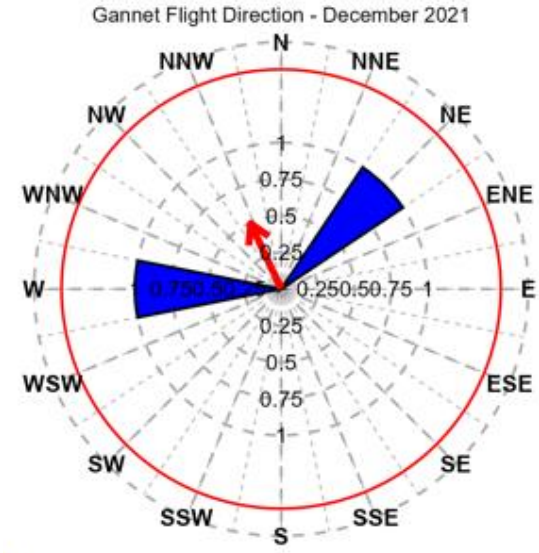
Figure 5-35: Summary of flight direction of gannet within surveys where a significant flight direction was recorded during the May 2021 to April 2023 survey period.

5.6.2.40 As very few birds were recorded in flight in other surveys, they were too infrequent to determine any preference in flight direction (Figure 5-36).

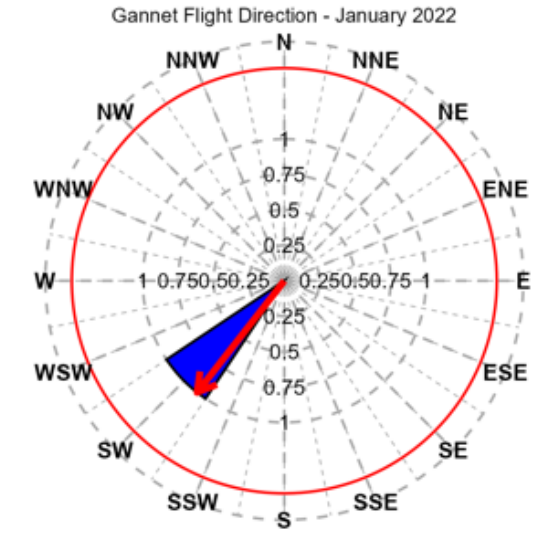


Number of Observations	10	Number of Observations	14
Mean Vector (μ)	324.946	Mean Vector (μ)	16.946
Length of Mean Vector (r)	0.564	Length of Mean Vector (r)	0.386
Rayleigh Test (Z)	3.180	Rayleigh Test (Z)	2.091
Rayleigh Test (p)	0.037	Rayleigh Test (p)	0.123

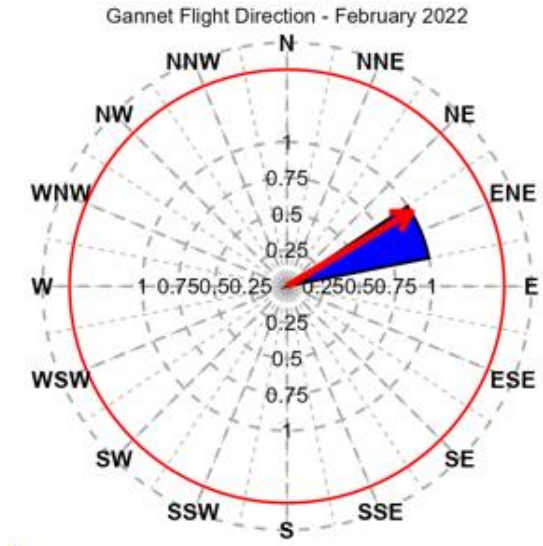




Number of Observations	39	Number of Observations	2
Mean Vector (μ)	160.079	Mean Vector (μ)	335.309
Length of Mean Vector (r)	0.261	Length of Mean Vector (r)	0.493
Rayleigh Test (Z)	2.667	Rayleigh Test (Z)	0.486
Rayleigh Test (p)	0.069	Rayleigh Test (p)	0.678

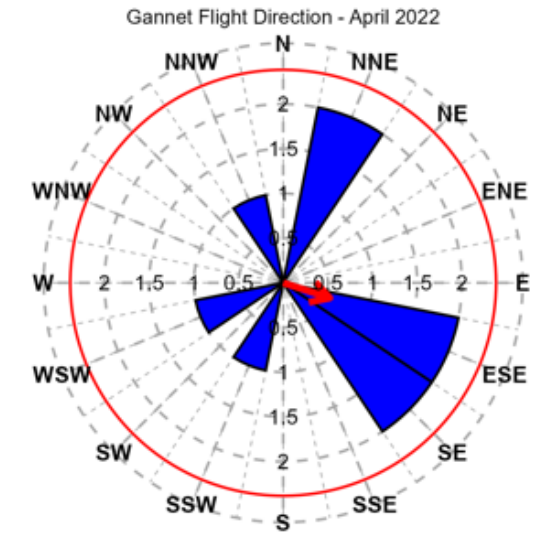


Number of Observations	1
Mean Vector (μ)	218.251
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512

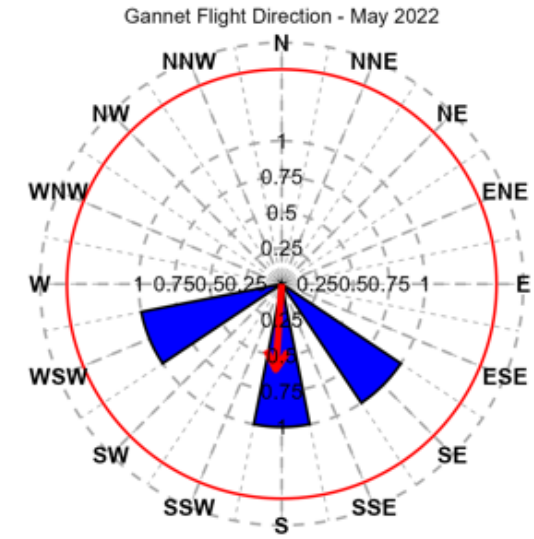


Number of Observations	1
Mean Vector (μ)	59.462
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512

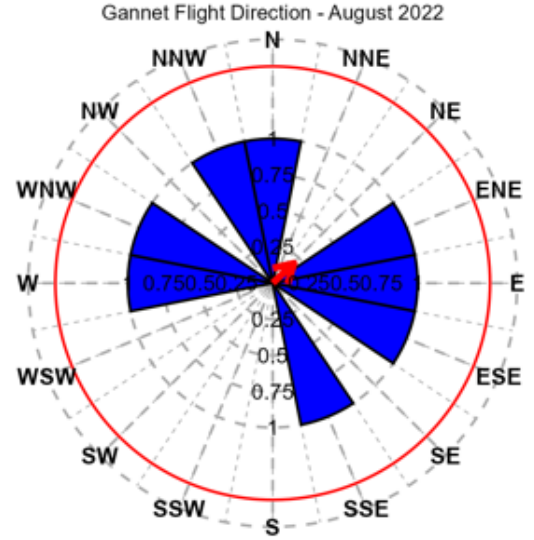
Number of Observations	1
Mean Vector (μ)	158.760
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512



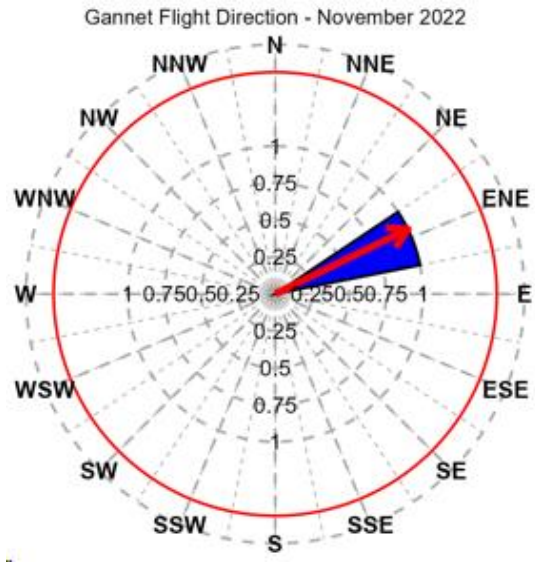
Number of Observations	9
Mean Vector (μ)	108.765
Length of Mean Vector (r)	0.274
Rayleigh Test (Z)	0.677
Rayleigh Test (p)	0.521



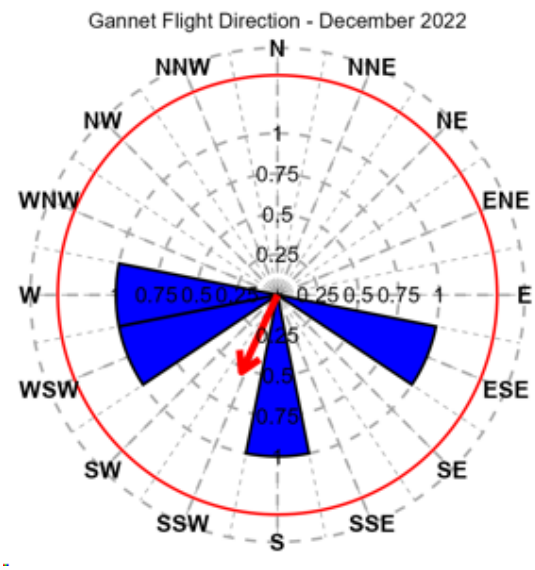
Number of Observations	3
Mean Vector (μ)	184.150
Length of Mean Vector (r)	0.599
Rayleigh Test (Z)	1.077
Rayleigh Test (p)	0.375



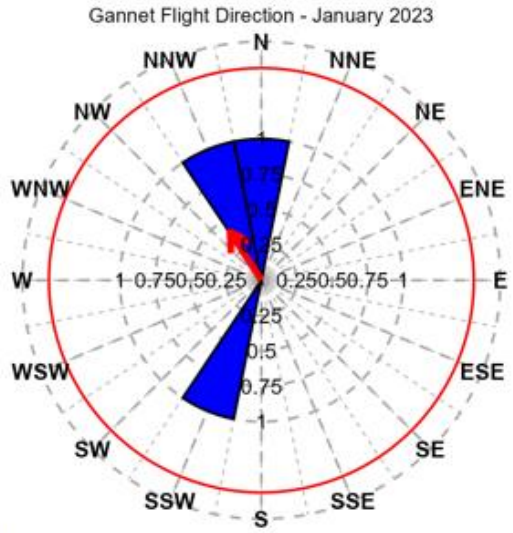
Number of Observations	8
Mean Vector (μ)	47.195
Length of Mean Vector (r)	0.201
Rayleigh Test (Z)	0.322
Rayleigh Test (p)	0.737



Number of Observations	1
Mean Vector (μ)	64.341
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512

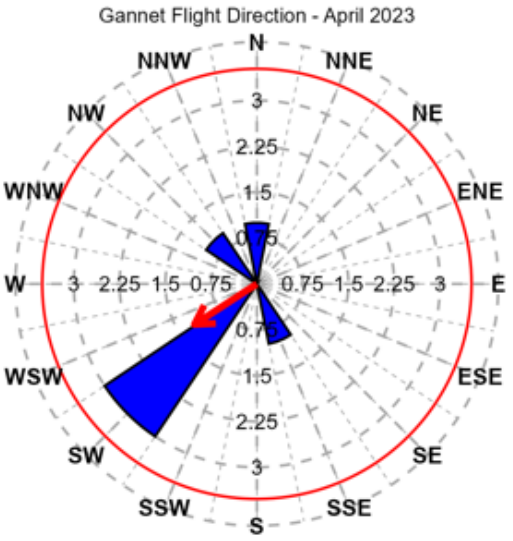


Number of Observations	4
Mean Vector (μ)	205.578
Length of Mean Vector (r)	0.526
Rayleigh Test (Z)	1.107
Rayleigh Test (p)	0.354



Number of Observations	3
Mean Vector (μ)	327.160
Length of Mean Vector (r)	0.407
Rayleigh Test (Z)	0.496
Rayleigh Test (p)	0.650

Number of Observations	1
Mean Vector (μ)	155.027
Length of Mean Vector (r)	1.000
Rayleigh Test (Z)	1.000
Rayleigh Test (p)	0.512



Number of Observations	6
Mean Vector (μ)	237.237
Length of Mean Vector (r)	0.407
Rayleigh Test (Z)	0.992
Rayleigh Test (p)	0.388

Figure 5-36: Summary of flight direction of gannet within surveys where a no significant flight direction was recorded during the May 2021 to April 2023 survey period.

Predicted Impacts

5.6.2.41 As recommended by the NatureScot (2023[1]) guidance, gannet has been scoped into the assessment for:

- Potential operational phase displacement; and
- Potential collision risk.

5.6.2.42 As a result, detailed consideration of mean seasonal peak abundance (all birds), and monthly flying bird density is provided in the following sections.

Mean Seasonal Peak

5.6.2.43 The mean peaks used for this assessment have been presented in Table 5–33. The offshore ornithology distributional responses assessment has been carried out separately for the Caledonia OWF, Caledonia North and Caledonia South. The peaks have been defined using the seasonal definitions presented in Table 5–31 and Table 5–32.

5.6.2.44 Gannet were present in the greatest abundance during the breeding season (Late-August to October) with a mean peak abundance of 909 birds within Caledonia OWF (plus a 2km buffer); 240 birds within Caledonia North (plus a 2km buffer) and 708 birds within Caledonia South (plus a 2km buffer).

5.6.2.45 Outside of the breeding season, fewer gannet were present within the Caledonia OWF (plus a 2km buffer) and Caledonia North (plus a 2km buffer) and Caledonia South (plus 2km buffer) with a mean peak abundance of 29 birds, 20 birds and 17 birds respectively during the Spring migration. In the Autumn migration, 315 birds, 195 birds and 183 birds were present within Caledonia OWF (plus a 2km buffer) and Caledonia North (plus a 2km buffer) and Caledonia South (plus 2km buffer) respectively.

Table 5–33: Mean Seasonal Peaks of gannet within Caledonia OWF (+2km buffer), Caldonia North (+2km buffer) and Caledonia South (+2km buffer), during the NatureScot defined seasons and the BDMPS Non-breeding Seasons as per Furness (2015[48]).

Defined Season	Breeding Season	Non-breeding Season	Autumn migration	Spring migration
Caledonia OWF	909 (528 / 1,289)	315 (525 / 105)	315 (525 / 105)	29 (23 / 34)
Caledonia North	240 (272 / 208)	195 (349 / 41)	195 (349 / 41)	20 (11 / 29)
Caledonia South	708 (302 / 1,113)	183 (267 / 98)	183 (267 / 98)	17 (21 / 12)
Note, the seasonal peaks from Year 1 and Year 2 of DAS data used to calculate the mean seasonal peaks are provided within the brackets '()'.				

Density in Flight

5.6.2.46 The monthly density estimates (birds/km^2) used for this assessment have been presented in Table 5–34 and Figure 5-37. The monthly density estimates are using in CRM for the individual assessment within Caledonia OWF, Caledonia North and Caledonia South.

5.6.2.47 During the breeding season (Mid-March to September) the greatest density of gannet in flight were recorded in June 2022 within Caledonia OWF (1.20 birds/km^2); 0.37 birds/km^2 in September 2021 within Caledonia North and 2.21 birds/km^2 in June 2022 within Caledonia South.

5.6.2.48 Outside the non-breeding (October to early March) season fewer gannet were present with the greatest density of 0.44 birds/km^2 (October 2021) recorded within Caledonia OWF; 0.59 birds/km^2 (October 2021) within Caledonia North and 0.28 birds/km^2 (October 2021) within Caledonia South.

Table 5–34: Estimated densities (birds/km^2) of all flying kittiwake across the 24-month survey period for Caledonia OWF, Caledonia North and Caledonia South.

Year	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Caledonia OWF												
1	0.01	0.29	0.08	0.24	0.27	0.44	0.10	0.03	0.01	0	0.01	0.04
2	0.01	1.20	0.21	0.08	0.42	0.11	0.01	0.01	0.01	0.01	0	0.08
Caledonia North												
1	0	0.30	0.08	0.24	0.37	0.59	0.05	0.05	0	0	0	0.05
2	0	0.31	0.13	0.03	0.29	0.11	0	0	0	0.03	0	0
Caledonia South												
1	0.03	0.28	0.09	0.25	0.17	0.28	0.14	0	0.03	0	0.02	0.03
2	0.03	2.12	0.28	0.14	0.56	0.11	0.03	0.03	0.03	0	0	0.16
Note, estimates calculated using design-based analysis.												

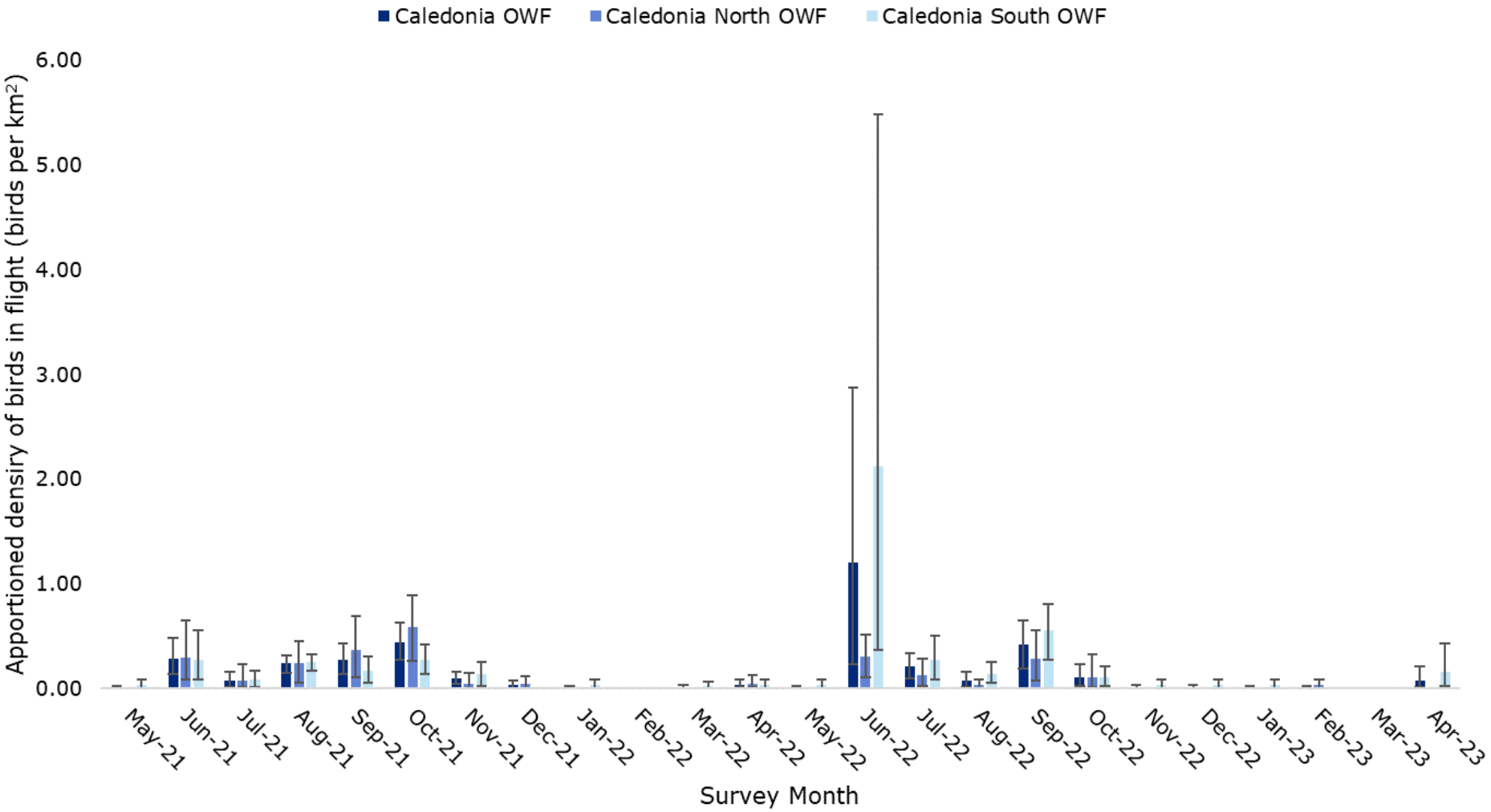


Figure 5-37: Bar plot of monthly densities (birds/km^2) of flying gannet (with 95% confidence intervals) recorded in each reporting region of the Survey Area, during the May 2021 to April 2023 survey period.

5.7 Summary

5.7.1.1 Over the 24-month survey period from May 2021 to April 2023, 21 species of seabird were recorded in total (13 included in this Technical Report). Of those species discussed in this Technical Report, a total of 36,501 birds were recorded in the Caledonia OWF (plus a 4km buffer), with 15,331 birds recorded in Caledonia North (plus a 4km buffer) and 27,243 birds recorded in Caledonia South (plus a 4km buffer). The peak abundance for all birds included in this Technical Report at Caledonia OWF was generally recorded in May, June, July and August for both 2021 and 2022.

5.7.1.2 The total number of birds observed across the 24 surveys in the Caledonia OWF, Caledonia North and Caledonia South, that were identified to species level, are detailed in the following annexes:

- Volume 7B, Appendix 6-1, Annex 1: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 4: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 7: Model-based and Design-based Density and Abundance Estimates of All Birds (Caledonia South).

5.7.1.3 Additionally, the following annexes have been provided detailing the abundance and density estimates of birds in flight and birds on sea:

- Volume 7B, Appendix 6-1, Annex 3: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 6: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia North);
- Volume 7B, Appendix 6-1, Annex 9: Design-based Density and Abundance Estimates of Birds on Sea (Caledonia South);
- Volume 7B, Appendix 6-1, Annex 2: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 5: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia North); and
- Volume 7B, Appendix 6-1, Annex 8: Model-based and Design-based Density and Abundance Estimates of Birds in Flight (Caledonia South).

5.7.1.4 Spatial distribution maps generated using design-based estimates for Caledonia OWF, Caledonia North and Caledonia South, and relevant buffers (2km and 4km) are presented within the following annexes:

- Volume 7B, Appendix 6-1, Annex 12: Spatial Distribution Figures (Caledonia OWF);
- Volume 7B, Appendix 6-1, Annex 13: Spatial Distribution Figures (Caledonia North); and

- Volume 7B, Appendix 6-1, Annex 14: Spatial Distribution Figures (Caledonia South).

5.7.1.5 Within this summary, estimated mean peak abundances and distributions for Caledonia OWF, Caledonia North and Caledonia South are presented for key species to be considered within OWF assessments:

- Kittiwake were the most abundant gull species, and were recorded in all 24 surveys. Peak abundances occurred in the breeding season (April to August), with an estimated mean peak abundance of 3,977 within Caledonia OWF (plus a 2km buffer); 1,823 birds within Caledonia North (plus a 2km buffer) and 3,485 birds within Caledonia South (plus a 2km buffer). Kittiwake were widely distributed throughout the Caledonia OWF (plus a 4km buffer) for the majority of the 24-month baseline survey.
- Great black-backed gull were recorded in all 24 surveys, with highest abundances recorded during the non-breeding season (September to early-March). The estimated mean peak abundance for this species was 461 birds within Caledonia OWF (plus a 2km buffer); 218 birds within Caledonia North (plus a 2km buffer) and 284 birds within Caledonia South (plus a 2km buffer). Great black-backed gulls were concentration in the west of Caledonia OWF (plus a 4km buffer) in the 24-month surveys, predominantly within the 4km Buffer Zone.
- Herring gull were recorded in generally low abundances (99 birds in total). Herring gulls were the most abundant during the non-breeding season (September to March), with an estimated mean peak abundance of 63 birds within Caledonia OWF (plus a 2km buffer); 38 birds within Caledonia North (plus a 2km buffer) and 41 birds within Caledonia South (plus a 2km buffer). Herring gull distribution in the 24-month surveys were recorded predominately in the north and the west of Caledonia North (plus a 4km buffer zone).
- Lesser black-backed gull were recorded in very low the Caledonia OWF (plus a 4km buffer) during both years of baseline surveys (12 birds total). Lesser black-backed gull were only recorded during the breeding season (August to October), with an estimated mean peak abundance of 22 within Caledonia OWF (plus a 2km buffer); six birds within Caledonia North (plus a 2km buffer) and 23 birds within Caledonia South (plus a 2km buffer). As very few birds were recorded in flight, they were too infrequent to determine their distribution.
- Great skua were recorded in low the Caledonia OWF (plus a 4km buffer) during both years of baseline surveys (22 birds total). Great skua were only recorded during the breeding season (August to October), with an estimated mean peak abundance of 24 within Caledonia OWF (plus a 2km buffer); 15 birds within Caledonia North (plus a 2km buffer) and 18 birds within Caledonia South (plus a 2km buffer). From the 24-month surveys, great skua were generally distribution across Caledonia North (plus a 4km buffer).

- Guillemot were recorded in all 24 surveys, with highest abundances recorded from May to July. Guillemot had the greatest abundance during the breeding season (April to mid-August) with a mean peak abundance of 17,542 birds within Caledonia OWF (plus a 2km buffer); 8,759 birds within Caledonia North (plus a 2km buffer) and 10,873 birds within Caledonia South (plus a 2km buffer). Throughout the 24-month surveys guillemot were distributed across the Caledonia OWF (plus a 4km buffer) without any discernible distribution pattern.
- Razorbill were recorded in every survey apart from November 2021. In contrast to guillemot, highest abundances of razorbills were recorded during the non-breeding period (September to February), with the peak abundance in September 2022. Razorbill were present in the greatest abundance during the Autumn migration (Late-August to October), with a mean peak abundance of 2,077 birds within Caledonia OWF (plus a 2km buffer); 1,421 birds within Caledonia North (plus a 2km buffer) and 902 birds within Caledonia South (plus a 2km buffer). Throughout the 24-month surveys razorbills were primarily recorded through Caledonia OWF without any discernible distribution pattern.
- Puffin were recorded in every survey except November 2021 to February 2022 and November to December 2022. Puffins were the most abundant during the breeding season (April to mid-August, with birds attending colonies from mid-March onwards). The peak abundance of puffin was recorded in August 2021, with an estimated mean peak abundance of 2,320 birds within the Caledonia OWF (plus 2km buffer); 1,461 birds within Caledonia North (plus 2km buffer) and 1,364 birds within Caledonia South (plus 2km buffer). While puffins were mostly loosely distributed across the Caledonia OWF (plus a 4km buffer), higher numbers of records were made in Caledonia South (plus a 4km buffer).
- Red-throated diver was recorded in a single instance within the Survey Area during the second year of the baseline surveys. The individual was recorded in October 2022 in Caledonia South. Therefore, abundance and density estimates were very low (total abundance estimate of six individuals). In October 2022, the single red-throated diver was recorded in the north of Caledonia South, near the border with Caledonia North.
- Fulmar were recorded in all 24 surveys, and were the most abundant during the breeding season (April to mid-September), with an estimated mean peak abundance of 4,977 birds within the Caledonia OWF (plus 2km buffer); 1,228 birds within Caledonia North (plus 2km buffer) and 4,125 birds within Caledonia South (plus a 2km buffer). Throughout the 24-month surveys fulmars displayed no discernible distribution pattern. However, slightly higher abundances were recorded in the southeast of the Caledonia OWF (plus a 4km buffer).

- Gannet were recorded throughout the year, being recorded in Caledonia OWF in 23 of 24 baseline surveys. Gannet were present in the greatest abundance during the breeding season (Late-August to October) with an estimated mean peak abundance of 909 birds within Caledonia OWF (plus a 2km buffer); 240 birds within Caledonia North (plus a 2km buffer) and 708 birds within Caledonia South (plus a 2km buffer). Throughout the 24-month surveys gannets were distributed across the Caledonia OWF (plus a 4km buffer).

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