Hornsea Project Four

Compensation measures for FFC SPA: Ecological Connectivity of Compensation Measures Annex 1

Deadline: 3, Date: 21 April 2022
Document Reference: G3.4.1
Revision: 01

Prepared GoBe Consultants Ltd, March 2022
Checked Dr Sarah Randall, April 2022
Accepted Francesca De Vita, April 2022
Approved Dr Julian Carolan, April 2022

G3.4.1
Ver. A

Revision Summary

Rev	*Date*	*Prepared by*	*Checked by*	*Approved by*
A	24/03/2022	GoBe Consultants Ltd, March 2022	Dr Sarah Randall, April 2022	Dr Julian Carolan, April 2022
01	21/04/2022	GoBe Consultants Ltd	Dr Sarah Randall, April 2022	Dr Julian Carolan, April 2022

Revision Change Log

Rev	*Page*	*Section*	*Description*
A	-	-	Submitted to Defra
01	-	-	Submitted at Deadline 3

Table of Contents

List of Tables

List of Figures

Glossary

Term	Definition
Compensation / Compensatory Measures	If an Adverse Effect on the Integrity on a designated site is determined during the Secretary of State's Appropriate Assessment, compensatory measures for the impacted site (and relevant features) will be required. The term compensatory measures is not defined in the Habitats Regulations. Compensatory measures are however, considered to comprise those measures which are independent of the project, including any associated mitigation measures, and are intended to offset the negative effects of the plan or project so that the overall ecological coherence of the national site network is maintained.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
European site	A Special Area of Conservation (SAC) or candidate SAC (cSAC), a Special Protection Area (SPA) or a site listed as a Site of Community Importance (SCI). Potential SPAs (pSPAs), possible SACs (pSACs) and Ramsar sites are also afforded the same protection as European sites by the National Planning Policy Framework – para 176 (Ministry of Housing, Communities and Local Government, 2019). European offshore marine sites are also referred to as "European sites" for the purposes of this document.
Habitats Regulations	The Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017.
Habitats Regulations Assessment (HRA)	A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of overriding public interest (IROPI).
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e., both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Hornsea Zone	The former Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by TCE during its third round of offshore wind licensing. In March 2016, the Hornsea Zone Development Agreement was terminated and project specific agreements, AfLs, were agreed with TCE for Hornsea Project One, Hornsea Project Two, Hornsea Three and Hornsea Four. The Hornsea Zone has therefore been dissolved and is referred to throughout the ES as the former Hornsea Zone.

Impact	Change that is caused by an action; for example, land clearing (action) during construction which results in habitat loss (impact).
National Grid Electricity Transmission (NGET) substation	The grid connection location for Hornsea Four.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Special Area of Conservation (SAC)	Strictly protected sites designated pursuant to Article 3 of the of the Habitats Directive (via the Habitats Regulations) for habitats listed on Annex I and species listed on Annex II of the Directive.
Special Protection Area (SPA)	Strictly protected sites designated pursuant to Article 4 of the Birds Directive (via the Habitats Regulations) for species listed on Annex I of the Directive and for regularly occurring migratory species.
Wind turbine generator	All the components of a wind turbine, including the tower, nacelle, and rotor.

Acronyms

Term	Definition
AEoI	Adverse Effect on Integrity
BTO	British Trust for Ornithology
CIMP(s)	Compensation Implementation and Monitoring Plan(s)
DCO	Development Consent Order
DEFRA	Department for Environment, Food and Rural Affairs
FFC	Flamborough and Filey Coast
GRIMP	Guillemot and Razorbill Implementation and Monitoring Plan
IMP	Implementation and Monitoring Plan
JNCC	Joint Nature Conservation Committee
LEB	Looming Eyes Buoy
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
NGET	National Grid Electricity Transmission
NSIP	Nationally Significant Infrastructure Project
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
SNCB	Statutory Nature Conservation Bodies
SoS	Secretary of State
SPA	Special Protection Area
TJB	Transition Joint Bay
WTGs	Wind Turbine Generators
UK	United Kingdom

Units

Unit	Definition
%	Percentage (proportion)
Km	Kilometre (distance)

1 Summary

1.1 Background

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter the 'Applicant') is proposing to develop Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm) including up to 180 wind turbine generators (WTGs), export cables to landfall, and connection to the National Grid Electricity Transmission (NGET) network at Creyke Beck. Detailed information on the project design can be found in **A1.4: Project Description (APP-010)**, with detailed information on the site selection process and consideration of alternatives described in **A1.3: Site Selection and Consideration of Alternatives (APP-009)** (submitted as part of the DCO application).

1.1.1.2 This document has been prepared to support the 'without prejudice' compensatory measures for Hornsea Four. In response to stakeholder consultation on potential effects from Hornsea Four on kittiwake, gannet, guillemot and razorbill features of Flamborough and Filey Coast (FFC) Special Protection Area (SPA). The Applicant has proposed a range of compensation measures as part of its 'without prejudice' compensation case (as detailed within **B2.6: Compensation measures for Flamborough and Filey Coast (FFC) Special Protection Area (SPA): Overview (APP-183)**). For guillemot and razorbill, the proposed compensation measures are bycatch reduction and predator eradication, delivered within in the English Channel and Bailiwick of Guernsey (Channel Islands) respectively.

1.1.1.3 This document evidences guillemot and razorbill connectivity between the English Channel/ Channel Islands and FFC SPA, as well as the wider UK National Site Network. The purpose of this work is to show that the proposed compensation measures feed back into FFC SPA and the wider UK National Site Network, thus ensuring the maintenance of UK National Site Network integrity. In addition, this document sets out the wider non-like-for-like benefits that the proposed compensation measures would bring for other species. This section of the report has a particular focus on puffin, Manx shearwater, storm petrel, cormorant and great Northern diver, and discusses connectivity between the sites of compensation delivery and National Site Network

1.1.1.4 In addition, GIS modelling of guillemot and razorbill at sea distributions per calendar month is appended.

1.2 Summary of key findings

1.2.1.1 There is connectivity of guillemot and razorbill from the Channel Islands/English Channel with populations across England both during winter and the breeding season. It can be concluded that the proposed compensation measures of predator eradication (targeting breeding birds on the Channel Islands) and bycatch reduction (targeting wintering birds in the English Channel) will feed back into the National Site Network populations. The presented evidence shows that guillemot and razorbill are capable of dispersing the distances between the proposed sites of compensation and National Site Network sites. Tagging research shows with certainty that birds from at least one National Site Network site (Farne Islands) winter in the English Channel. In relation to the FFC SPA specifically,

ringing data shows that birds from the northeast have been recaptured in both the English Channel and on the Channel Islands.

1.2.1.2 In addition to direct benefits to the target seabird species, it is worth noting that both predator eradication and bycatch reduction will also provide additional benefits (as per level 4 of the draft Defra compensation hierarchy) to a wider range of species, including protected species at SPAs other than FFC SPA. A review of existing evidence presented in this document shows that there is confirmed or highly likely connectivity between the sites of compensation delivery and National Site Network sites.

1.2.1.3 For a full overview of key findings, see **Section 6**.

2 Introduction

2.1 Project Background

2.1.1.1 In accordance with the Habitats Regulations, the RIAA (**B2.2: Report to Inform Appropriate Assessment (RIAA) (APP-167)**) considers whether Hornsea Four could result in an Adverse Effect on Integrity (AEoI) on a conservation site of European importance (European site). The Applicant's RIAA concluded that Hornsea Four will potentially have an AEoI, in combination, on the kittiwake feature of the FFC SPA. No AEoI was concluded for all other European site features.

2.1.1.2 It is material to note that in granting consent for Hornsea Three Offshore Wind Farm (Hornsea Three), the SoS[1] did so in light of a conclusion of adverse effect with respect to three designated sites; of these three sites the FFC SPA is also a material consideration for Hornsea Four. Further, during the consideration of the DCO application for Hornsea Three, the SoS clarified the importance of i) identifying the potential for AEoI of designated sites during the pre-application period and ii) considering the need for derogation of the Habitats Regulations during examination, where there is potential for AEoI. The SoS further expected Applicants and Statutory Nature Conservation Bodies (SNCBs) to engage constructively during the pre-application period and on these matters, including possible compensatory measures, for consideration during examination. The SoS was clear that this does not require that an agreement is reached between the Applicant and the SNCBs on the potential for significant adverse impacts on designated sites, and that evidence relating to derogation can be provided on a 'without prejudice' basis, as the final decision on such matters remains with the SoS.

2.1.1.1 As such, the Applicant is proposing a suite of compensation measures that could be implemented in the event that the SoS concludes that there would be an AEoI on the FFC SPA for guillemot and/or razorbill as a result of Hornsea Four. These compensation measures are set out in a 'without prejudice' Derogation Case which forms part of the DCO Application (see **B2.5: Without Prejudice HRA Derogation Case (APP-182)** and **B2.6 Compensation measures for Flamborough and Filey Coast (FFC) Special Protection Area (SPA): Overview (APP-183)**). The compensation measures are proposed 'without prejudice' to the Applicant's RIAA conclusion of no AEoI in relation to gannet, guillemot and razorbill features of the FFC SPA. Compensation measures for kittiwake are not presented 'without prejudice' based on

[1] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-003265-EN010080%20Hornsea%20Three%20-%20Secretary%20of%20State%20Decision%20Letter.pdf

the AEoI conclusion for the species from Hornsea Four in-combination with other plans and projects.

2.1.1.2 This document has been prepared to support the 'without prejudice' compensatory measures for Hornsea Four. The proposed compensation measures were submitted as part of the DCO application (**B2.6: Compensation measures for FFC SPA Overview (APP-183)**). A potential plan for execution of the guillemot and razorbill, compensation measures was submitted as part of the DCO application within the Guillemot and Razorbill Compensation Plan (**B2.8: FFC SPA: Gannet, Guillemot and Razorbill Compensation Plan (APP-193)**). Should this compensation measure be taken forward, further details on the precise delivery methodology for the measure would also be provided within Implementation and Monitoring Plans (IMPs). An outline of the IMP was presented by the Applicant within the Guillemot and Razorbill Implementation and Monitoring Plan (GRIMP) (**B2.8.7: Outline Guillemot and Razorbill Compensation Implementation and Monitoring Plan (APP-200)**).

2.2 Document Purpose

2.2.1.1 In response to stakeholder consultation on potential effects from Hornsea Four on certain ornithological features of FFC SPA, the Applicant has proposed a range of compensation measures as part of its 'without prejudice' compensation case. For guillemot and razorbill, the proposed compensation measures are bycatch reduction and predator eradication, delivered within in the English Channel and Bailiwick of Guernsey (Channel Islands) respectively (**Figure 1**).

2.2.1.2 The aim of this document is to evidence guillemot and razorbill connectivity between the sites of the proposed compensation measures (English Channel / Channel Islands) and FFC SPA, as well as the wider National Site Network, thus ensuring National Site Network integrity.

2.2.1.3 In addition, this document sets out the wider benefits to non-target species at different sites that the proposed compensation measures would bring.

Hornsea Four

Figure 1

Compensation Measures Search Areas and Consultation Extent

APFP Regulations Reference : 5(2)(a) Application Document Number : A4.6.2

N

GRID NORTH

- Hornsea Four Array Area
- Economic Exclusion Zone Boundary
- UK Offshore Windfarms

Compensation Measures Areas of Search

- Offshore nesting
- Onshore nesting
- Bycatch
- Predator eradication
- Seagrass

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:3,200,000

0 25 50 100 Kilometres

0 10 20 40 Nautical Miles

REV	REMARK	DATE
	First issue	02/09/2021
A	Revised the Search Areas	18/01/2022

Compensation Measures Search Areas and Consultation Extent
Document no: HOW040485
Created by: XDAOO
Checked by: WATTS
Accepted by: JULCA
Approved by: JAMIB

Ørsted

3 Guillemot and Razorbill Overview

3.1 Guillemot

3.1.1.1 It is estimated that there are currently 950,000 breeding guillemot pairs in the UK, (RSPB, 2021a). During the breeding season (March - July) guillemots breed in tightly packed colonies of many tens of thousands of individuals on steep ledges and cliffs (Sweet, 2008; JNCC, 2020a; Wildlife Trust, 2021). Breeding colonies in the UK are most notably located in Scotland, although guillemot can be found around the UK and Ireland, with the exception of south-east England from Flamborough to the Isle of Wight (Sweet, 2008; Natural England, 2020). During winter, birds disperse across the UK coastlines, and beyond (see **Section 4.2.1**).

3.1.1.2 There are five distinct subspecies (races) of guillemot, each with their own geographic range (Knox, 2012). In the UK, two subspecies are found, *Uria aalge aalge* and *Uria aalge albionis* (**Table 1**). The geographic boundary between the two races lies in Scotland at approximately 55°38'N. *Aalge* is the more northernly race; it is found only in Scotland and Northumbria (north of 55°38'N). *Albionis* is mostly located on the coasts of Ireland, England and Wales, as well as southern Scotland (south of 55°38'N) (Furness, 2015; AEWA, 2019). The breeding guillemot colony within the FFC SPA is of the southern *albionis* race. In winter, both races will spend the winter in intermixed groups as the most northern colonies travel the furthest distances during the winter dispersal (Furness, 2015).

3.1.1.3 Whilst the Habitat Regulations do not refer to sub-species level, in response to stakeholder feedback the Applicant has investigated guillemot subspecies and have targeted compensation measures at the impacted *albionis* subspecies.

Table 1: Guillemot subspecies (adapted from Knox, 2021).

Subspecies	Ocean basin	Location
aalge	Atlantic	Eastern Canada Greenland Iceland Faeroes Britain (north of 55°38'N) Baltic Norway (south of 69°N)
albionis	Atlantic	Britain (south of 55°38'N) Ireland Helgoland Brittany Western Iberia
hyperborea	Atlantic	Norway (north of 69°N) Murmansk Bear Island Spitsbergen Novaya Zemlya
inornata	Pacific	North Pacific
californica	Pacific	California

3.1.1.4 Guillemots ringed as chicks within the *albionis* range have been recorded breeding within *aalge* range and vice versa (Knox, 2012). Therefore, although there are definitive subspecies ranges, in colonies surrounding the race range boundary of 55°38'N, there will be an overlap in guillemot races (Furness, 2015).

3.1.1.5 Guillemots within SPAs have been mapped in **Figure 2** with the subspecies within the SPA network during the breeding season identified; FFC SPA is within the *albionis* subspecies range. The location of the Channel Islands, where predator eradication is proposed, is also shown on the figure. As both races have been recorded breeding within colonies of the other race, the figure identifies the area that may contain breeding populations of both *aalge* and *albionis*.

Hornsea Four

Figure 2

Common Guillemot
Race Distribution

-500000 0 500000

6500000

6000000

5500000

N
GRID
NORTH

56°38'N
55°38'N
54°38'N

Hornsea 4 array and cable corridor

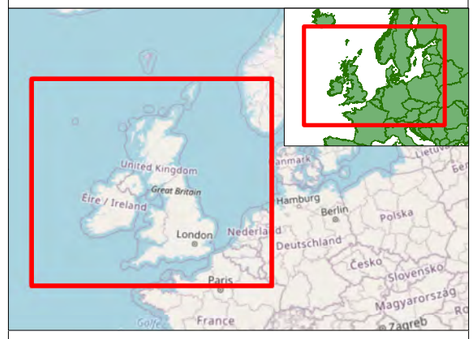
UK SPA network – guillemot race

aalge

albionis

Channel Islands – guillemot race

albionis



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:5,000,000

0 100 200 Kilometres

0 50 100 Nautical Miles

REV	REMARK	DATE
....	First Issue	14/04/2022

Common Guillemot
Race Distribution
Document no: HOW04GB0020
Created by: BPHB
Checked by: FC
Approved by: NS

GoBe
Ørsted

Date: 14/04/2022 Author: BenBlakeman Name: HOW04GB0020_Fig2_Guillemot_Race_Distribution_v1

3.2 Razorbill

3.2.1.1 Razorbill in Great Britain are part of the *Alca torda islandica* subspecies, found in Great Britain, Ireland and Northwest France. The only other subspecies, *Alco torda torda,* is found in the Baltic Sea, White Sea, Norway, Bear Island, Iceland, Greenland and Eastern North America.

3.2.1.2 There are currently an estimated 130,000 breeding pairs of razorbill in the UK (RSPB, 2021b). Razorbill, like guillemot, nest on steep ledges and cliffs and therefore exhibit a similar distribution around the UK. During the breeding season they breed around the coast of the UK (mostly in Scotland), with the exception of the coastline between the Humber and the Isle of Wight (RSPB, 2021b). During winter, birds move away from their wintering grounds to spend the winter in coastal areas in various locations across the UK and Europe (see **Section 4.2.2**).

3.3 Razorbill and Guillemot at Flamborough and Filey Coast SPA

3.3.1.1 FFC SPA is located on the east coast of England, on the border of east and north Yorkshire (Natural England, 2020). The SPA supports the largest guillemot and razorbill colonies in England (Natural England, 2020). Moreover, FFC SPA is the most southerly large cliff-nesting seabird colony on the North Sea coast (Aitken et al.,2017).

3.3.1.2 The total UK guillemot population increased by 1% between the 2000 seabird census and 2018, whilst the population within the FFC SPA has increased by 81% (JNCC, 2020a; JNCC, 2020b). The breeding population within the FFC SPA has been increasing at a similar rate since the 1970s, and currently holds over 60,000 breeding pairs (Aitken et al., 2017). FFC holds 15.6% of the southern *albionis* biogeographical subspecies population (Natural England, 2020). Outside of the breeding season, guillemots of the *aalge* race have been recorded off the Flamborough coast while traveling south from their breeding colonies

3.3.1.3 The UK razorbill population increased by 33% since the 2000 seabird census, with a 228% increase recorded within the FFC SPA, double the increase of any other UK SPA (JNCC, 2020b; JNCC, 2020c). The colony has increased in size since the 1970s, although there was no increase in individuals in the 2000 seabird census. Current population size is estimated at ~20,000 breeding pairs (Aitken et al., 2017).

3.3.1.4 The guillemot and razorbill breeding season at FFC SPA is typically between April to August (Natural England, 2020). Nesting birds are distributed throughout the SPA, apart from the coastal cliffs south of Flamborough Head, with concentrations found on the highest ledges at Bempton Cliffs and around Breil Newk (Natural England, 2020).

3.4 Limitations of Studying Guillemot and Razorbill Connectivity

3.4.1.1 Determining connectivity of guillemot and razorbill, particularly natal dispersal, is currently challenging due to technological limitations. Assessing natal dispersal requires technology with a battery life of >6 years (from chick to breeding adults) and would require the use of tags that do not need to be recovered from the birds, such as satellite, radio or archival tags/ loggers. Colour-ringing of chicks, with the aim of resighting in subsequent years could be considered, however, the probability of resighting colour-ringed birds in large colonies with restricted visibility of nests, such as FFC SPA, is expected to be low. This method is therefore

unlikely to provide sufficient qualitative evidence to establish interchange between colonies.

3.4.1.2 Additionally, due to difficulties of accessing guillemot and razorbill at FFC SPA, there is no ringing data for guillemot or razorbill from FFC SPA specifically. The inaccessibility has also led to a lack of tagging data, thereby resulting in a lack of data of guillemot and razorbill winter dispersal from this site. This document has therefore used information from colonies near to FFC SPA to describe the current knowledge of guillemot and razorbill connectivity between FFC SPA, the UK National Site Network and the English Channel/ Bailiwick of Guernsey (Channel Islands).

4 Connectivity

4.1 Breeding Season Connectivity

4.1.1 Introduction To Philopatry

4.1.1.1 Philopatry is defined as the tendency of an animal to return to a particular area. Table 2 defines the types of philopatry that are distinguished in the context of seabird ecology.

Table 2: The different uses of the term 'philopatry', see Coulson (2016).

Philopatry	Definition
Natal	Returning to the area the chick hatched from.
Colony	Returning to the colony the chick hatched from, but not necessarily near the location it hatched.
Breeding	Returning to the same breeding location after the first successful breed.
Wintering	Returning to the same migratory location during the winter period.

4.1.1.2 Dispersal within a colony is likely to be affected by environmental stability. If resources are abundant, most species tend to remain close to their natal area, whereas colonies under variable conditions on average disperse further (Steiner and Gaston, 2005). Likewise, as a population increases, competition for resources will also increase, therefore populations with high or increasing densities may be associated with high levels of dispersal (Greenwood, 1980; Matthysen, 2005). The degree of philopatry varies greatly between seabirds, with guillemot and razorbill showing high philopatry (Table 3).

Table 3: Degree of philopatry in guillemot and razorbill.

Species	Degree of colony philopatry	Degree of breeding philopatry	References
Guillemot	42-58%	>99%	Swann and Ramsay, 1983; Lyngs, 1993; Harris *et al.*, 1996
Razorbill	83%	>97%	Lavers *et al.*, 2007; Coulson, 2016

4.1.1.3 However, Coulson (2016) has suggested that these studies may have overestimated the degree of philopatry due to a detection bias; individuals returning to the natal site are more likely to be resighted, leading to an overestimate of the degree of philopatry. This has been

supported by Harris *et al.* (1996) who stated a bias in their results due to the inability to recover individuals that moved to other colonies.

4.1.1.4 Moreover, Coulson (2016) also stated: "The expression of philopatry is probably variable within a species and is influenced by environmental conditions and population pressures and so should not be considered a constant for individual species." Therefore, colonies of the same species will have varying degrees of philopatry and should be expressed individually, taking into account environmental stability and competition within a population.

4.1.2 Guillemot

4.1.2.1 As shown in **Table 3**, adult guillemots display a high degree of breeding philopatry; once they first start to breed, they repeatedly return to the same nesting site each year (Lyngs, 1993; Harris *et al.*, 1996; Halley *et al.*, 1995). Guillemots also display a relatively high degree of colony philopatry, with a significant percentage of birds returning to the colony in which they were born for the breeding season (42% Harris *et al.*, 1996; 57% Halley *et al.*, 1995). However, Harris *et al.* (1996) stated that the recorded percentage philopatry was most likely an overestimation due to dispersed individuals being less likely to be resighted (see also **Section 4.1.1**).

4.1.2.2 Migration and immigration of juveniles occurs between colonies, with ~50% of guillemots recruiting at non-natal colonies (Harris *et al.*, 1996; Knox, 2012). Findings from Lyngs, (1993) and Olsson *et al.*, (2000) both suggest that Baltic guillemots breed away from the natal colony fairly regularly, with individuals breeding at colonies up to 780km away from their natal site. In addition to this, certain colonies have increased at a faster rate than would be expected from reproductive growth alone, indicating that net immigration is occurring (Hudson, 1985).

4.1.2.3 A high degree of philopatry inhibits gene flow between colonies, causing genetic differences between the populations. Therefore, genetic differentiation can be studied to understand the degree of philopatry between populations. Past studies on Atlantic guillemot demonstrated low levels of genetic differentiation between colonies (Moum and Árnason, 2001; Cadiou *et al.*, 2004; Riffaut *et al.*, 2005), or suggested differences with latitude (Friesen *et al.*, 1996) or across the Atlantic basin (Morris-Pocock *et al.*, 2008). This indicates that there is likely a high degree of interbreeding between surrounding colonies as there is no abrupt genetic change between colonies, but rather changes are occurring over a large spatial cline.

4.1.2.4 This genetic exchange is also supported by the distribution of the bridled morph (this morph is distinguished by a white eye-ring with a white stripe behind the eye) as the bridling is genetically determined (Harris *et al.*, 1996). Although there is some clumping of individuals with the bridled morph, there is a gradual increase of the morph found with latitude (JNCC, 2020a). This evidence emphasises that there is some philopatry observed in guillemots, however, it is not high enough to inhibit inter-colony movement of juveniles.

4.1.3 Razorbill

4.1.3.1 Razorbills are very similar to guillemots in terms of breeding site fidelity; once a bird has reared a successful chick, it will continue returning to the same breeding location (>97% of adults - Lavers *et al.*, 2007). However, razorbill have a substantially higher recorded colony philopatry than guillemot (**Table 3**; Lavers *et al.*, 2007). Despite this, there are records of

long-distance razorbill dispersal. For example, Lavers *et al.* (2007) showed that birds natal dispersal distances as far as 1,737km.

4.1.3.2 The high degree of philopatry may be an overestimate due to observation bias (see Section 4.1.1; Coulson, 2016). Moreover, as stated in Section 4.1.1, different colonies exhibit different degrees of philopatry (Coulson, 2016). Therefore, the lack of research on razorbill may lead to a biased philopatry estimate due to only a limited number of geographical locations being investigated.

4.1.3.3 . A study by Barrett *et al.* (1997) investigated the morphological differences between different colonies of razorbill. They found that razorbill size increased with latitude from the south-west to north-east of the species range (with the exception of Iceland and Britain, which are not significantly different in size). Therefore, the findings of Barrett *et al.*, (1997) could potentially imply high philopatry and limited gene flow, however, there is overlap of razorbill size across the cline, supporting the idea that there isgene flow, and therefore connectivity, between colonies, despite the high philopatry (Barrett *et al.*, 1997). In addition, a study on razorbill genetic diversity of by Moum and Árnason (2001) concluded that there is relatively high gene flow among colonies.

4.1.4 Breeding Season Connectivity Conclusions

4.1.4.1 Evidence of connectivity between colonies was found for both guillemot and razorbill. Research has shown that whilst philopatric, a large proportion of guillemot breed away from their natal colonies, and individuals have been found breeding as far as 780km from their natal site (Lyngs, 1993). The presence of low levels of genetic differentiation also indicates that there is a high degree of exchange between colonies. Research on razorbill indicates stronger philopatry than in guillemot, but nonetheless, evidence of breeding dispersal, recruitment to new breeding sites and some gene flow between colonies was found.

4.1.4.2 From past research it can be concluded that guillemot and razorbill can breed away from their natal sites, as well as moving breeding locations as adults. Therefore, birds born or breeding on the Channel Islands can feasibly move to breed within the UK National Site Network, and vice versa, in particular given that dispersal distances as far as 780km and 1,737km were recorded for guillemot and razorbill respectively (Lyngs, 1993; Lavers *et al.*, 2007).

4.2 Wintering connectivity

4.2.1 Guillemot

4.2.1.1 As discussed in Section 3, during the breeding season guillemot breed in colonies most notably located in Scotland, but also at other sites across the UK and Ireland, with the exception of south-east England from Flamborough to the Isle of Wight (Sweet, 2008; Natural England, 2020). Figure 3 shows the distribution of guillemot in the UK, including the presence of wintering guillemot along the English Channel coastline.

4.2.1.2 Outside of the breeding season guillemots disperse from their breeding grounds and can be seen all around the UK (see panel B in Figure 3). Figure 4 shows the direction of winter dispersal; most individuals travel in a southerly direction, but some have been recorded moving further north than their breeding colony. Juvenile birds travel larger distances than adults, and juvenile birds from the UK have been recorded as far as Portugal and north

Norway, whereas adults mostly stay within UK waters (Swann and Ramsay, 1983; Furness, 2015).

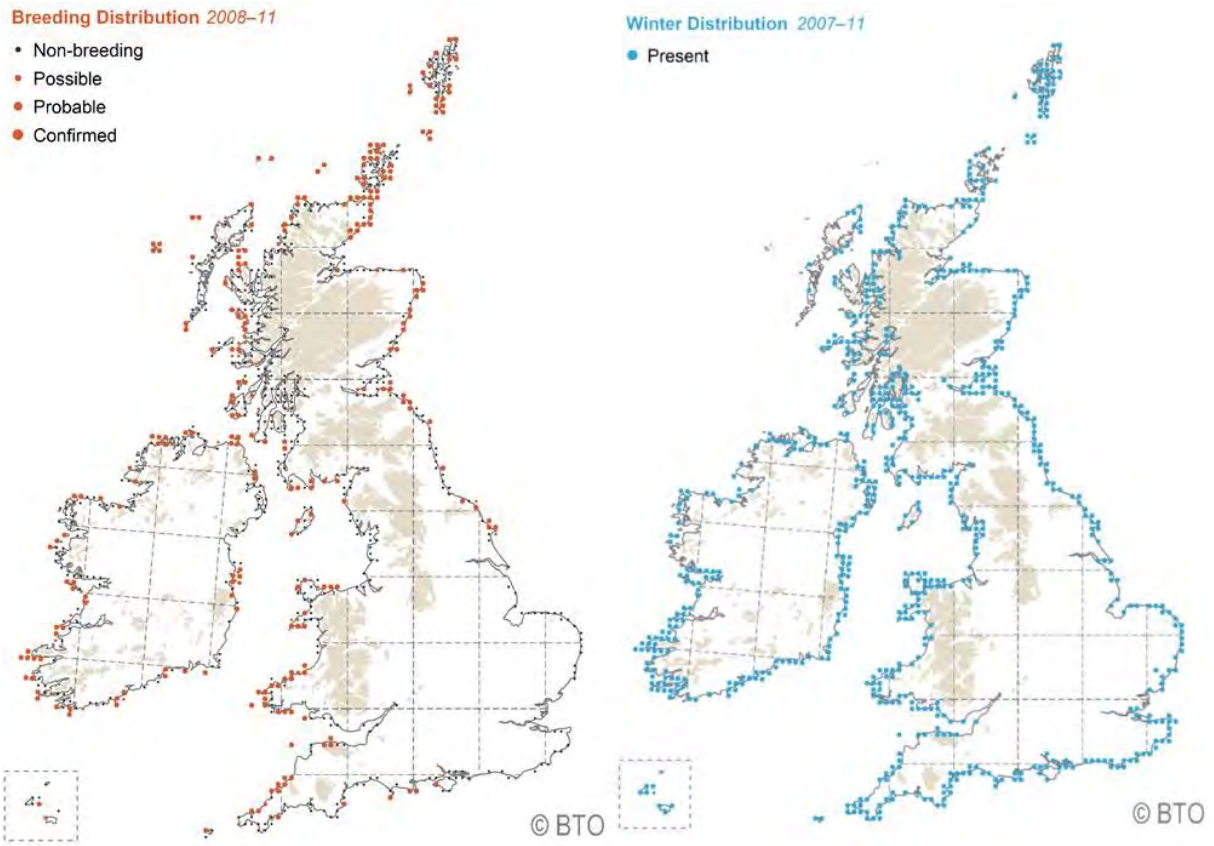


Figure 3: Map of guillemot, *Uria aalge*, distribution in the UK and Ireland during the breeding season (A - left) and winter (B - right) (Bird Atlas, 2021a).

4.2.1.3 Monthly densities of guillemot and razorbill were modelled at a 10km resolution by Waggitt *et al.*, (2019). Sightings from aerial and vessel survey data, collected between 1980 and 2018, were modelled against a wide range of environmental characteristics and used to estimate seabird densities around the UK. The results (see **Appendix A**) show that from April to July, guillemot are located tightly around their colonies, aligned with the known breeding season when adults are nesting onshore. In August birds move further offshore, then start moving south from September onwards. From December to March guillemot are found around the entire UK coastline.

4.2.1.4 There have also been a number of studies on guillemot and razorbill dispersal conducted specifically within the North-East of England and Scotland. As that geographic extent includes FFC SPA, we discuss those findings here in more detail to show connectivity between birds breeding within North-East of England and Scotland, and the proposed site of bycatch reduction delivery in the English Channel. Through analysing bird ringing data, Mead (1974) found that guillemot from colonies in the Irish Sea were recovered in the English Channel in winter, as well as in the Southern North Sea and further South along the French

coast. Whereas, guillemot from the North and East of the UK disperse across the North Sea to Norway, as well as dispersing south through the English Channel (Figure 5). Distance travelled generally decreased with increasing age (Mead, 1974). Further studies have confirmed this analysis (Birkhead, 1974; Lloyd, 1974; Swann and Ramsay, 1983; Lyngs, 1993; Wright *et al.*, 2012). Furthermore, Harris *et al.*, (2015) used kernel densities to identify winter distribution hotspots of guillemots from colonies on the Isle of May, Scotland (north of the FFC SPA). The majority of individuals stayed within the North Sea. These are most likely adult birds, given that as they are more inclined to stay closer to the breeding colony during the winter dispersal. A 75% kernel density identified birds moving into the English Channel and a 50% density identified individuals moving fully through the channel as well as individuals off the coast of Norway.

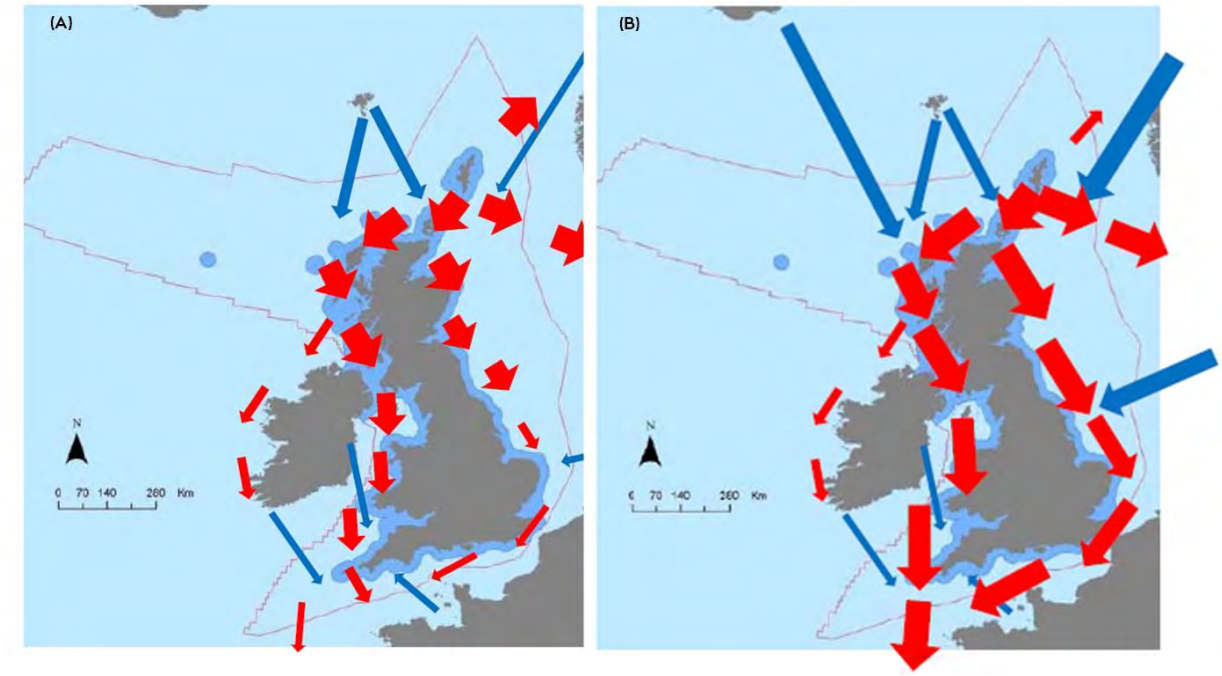


Figure 4: Estimated winter dispersal of (A) guillemots, *Uria aalge*, and (B) razorbill, *Alca torda*. Red arrows represent UK colonies, blue arrows represent colonies from other countries (Furness, 2015).

4.2.1.5 Recent geolocator tagging provides further evidence of guillemot from the North of the UK spending time in the English Channel during winter. MacArthur Green (2019) and Buckingham (2022) both tagged guillemot at a range of breeding sites in the north of the UK. Both studies recorded individuals using the English Channel in winter for multiple colonies, with one of the colonies (Treshnish) using the English Channel and French Coast as a core area in winter (50% kernel density). It is worth noting that Buckingham (2022) tagged birds on the Farne Islands; an English site and an SPA for which guillemot is a qualifying ornithological feature. Whilst the core winter area was determined to be in the North Sea, tracking data showed birds from the Farne Islands in the English Channel in winter, thus providing definite evidence of connectivity between the English Channel and the North of England and the UK National Site Network.

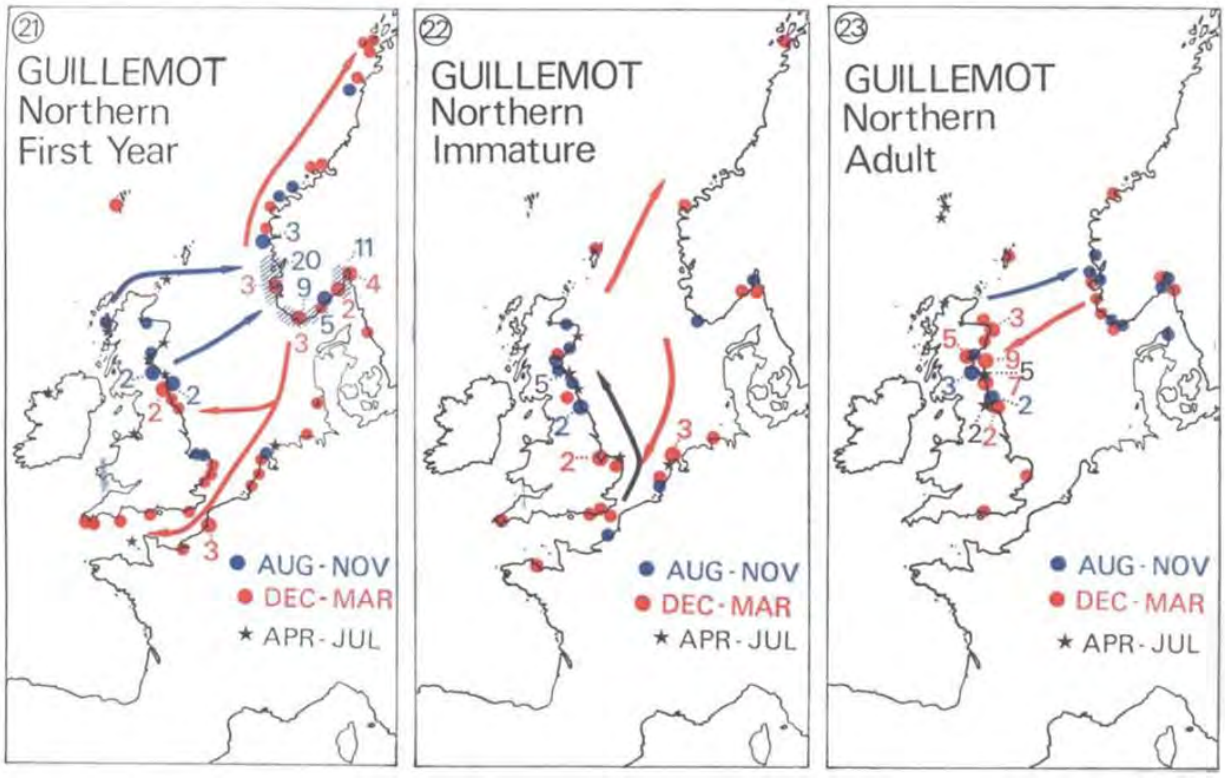


Figure 5: Locations of guillemot from northern Britain (Scotland and North-East England) colonies outside of the breeding season. Colours show the season in which the ring was recovered, arrows show the direction of dispersal. Each panel represents a different age class: (A) first year chicks, (B) two-to-four-year immatures, and (C) adults (5+ years). Figure derived from Mead (1974).

4.2.2 Razorbill

4.2.2.1 As discussed in Section 3.1.1.4, Razorbill breed around most of the coast of the UK, with particularly large numbers in Scotland, and a lack of breeding colonies between the Humber and the Isle of Wight (RSPB, 2021b). Figure 6 shows the distribution of razorbill in the UK and Ireland, including the presence of wintering razorbill along the English Channel coastline.

4.2.2.2 Winter dispersal of razorbill is very similar to guillemot. Figure 4 represents the estimated winter dispersal for UK razorbill (Furness, 2015). Lloyd (1974) found dispersive movements differed between geographical locations. Colonies from the Irish Sea most frequently winter in the Irish Sea, the English Channel and the north of Bay of Biscay. Juveniles disperse further and there have been recoveries from the west coast of Spain and Portugal from October onwards (Lloyd, 1974; Wright *et al.*, 2012). Juveniles from northern UK colonies mostly move south to winter with the birds from the Irish Sea colonies off Bay of Biscay, Iberia and North Africa (Lloyd, 1974). Adults were mostly found within the North Sea, but with some recoveries in the Bay of Biscay, thus showing adult Razorbill movement through the English Channel.

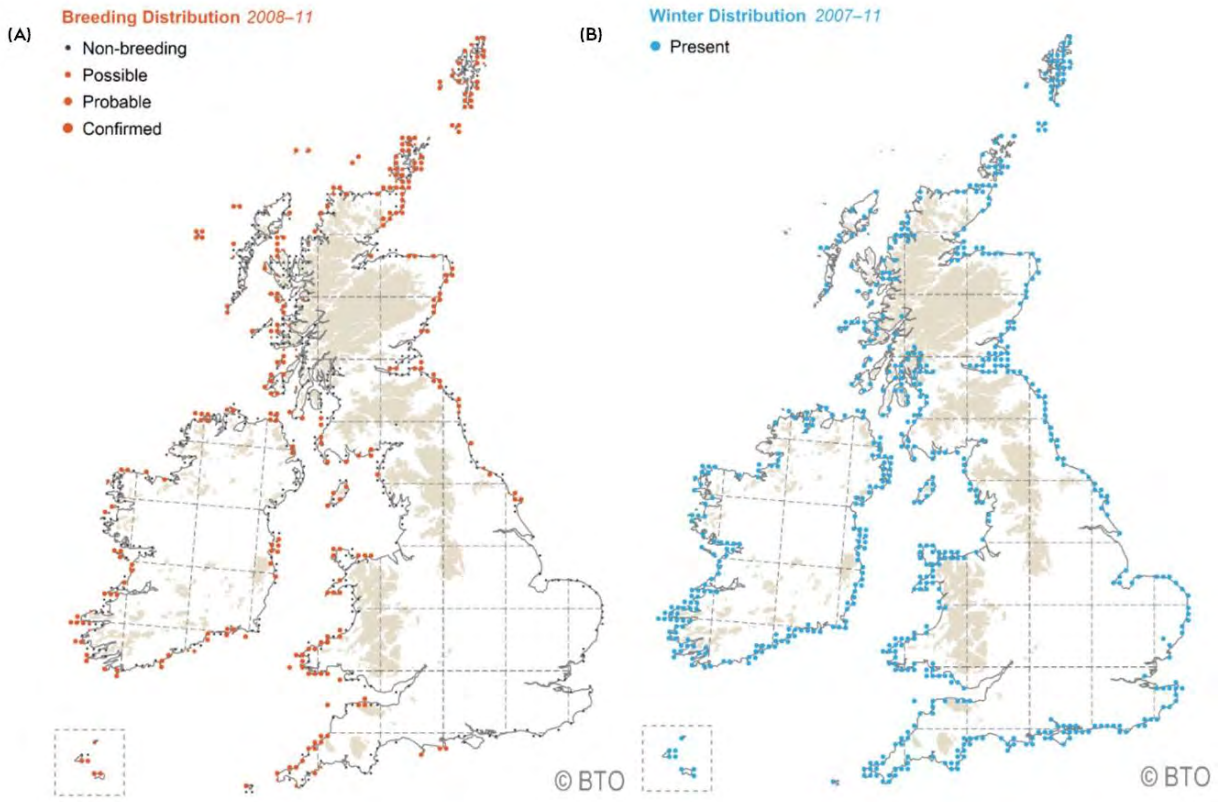


Figure 6: Map of razorbill, *Alca torda*, distribution in the UK and Ireland during the breeding season (A - left) and winter (B - right) (Bird Atlas, 2021b).

4.2.2.3 As discussed in **paragraph 4.2.1.3**, monthly densities of guillemot and razorbill were modelled at a 10km resolution by Waggitt *et al.*, (2019). The results for razorbill (see **Appendix A**) show that from April to July, birds are located tightly around their colonies, aligned with the known breeding season when adults are nesting onshore. As in guillemots, razorbill move further offshore from August and from December to March are found around the entire UK coastline.

4.2.2.4 As noted in paragraph 4.2.1.4**,** there have been a number of studies on guillemot and razorbill dispersal conducted specifically within North-east of England and Scotland, i.e. the region within which FFC SPA lies. Mead (1974) studied winter dispersal for guillemot and razorbill from colonies in the North and East of the UK. It was found that razorbill from Irish Sea colonies moved East and South into the English Channel and along the French coast. Razorbill from the colonies in the North and East of the UK were recovered in winter in the Southern North Sea and English Channel, with first-year birds recovered as far south as Morocco. Razorbill, like guillemot, showed a decrease in distance travelled with increasing age (**Figure 7**).

4.2.2.5 Recent geolocator tagging studies by MacArthur Green (2019) and Buckingham (2022) provide further evidence that razorbill from the North of the UK are present in the English Channel during winter. Both studies tagged razorbill at various colonies in the north of the UK, and both studies recorded individuals using the English Channel in winter. Whilst

Buckingham (2022) found that core wintering areas were generally located in the North Sea and Atlantic, birds from several colonies were recorded in the English Channel, and the English Channel was identified as a core area (50% kernel density) for one of the sites (Canna).

4.2.2.6 It is worth noting that Buckingham (2022) tagged birds on the Farne Islands; an English site and an SPA. Whilst the core razorbill winter area was determined to be in the North Sea, tracking data showed birds from the Farne Islands in the English Channel in winter, thus providing definite evidence of connectivity between the English Channel and the North of England and the UK National Site Network.

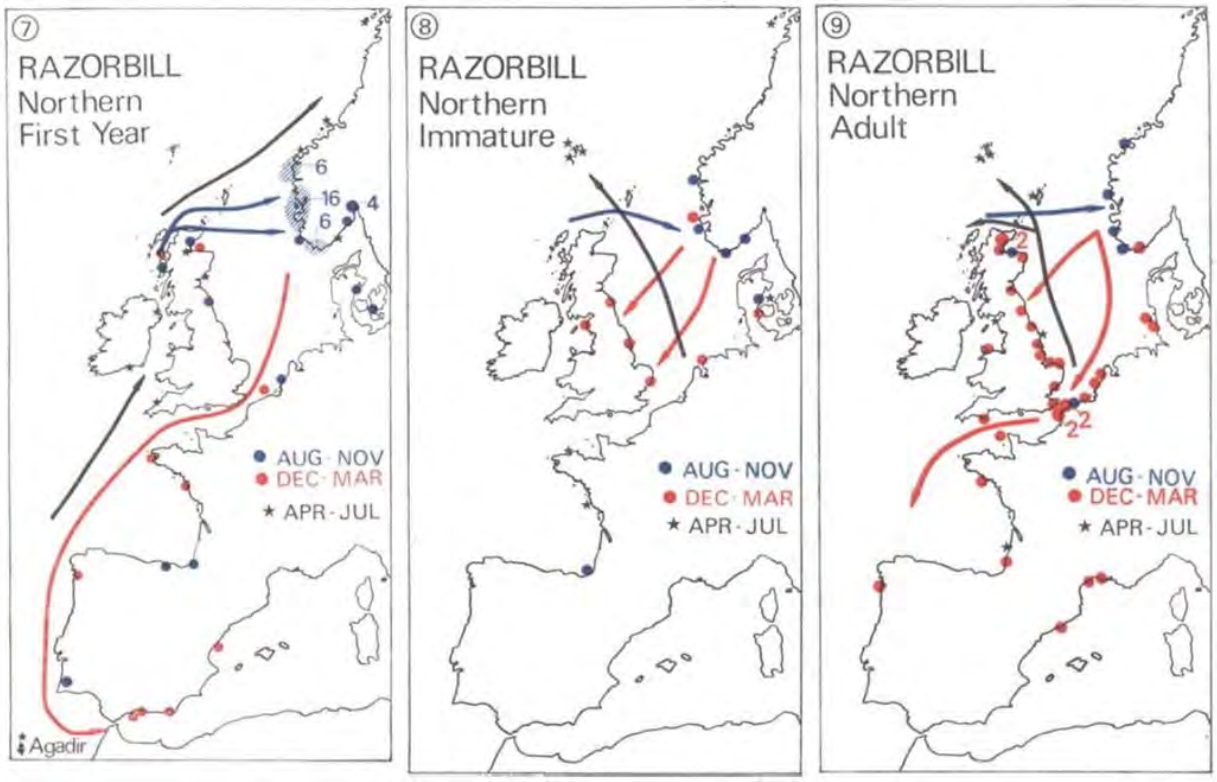


Figure 7: Locations of razorbill from northern Britain (Scotland and North-East England) colonies outside of the breeding season. Colours show the season in which the ring was recovered, arrows show the direction of dispersal. Each panel represents a different age class: (A) first year chicks, (B) two-to-four-year immatures, and (C) adults (5+ years). Figure derived from Mead (1974).

4.2.3 Wintering Connectivity Conclusions

4.2.3.1 The ringing, tagging and modelling studies discussed all provide strong evidence of connectivity between the North of the UK and the English Channel (the proposed site for bycatch reduction). Based on the evidence presented, it can be concluded that guillemot and razorbill from FFC SPA are likely to use the English Channel during winter. It was established with certainty that birds from SPAs use the English Channel, with tagging research showing birds from the Farne Islands in the English Channel in winter. More broadly,

the ringing data, such as those provided by Mead (1974) for the Irish Sea colonies, show connectivity between the English Channel and the wider National Site Network.

4.2.3.2 Given that guillemot from both the North and South of the UK are found to winter in the English Channel means that bycatch reduction in the English Channel will benefit both the *aalge* and *albionis* subspecies.

4.3 Ringing Recoveries

4.3.1.1 As part of the British bird ringing scheme, which began in 1909, birds are tagged with metal rings with a unique number. Data on the locations where ringed birds are recovered can thus be used to understand movements of birds. An analysis undertaken by Mead (1974) on ringing of auks in Britain and Ireland found that although relatively large numbers of auks had been ringed, very few rings had been recovered. This is due to the fact that ring recoveries for this study only covered birds that were found deceased, as ringers were unable to trap and handle auks (Mead, 1974). Although there is limited ringing recovery data for guillemot and razorbill, an analysis of the available data can provide some insight into the dispersal of the two species, and help establish connectivity between the FFC area and English Channel and Channel Islands.

4.3.1.2 There is no ringing or ringing recovery for guillemot and razorbill within FFC SPA itself. As such, the wider east coast area (Farne Islands to Norfolk) was selected to represent the part of the biogeographic population within which FFC sits. Ringing recovery data for guillemot and razorbill ringed on this part of the east coast, and recovered elsewhere in the UK and Europe, was obtained from the British Trust for Ornithology[2] in order to investigate connectivity between the area around FFC and the area in and around the Channel Islands and English Channel. In addition, ringing recovery data from the east coast of England was obtained to establish connectivity in the opposite direction.

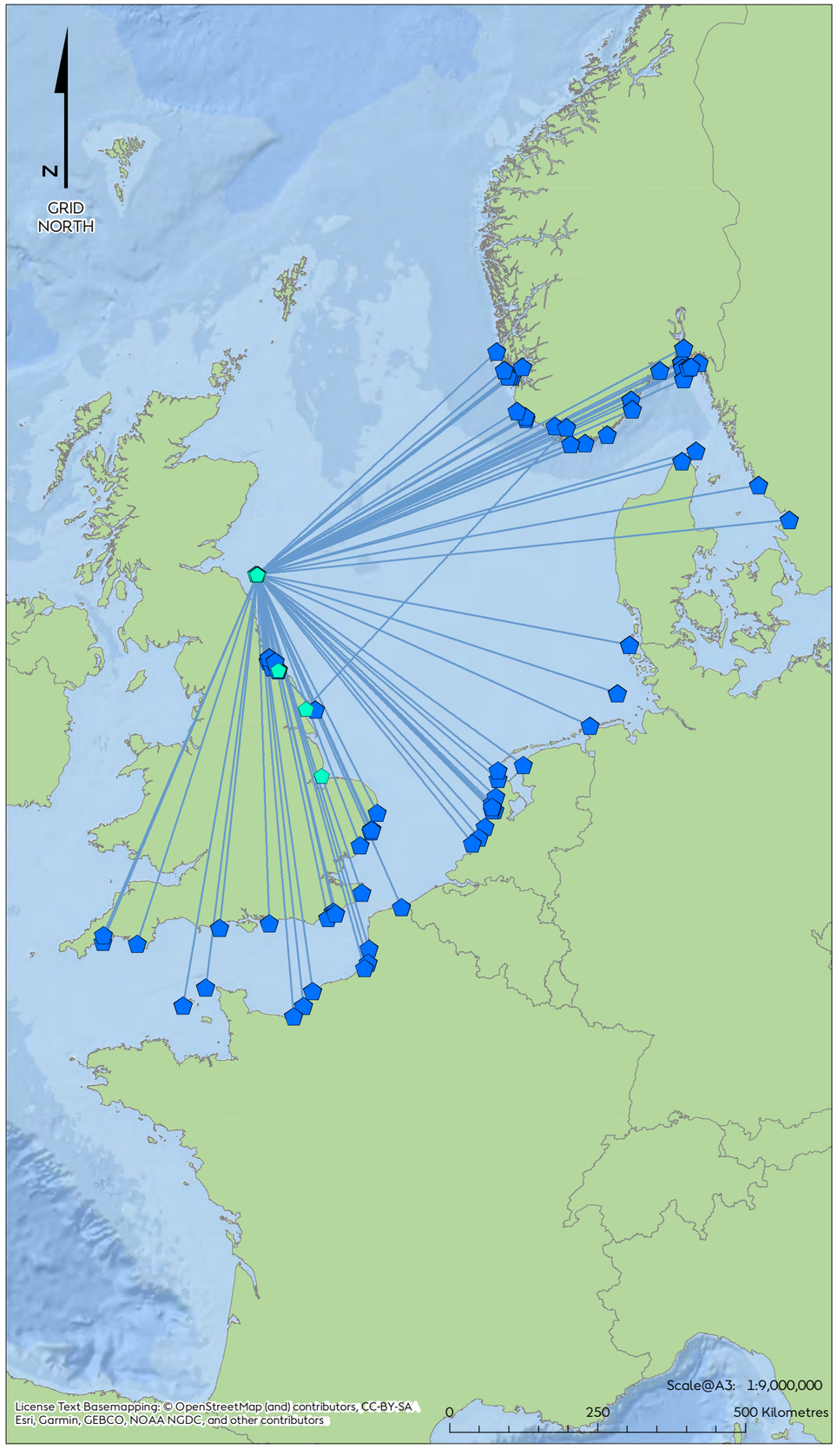
4.3.1.3 There was a total of 82 ringing recoveries of guillemot in Europe from individuals that were ringed between the Farne Islands and Norfolk, dating back as early as 1918. For birds ringed elsewhere in the UK and Europe, a total of 46 rings were recovered in the area from the Farne Islands to Norfolk (36 guillemot and 10 razorbill).

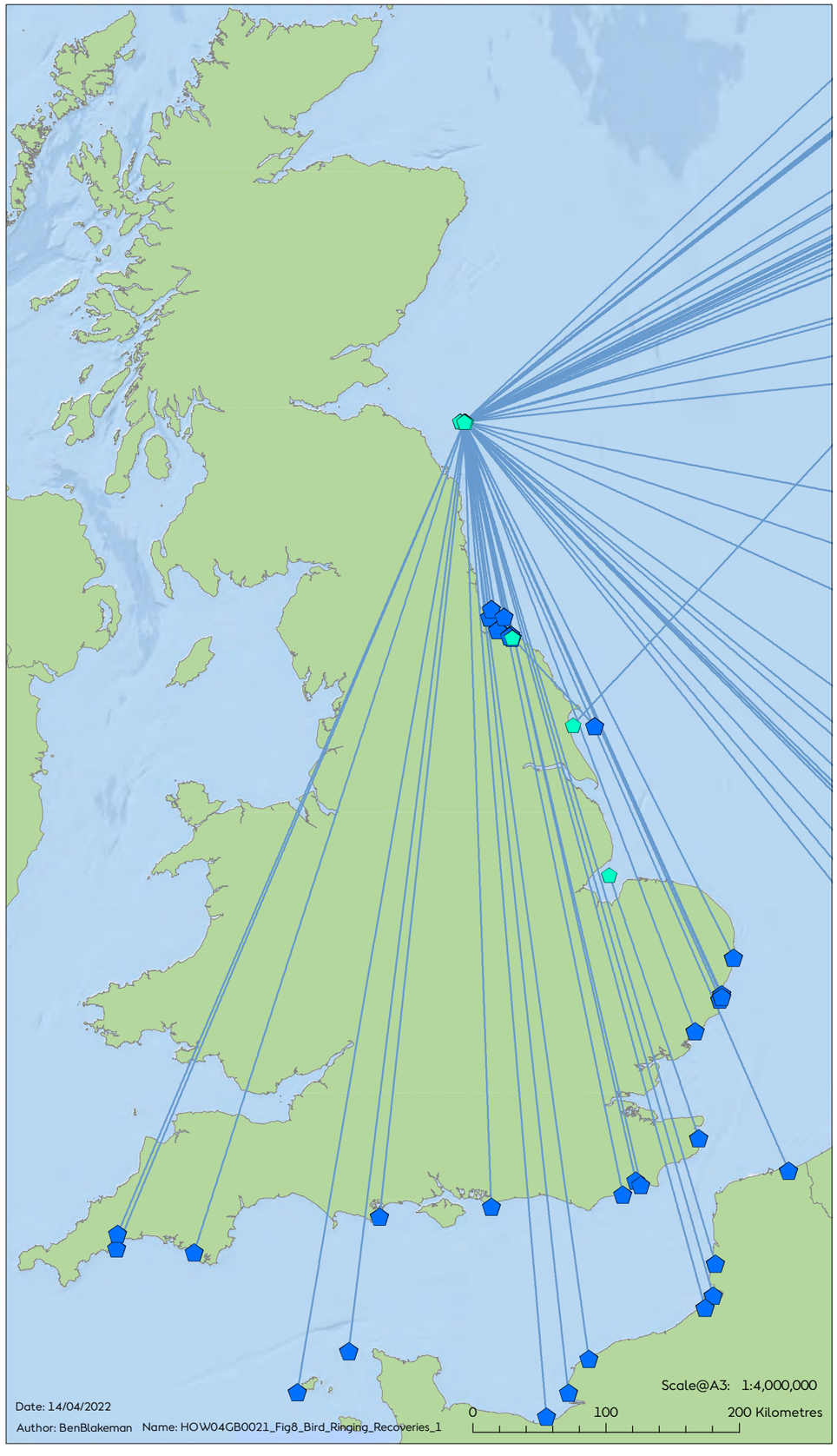
[2] The BTO Ringing Scheme is funded by a partnership of the British Trust for Ornithology, the Joint Nature Conservation Committee (on behalf of: Natural England, Natural Resources Wales and Scottish Natural Heritage and the Department of the Environment Northern Ireland), The National Parks and Wildlife Service (Ireland) and the ringers themselves.

Hornsea Four

Figure 8

Bird Ringing Recoveries





Guillemot Ringing Locations

Guillemot Ringing Recoveries

Guillemot Ringing

Coordinate system: ETRS 1989 UTM Zone 31N

REV	REMARK	DATE
1	First Issue	14/04/2022

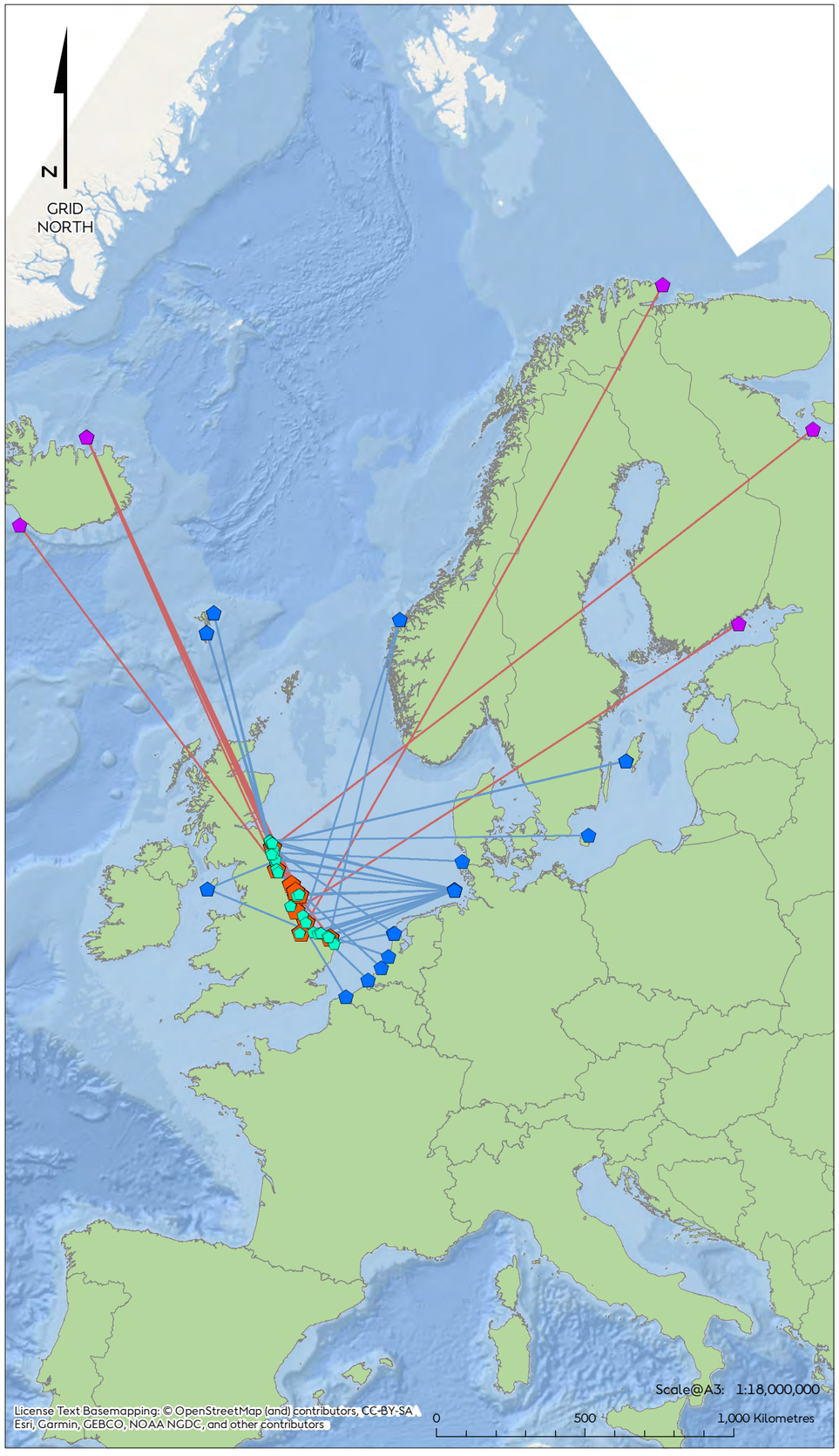
Bird Ringing
Recoveries
Document no: HOW04GB0021
Created by: SWM
Checked by: BPHB
Approved by: NS

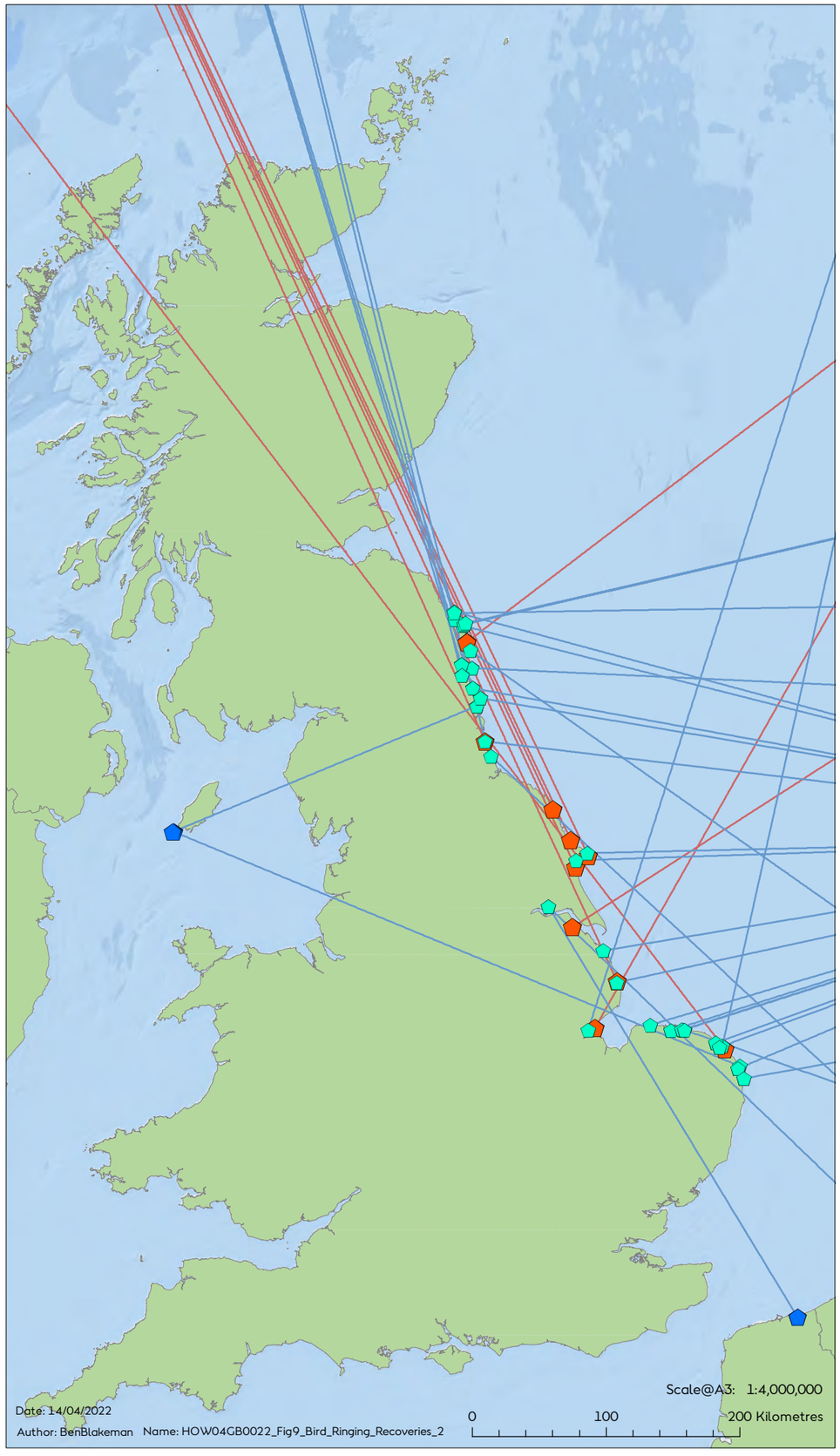
GoBe
Ørsted

Hornsea Four

Figure 9

Bird Ringing Recoveries





- Guillemot Ringing Locations
- Guillemot Ringing Recoveries
- Guillemot Ringing
- Razorbill Ringing Locations
- Razorbill Ringing Recoveries
- Razorbill Ringing

Coordinate system: ETRS 1989 UTM Zone 31N

Date: 14/04/2022

Author: BenBlakeman Name: HOW04GB0022_Fig9_Bird_Ringing_Recoveries_2

REV	REMARK	DATE
1	First Issue	14/04/2022

Bird Ringing Recoveries
Document no: HOW04GB0022
Created by: SWM
Checked by: BPHB
Approved by: NS

GoBe Ørsted

4.3.1.4 The ringing recovery data from the BTO shows that there is auk connectivity between the east coast of England and the wider east Atlantic populations, including the English Channel and Channel Islands area. Rings from the east of England have been recaptured in various sites across the UK and NE Europe (Figure 8), and vice versa (Figure 9). Guillemot ringed in the northeast of the UK were recaptured in the English Channel and on the Channel Islands. There is connectivity from east coast guillemot with sites across the North Sea, along both sides of the English Channel, and as far as Iceland, Norway, and Finland into the North Sea. Whilst there was limited ringing data for razorbill (10 individuals only), the data show substantial connectivity distances, with razorbill ringed in Scandinavia, Iceland and Russia being recovered in the northeast of the UK. No razorbill data on birds ringed in the northeast of the UK was available, and thus no recoveries of birds ringed there and recaptured in the Channel Islands and English Channel could be reported. However, as the ringing recovery data showed that razorbill recovered in the UK came from sites further away than guillemot, it is clear that razorbill are capable of reaching the Channel Islands and English Channel, and the absence of recoveries within the Channel Islands and English Channel is likely driven by a lack of data, rather than a lack of connectivity.

4.3.2 Ringing Recoveries Conclusions

4.3.2.1 Ringing recovery data for guillemot and razorbill from populations on the east coast (i.e. the area around FFC SPA) shows significant dispersal distances recorded for both species, and highlights the connectivity of the populations both within and outside of the UK.

4.3.2.2 The data show connectivity between east coast birds and the English Channel and Channel Islands area, thus establishing connectivity between those sites where compensation is due to be delivered, and the area within which FFC SPA is located.

4.4 Connectivity Summary

4.4.1.1 From the evidence presented here, it can be concluded that guillemot and razorbill are capable of dispersing the distances between the proposed sites of compensation and National Site Network sites. There is connectivity between the UK breeding populations and the English Channel and Channel Islands, and tagging research shows with certainty that birds from at least one SPA site (Farne Islands) winter in the English Channel. In relation to FFC SPA specifically, ringing data shows that birds from the northeast have been recaptured in both the English Channel and on the Channel Islands.

4.4.1.2 In summary, there is connectivity of birds from the Channel Islands/English Channel with populations across England both during winter and the breeding season. It can thus be concluded that the proposed compensation measures of predator eradication (targeting breeding birds in the Bailiwick of Guernsey in the Channel Islands) and bycatch reduction (targeting wintering birds in the English Channel) will benefit the UK National Site Network populations.

5 Additional Benefits from Compensation Measures

5.1 Background

5.1.1.1 In its draft guidance for developing compensation measures, Defra (2021) outlines a hierarchy of compensation measures covering the use of non-like for like options, i.e.

compensation measures that benefit a different feature than the one impacted. The hierarchy is as follows:

1. "***Address same impact at same location**: Address the specific impact caused by the permitted activity in the same location (within the site* [SPA] *boundary);*
2. ***Same ecological function, different location**: Provide the same ecological function as the impacted feature; if necessary, in a different location (outside of the site* [SPA] *boundary;*
3. ***Comparable ecological function, same location**: Provide ecological functions and properties that are comparable to those that originally justified the designation in the same location as the impact;*
4. ***Comparable ecological function, different location**: Provide ecological functions and properties that are comparable to those that originally justified designation; if necessary, in a different location (outside of the site boundary);"*

5.1.1.2 Both predator eradication and bycatch reduction measures fall under level 2 of the hierarchy; the measures target the species impacted (guillemot and razorbill) and will be delivered off-site (i.e. outside the location where the potential impacts are predicted, FFC SPA). As agreed with SNCBs no feasible compensation options were identified for guillemot and/ or razorbill at FFC SPA (please see responses RR-029-APDX:C-4 and RR-029- APDX:C-71 in **G1.9 Applicant's comments on Relevant Representations Revision: 01 (REP1-038)**). The options presented here thus represent the best available compensation options as identified for this species and SPA.

5.1.1.3 In its compensation hierarchy, Defra (2021) uses the delivery of "*measures to enhance population of a different protected seabird species*" (i.e. as per level 3 and 4) as an example of how compensation can be delivered for a comparable ecological function when a seabird species is lost to 'birdstrike'. Predator eradication and bycatch reduction will benefit not only guillemot and razorbill, the delivery of these two measures will also benefit other seabird species. Therefore, as well as delivering compensation at level 2 of the hierarchy, the proposed compensation measures as proposed by the Applicant, also provide benefits corresponding to level 4 of the hierarchy, i.e. benefits to other non-target seabird species at the sites where the measures are delivered (English Channel for bycatch reduction, Bailiwick of Guernsey (Channel Islands) for predator eradication).

5.1.1.4 In this section, we provide examples of the species which are likely to benefit from the proposed predator eradication and bycatch reduction, and establish connectivity between the sites of compensation delivery and National Site Network for a selection of key species.

5.1.2 Predator Eradication Benefits to non-target species

5.1.2.1 The proposed compensation measures targeting guillemot and razorbill will also benefit other seabird species and therefore deliver benefits corresponding to level 4 of the draft Defra hierarchy (Defra, 2021). Predator eradication work in the Bailiwick of Guernsey in the Channel Islands will benefit species that are susceptible to ground predation, such as seabirds that nest in burrows. Examples of key burrow-nesting bird species which may benefit in the Channel Islands are Manx shearwater (*Puffinus puffinus*), Atlantic puffin (*Fratercula arctica*) and European storm petrel (*Hydrobates pelagicus*). Manx shearwater, Atlantic puffin and storm petrel are all species of significant conservation concern; Puffin are

red-listed in the UK, and Manx shearwater and storm petrel are both amber-listed (Stanbury *et al.*, 2021). All three species have been shown to benefit significantly from rat eradication projects, with strong increases in breeding numbers reported (see **B2.8.3: Compensation measures for FFC SPA: Predator Eradication: Ecological Evidence (APP-196)**).

5.1.3 Bycatch Reduction Benefits on Non-target Species

5.1.3.1 A wide range of seabird and sea-duck species are bycaught in set gillnet (static net) fisheries. For example, it is estimated that at least 265 great cormorant (*Phalacrocorax carbo*) are bycaught in static nets per annum (Miles *et al.*, 2020, Northridge *et al.*, 2020). Other species caught in static nets include the amber-listed great Northern diver (*Gavia immer*) and red-listed shag (*Phalacrocorax aristotelis)* (Miles *et al.*, 2020, Stanbury *et al.*, 2021). Bycatch rate data for other species, such as sea ducks, are limited (Miles *et al.*, 2020). However, there are numerous studies showing that bycatch can be reduced by the use of the reduction technology, such as the looming eye buoy (LEB), one of the compensation measures proposed by the Applicant (see **B2.8.1: Compensation measures for FFC SPA: Bycatch Reduction: Ecological Evidence (APP-194)**). In summary, bycatch reduction measures for set gillnet fisheries, as proposed by the Applicant for Hornsea Four, will therefore benefit a variety of seabird and sea-duck species including cormorant, Northern diver, shag and long-tailed duck.

5.1.4 Non-target Species Connectivity

5.1.4.1 This section briefly outlines evidence for connectivity between the proposed compensation sites and the National Site Network for those species for which strong evidence of potential benefits from compensation measures was found (see **Section 5.1.2** and **Section 5.1.3**). It outlines breeding movements of Manx shearwater, puffin and storm petrel in the context of predator eradication on the Channel Islands, and winter movements of cormorant and great Northern diver in the context of bycatch reduction in the English Channel. Shag and long-tailed duck were not included further, as data on bycatch issues were more limited for those species.

Manx Shearwater Breeding Season Connectivity

5.1.4.2 Manx shearwater are a burrow-nesting species. They are highly mobile; shearwaters travel huge distances migrating to the coast of South America for the winter and breeding in the UK between March and July. During breeding season, they also have a very large foraging range of 1346.8km (mean-maximum plus one standard deviation [SD]; Woodward et al., 2019), because their breeding grounds are disconnected from their offshore foraging areas. Whilst Manx Shearwater are philopatric and have an incredible navigational ability to return to the same burrows from hundreds of kilometers away, Brooke (1978) estimated 50% of females breed away from their natal colony.

5.1.4.3 The large majority of all British and Irish Manx shearwaters breed within the UK National Site Network on just three islands; Skomer and Skokholm (off the coast of Pembrokeshire, part of the Skomer, Skokholm and the seas off Pembrokeshire SPA), and Rùm SPA in Northwest Scotland, with small numbers recorded to breed on the Channel Islands (JNCC, 2020b). There is a lack of ringing data for Manx shearwater on the Channel Islands, which is likely to explain why no records were found in the published literature of birds ringed in the Channel Islands and recaptured breeding elsewhere in the UK, or vice versa. However, given the fact

that Manx shearwater travel very large distances, with the known breeding sites in the UK National Site Network lying within the mean-max foraging range from the Channel Islands, and the fact that females have a relatively high likelihood of breeding in non-natal colonies, it can be deemed plausible that birds hatched on the Channel Islands could disperse to breed within the UK National Site Network. This is further illustrated by recapture data from elsewhere; for example, Fraser *et al.* (2013) reports the recapture of a bird in Newfoundland (Canada) which was ringed in Scotland as a chick. Thus, breeding connectivity between the UK National Site Network and the Bailiwick of Guernsey (Channel Islands), where compensation will be delivered is likely.

Puffin Breeding Season Connectivity

5.1.4.4 Atlantic puffin is a member of the Auk family. They nest in burrows on islands and are often found alongside Manx shearwaters. The philopatry of Atlantic puffin has been estimated at around 50% (Harris, 1984; Harris and Wanless, 1991), thus showing the potential for this species to breed away from their natal colonies. Puffin breed on the Eastern and Northwestern coasts of Britain, with notable SPA colonies in England including Bempton Cliffs and the Farne Islands (Bird Atlas, 2022). In the latest Channel Islands seabird census in 2016, 210 Apparently Occupied Burrows were recorded (JNCC, 2020b). There is likely connectivity between birds breeding on the Channel Islands and the National Site Network. For example, Harris (1984b) reports recoveries in the southern English coast and northern Irish sea of chicks fledged on the Channel Islands.

Storm petrel Breeding Season Connectivity

5.1.4.5 Storm petrels are the United Kingdom's smallest seabird. Similarly, to both shearwater and puffin, they are colonial nesters favouring small islands. Whilst storm petrel are known to be philopatric, little is known about their natal dispersal (Cadiou, 2010). A ringing study in Italy shows storm petrel can disperse substantial distances; a bird ringed at Filfla (Malta) as an adult in June, was found 5 years later breeding on the Italian island of Marettimo, over 300km away (Lo Valvo & Massa, 2000). Furthermore, one bird ringed as a chick on Marettimo was recovered two years later in July, i.e. the breeding season, on Filfla. Another was recovered 5 years later, also during July, 800km away on the Balearic Island of Cabrera (Lo Valvo & Massa, 2000). In addition, we know that the mean foraging range of storm petrel is 336km (Woodward et al., 2019). Based on these dispersal and foraging distances, most of the UK is within reach of storm petrels breeding in the Channel Islands, making connectivity with the UK National Site Network highly plausible.

Cormorant Wintering Connectivity

5.1.4.6 Cormorants from the UK are known to winter in a wide range of countries and regions, including the English Channel. UK ringing data shows that ringed birds have been recovered in winter along the English Channel and in the Bay of Biscay (Robinson *et al.,* 2021), the latter location also indicating movements through the English Channel. The proportion of birds using the English Channel during winter may also be increasing; Marion & Bergerot (2018) showed that the proportion of birds in France which winter along the English Channel is

increasing. These birds are thought to originate from northern European countries including the UK (Marion & Bergerot, 2018).

Great Northern Diver Wintering Connectivity

5.1.4.7 Whilst only a scarce breeder in the UK, great Northern diver are a UK wintering bird of Amber conservation concern (Bird Atlas, 2022d; Robinson, 2005). Great Northern diver are found in the English Channel in winter (Bird Atlas, 2022d; Virgili *et al.,* 2017). The species is a qualifying feature for an SPA along the English Channel (Falmouth Bay to St Austell Bay SPA)[3], and bycatch reduction in the English Channel could thus benefit great Northern diver from sites within the National Site Network, as well as the wider wintering population.

5.2 Non-target Species Benefits Conclusions

5.2.1.1 Predator eradication and bycatch reduction will not only benefit guillemot and razorbill, but the measures will also provide benefits to other seabird species at the sites where compensation is delivered (i.e. corresponding to level 4 of the Defra compensation hierarchy). Species likely to benefit include a range of species of conservation concern, including Manx shearwater, puffin, storm petrel, great Northern diver and cormorant. For these species, a review of existing evidence shows that there is confirmed or plausible connectivity between the sites of compensation delivery (Channel Islands and English Channel) and National Site Network sites. We can thus conclude that predator eradication in the Bailiwick of Guernsey in the Channel Islands and bycatch reduction in the English Channel will provide benefits to non-target species, feeding into the National Site Network.

6 Summary of Key Findings

6.1.1.1 There is connectivity of guillemot and razorbill from UK National Site Network populations and the Channel Islands/English Channel. It can therefore be concluded that the proposed compensation measures of predator eradication (targeting breeding birds in the Bailiwick of Guernsey in the Channel Islands) and bycatch reduction (targeting wintering birds in the English Channel) will feed back into and benefit the UK National Site Network.

6.1.1.2 Connectivity of both guillemot and razorbill has been identified during the breeding season. Research has shown that whilst philopatric, a large proportion of guillemot breed away from their natal colonies, and individuals have been found breeding as far as 780km from their natal site. The presence of low levels of genetic differentiation also indicates that there is a high degree of exchange between colonies. Razorbill have also recruited to new breeding sites and also have some gene flow between colonies. It can therefore be concluded that guillemot and razorbill can breed away from their natal sites. Consequently, birds born or breeding on the Channel Islands (proposed location for predator eradication) can likely move to breed within the UK National Site Network.

6.1.1.3 Connectivity has also been identified during winter dispersal, with strong evidence of connectivity between the North of the UK and the English Channel (the proposed site for bycatch reduction). Based on the evidence presented, it can be concluded that guillemot and razorbill from FFC SPA are likely to use the English Channel during winter. Additionally, tagging research shows with certainty that birds from at least one English SPA site (Farne

[3] European Site Conservation Objectives for Falmouth Bay to St Austell Bay SPA (UK9020323), http://publications.naturalengland.org.uk/publication/5504097741438976 [Accessed March 2022]

Islands) winter in the English Channel, thus indicating that bycatch reduction in the English Channel will feed into the wider National Site Network.

6.1.1.4 Moreover, ringing recovery data identified significant dispersal distances for both guillemot and razorbill from Northeast England. The data highlighted connectivity between east coast birds and the English Channel/ Channel Islands, thus establishing connectivity between those sites where compensation is due to be delivered, and the area within which FFC SPA is located.

6.1.1.5 Additionally, predator eradication and bycatch reduction will not only benefit guillemot and razorbill, but also other non-target seabird species at the sites of compensation delivery, (i.e. corresponding to level 4 of the Defra compensation hierarchy). Species likely to benefit include a range of species of conservation concern, including Manx shearwater, puffin, storm petrel, great Northern diver and cormorant. For these species, a review of existing evidence shows that there is confirmed or plausible connectivity between the sites of compensation delivery (Channel Islands and English Channel) and National Site Network sites. We illustrate that predator eradication in the Bailiwick of Guernsey in the Channel Islands and bycatch reduction in the English Channel will provide benefits to non-target species, and that these benefits can also feed into the UK National Site Network.

7 References

Aitken, D., Babcock, M., Barratt, A., Clarkson, C., Prettyman, S. 2017. Flamborough and Filey Coast pSPA Seabird Monitoring Programme, 2017 Report.

Barrett, R.T., Anker-Nilssen, T. and Krasnov, Y.V. 1997. Can Norwegian and Russian Razorbills *Alca torda* be identified by their measurements? *Marine Ornithology* 25: 5–8.

Bird Atlas. 2021a. Guillemot Breeding Distribution 2008-2011. [redacted] [Accessed March 2021].

Bird Atlas. 2021b. Razorbill Breeding Distribution 2008-2011. [redacted] [Accessed March 2021].

Bird Atlas. 2022c. Puffin Breeding Distribution 2008-2011. [redacted] [Accessed March 2022].

Bird Atlas. 2022d. Great Northern Diver Breeding and Winter Distribution 2008-2011. [redacted] [Accessed March 2022].

Birkhead, T. R. 1974. Movement and Mortality Rates of British Guillemots. *Bird Study* 21/4: 241-254.

Brooke, M. de L. 1978. The dispersal of female Manx Shearwaters *Puffinus puffinus. Ibis* 120: 545–551.

Buckingham, L., Bogdanova, M.I., Green, J.A., Dunn, R.E., Wanless, S., Bennet, S., Bevan, R.M., Call, A., Canham, M., Corse, C.J., Harris, M.P., Heward, C.J., Jardine, D.C., Lennon, J., Parnaby, D., Redfern, C.P.F., Scott, L., Swann, R.L., Ward, R.M., Weston, E.W., Furness, R.W., Daunt, F. 2022. Interspecific variation in non-breeding aggregation: a multi-colony tracking study of two sympatric seabirds. *Marine Ecology Progress Series* 684: 181-197.

Cadiou, B., Riffaut, L., McCoy, K.D., Cabelguen, J., Fortin, M., Gélinaud, G., Le Roch, A., Tirard, C. and Boulinier, T. 2004. Ecological impact of the "Erika" oil spill: determination of the geographic origin of the affected common guillemots. *Aquatic Living Resources* 17: 369–377.

Cadiou, B., Bioret, F., Chenesseau, D. 2009. Response of breeding European storm petrels to habitat change. *Journal of Ornithology* 151: 317-327.

Coulson, J. 2016. A Review of Philopatry in Seabirds and Comparisons with Other Waterbird Species. *Waterbirds* 39/3: 229-240.

Defra (2021, for consultation), 'Best practice guidance for developing compensatory measures in relation to Marine Protected Areas'. Defra guidance consultation document. https://consult.defra.gov.uk/marine-planning-licensing-team/mpa-compensation-guidance-consultation/supporting_documents/mpacompensatorymeasuresbestpracticeguidance.pdf [Accessed March 2022].

Fraser, G.S., Russell, J., Robertson, G.J., Bryant, R., Fifield, D.A. 2013. Prospects for the Manx shearwater colony on Middle Lawn Island, Newfoundland, Canada. *Marine Ornithology.* 41: 137-140.

Friesen, V., Montevecchi, W., Baker, A., Barrett, R. and Davidson, W. (1996). Population differentiation and evolution in the common guillemot *Uria aalge*. *Molecular Ecology* 5/6: 793-805.

Furness, R.W. 2015. Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Reports, Number 164.

Greenwood, P. 1980. Mating systems, philopatry and dispersal in birds and mammals. *Animal Behaviour* 28/4: 1140-1162.

Halley, D., Harris, M. and Wanless, S. 1995. Colony Attendance Patterns and Recruitment in Immature Common Murres (*Uria aalge*). *The Auk* 112/4: 947-957.

Harris, M. P. 1984. The Puffin. T. & A. D. Poyser, Calton, U.K.

Harris, M.P. 1984b. Movements and mortality patterns of North Atlantic Puffins as shown by ringing. *Bird Study.* 31: 131-140.

Harris, M., Halley, D. and Wanless, S. 1996. Philopatry in the Common Guillemot *Uria aalge*. *Bird Study* 43: 134-137.

Harris, M. P. and S. Wanless. 1991. Population studies and conservation of puffins *Fratercula arctica*. Pages 230–248 in Bird Population Studies (C. M. Perrins, J.-D. Lebreton and G. J. M. Hirons, Eds.). Oxford University Press, Oxford, U.K.

Hudson, P. J. 1985. Population parameters for the Atlantic Alcidae. Pages 233-262 in The Atlantic Alcidae (D. N. Nettleship and T. R. Birkhead, Eds.). Academic Press, London, U.K.

JNCC 2020a. Guillemot (*Uria aalge*) https://jncc.gov.uk/our-work/guillemot-uria-aalge/ [Accessed March 2021].

JNCC 2020b. Seabird Monitoring Programme Report 1986–2018. https://jncc.gov.uk/our-work/smp-report-1986-2018/ [Accessed March 2021].

JNCC 2020c. Razorbill (*Alca torda*). https://jncc.gov.uk/our-work/razorbill-alca-torda/ [Accessed March 2021].

Knox, A. 2012. The subspecies of Guillemot on the British List. *Scottish Birds* 32/3: 204-210.

Lavers, L. J., Jones I. L. and Diamond A. W. (2007). Natal and breeding dispersal of Razorbills *(Alca torda*) in eastern North America. *Waterbirds* 30: 588-594.

Lloyd, C. 1974. Movement and Survival of British Razorbills. *Bird Study* 21/2: 102-116.
Lo Valvo, F. and Massa, B. 2000. Some aspects of the population structure of Storm Petrels *Hydrobates pelagicus* breeding on a Mediterranean island. *Ringing & Migration* 20: 125-128.

Lyngs, P. 1993. Colony interchange in Baltic guillemots *Uria aalge*. *Dansk Ornitologisk Forenings Tidsskrift* 87: 247-250.

MacArthur Green, 2019. Auk Tagging and Monitoring, Interim Report 2019.

Marion, L. and Bergerot, B. 2018. Northern range shift may be due to increased competition induced by protection of species rather than to climate change alone. *Ecology and Evolution*: 8: 8364-8379.

Matthysen, E. 2005. Density-dependent dispersal in birds and mammals. *Ecography* 28: 403-416.

Mead, C. 1974. The Results of Ringing Auks in Britain and Ireland. *Bird Study* 21/1: 45-86.

Miles, J., Parsons, M. and O'Brien, S. 2020. Preliminary assessment of seabird population response to potential bycatch mitigation in the UK registered fishing fleet. Report prepared for the Department for Environment Food and Rural Affairs (Project Code ME6024).

Morris-Pocock, J., Taylor, S., Birt, T., Damus, M., Piatt, J., Warheit, K. and Friessen, V. 2008. Population genetic structure in Atlantic and Pacific Ocean common murres (*Uria aalge*): natural replicate tests of post-Pleistocene evolution. *Molecular Ecology* 17/22: 4859-4873.

Moum, T. and Árnason, E. 2001. Genetic diversity and population history of two related seabird species based on mitochondrial DNA control region sequences. *Molecular Ecology* 10: 2463–2478.

Natural England, 2020. Designated Sites View: Natural England Conservation Advice for Marine Protected Areas Flamborough and Filey Coast SPA.
[redacted] [Accessed March 2021].

Northridge, S., Kingston, A., and Coram, A. 2020. Preliminary estimates of seabird bycatch by UK vessels in UK and adjacent waters. Report prepared for the Department for Environment Food and Rural Affairs (Project Code ME6024).

Olsson, O., T, Nilsson and T. Fransson. 2000. Long-term study of mortality in the Common Guillemot in the Baltic Sea. Swedish Environment Protection Agency Report 5057, Berling Skogs, Trelleborg, Sweden.

Riffaut, L., McCoy, K.D., Tirard, C., V.L. and Boulinier, T. 2005. Population genetics of the common guillemot *Uria aalge* in the North Atlantic: geographic impact of oil spills. *Marine Ecology Progress Series* 291: 263–273.

Robinson, R.A. 2005. BirdFacts: profiles of birds occurring in Britain & Ireland. BTO, Thetford [redacted] [Accessed March 2022].

Robinson, R.A., Leech, D.I. & Clark, J.A. 2021. The Online Demography Report: Bird ringing and nest recording in Britain & Ireland in 2020. BTO, Thetford[redacted], created on 7 August 2021).

RSPB 2021a. Guillemot Bird Facts | *Uria aalge*.[redacted] [Accessed March 2021].

RSPB 2021b. Razorbill Bird Facts | *Alca torda*.[redacted] Accessed March 2021].

Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., Lindley, P., McCulloch, N., Noble, D., and Win I. 2021. The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. *British Birds* 114: 723-747.

Steiner, U. and Gaston, A. 2005. Reproductive consequences of natal dispersal in a highly philopatric seabird. *Behavioral Ecology* 16/3: 634-639.

Swann, R.L. and Ramsay, A.D.K. 1983. Movements from and age of return to an expanding Scottish Guillemot colony. *Bird Study* 30: 207-214.

Sweet, N. A. 2008. *Uria aalge* Common guillemot. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, Plymouth: Marine Biological Association of the United Kingdom, [redacted] [Accessed March 2021].

Virgili A., Lambert, C., Pettex, E., Doremus, G., Van Canneyt, O. and Ridoux, V. 2017. Predicting seasonal variations in coastal seabird habitats in the English Channel and the Bay of Biscay. *Deep Sea Research Part II: Topical Studies in Oceanography.* 141: 212-223.

Wildlife Trust 2021. Guillemot[redacted] [Accessed: March 2021].

Woodward, I., Thaxter, C.B., Owen, E., Cook, A.S.C.P. 2019. Desk-based revision of seabird foraging ranges used for HRA screening. BTO Research Report No. 724.

Wright, L. J., Ross-Smith, V. H., Austin, G. E., Massimino, D., Dadam, D., Cook, A. S. C. P., Calbrade, N. A. and Burton, N. H. K. 2012. Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and other Annex 1 species). BTO Research Report No. 592.

Appendix A Modelling of Guillemot and Razorbill Monthly Distribution

8 Methods

8.1.1.1 Monthly densities of guillemot and razorbill have been estimated at a 10km resolution by Waggitt *et al.*, (2019). Aerial and vessel survey data from 1980 to 2018 were collated and standardised to account for variations in survey techniques. Variations were first estimated using detection function models then adjustments were made to account for these. Biases that may cause variations have been summarised in **Table A 1**.

Table A 1: Biases derived from survey sampling (Waggitt *et al.*, 2019).

Bias	Description
Perception Bias	Undetected animals due to observer's visibility being compromised e.g., high sea state.
Availability Bias	Undetected animals due to animals being out of sight e.g., diving.
Response Bias	Animals' reaction to the presence of the platform. Can increase or decrease the likelihood of sightings depending on the animal's response e.g., disturbed by the platform (decrease) or approach the platform (increase).

8.1.1.2 Waggitt *et al.* (2019) modelled the sightings against environmental characteristics (annual temperature, annual temperature variance, depth, fronts, regional temperature, seabed roughness) as well as the proximity to land, proximity to the breeding colony and the point of the breeding cycle. Relationships between these factors were identified and used to estimate the seabird densities at monthly scales around the UK.

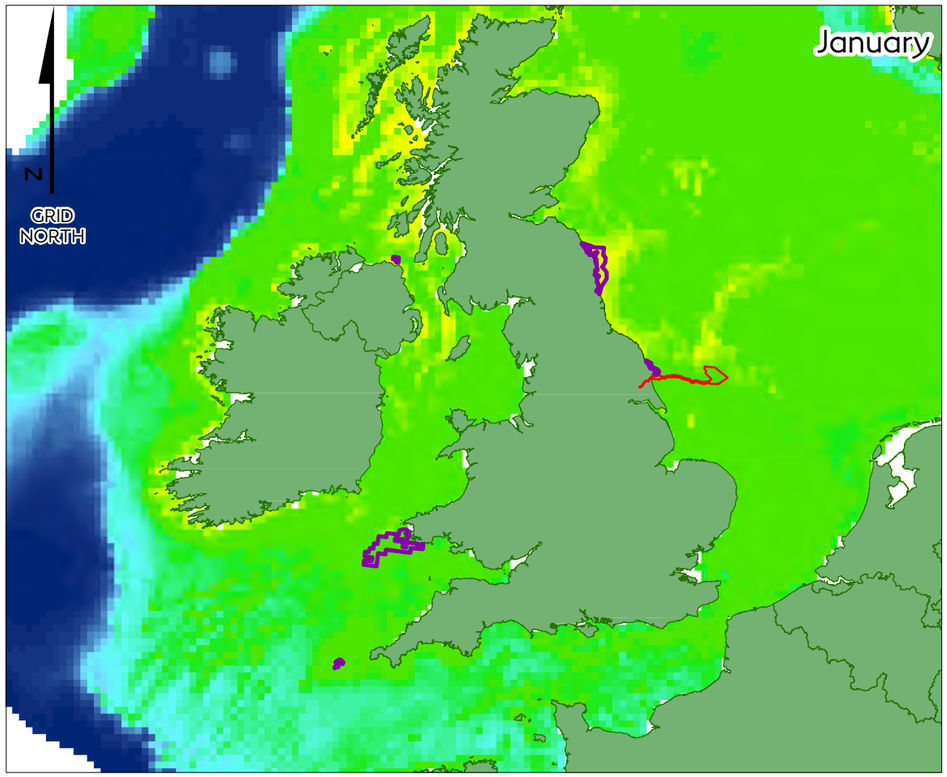
9 Results

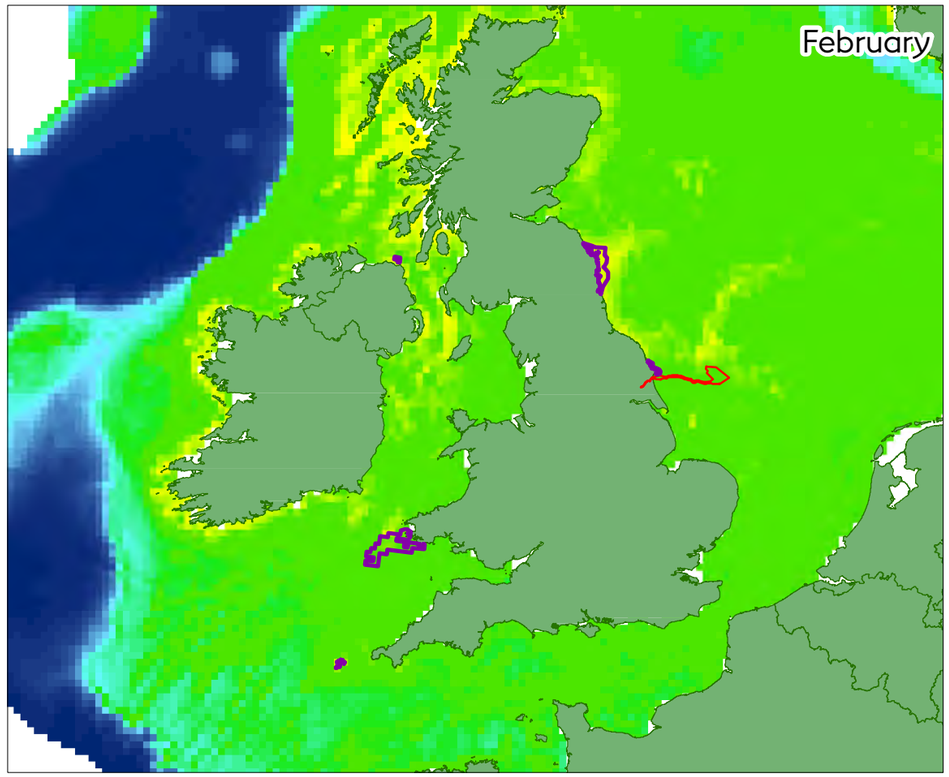
9.1.1.1 Monthly distribution densities of guillemot (**Figure A 1**; **Figure A 2**; **Figure A 3**) and razorbill (**Figure A 4**; **Figure A 5**; **Figure A 6** have been mapped around the UK. Guillemot cover a greater area offshore throughout the year when compared to razorbill.

9.1.1.2 From April to July, both guillemot and razorbill are located tightly around their colonies. This is expected as it aligns with the known breeding season when adults are nesting onshore. Outside of the breeding season, both species move further offshore, then start moving south post September. By December both species are located offshore around all UK coasts.

10 References

Waggitt, J., Evans, P., Andrade, J., Banks, A., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C., Durinck, J., Felce, T., Fijn, R., Garcia-Baron, I., Garthe, S., Geelhoed, S., Gilles, A., Goodall, M., Haelters, J., Hamilton, S., Hartny-Mills, L., Hodgins, N., James, K., Jessopp, M., Kavanagh, A., Leopold, M., Lohrengel, K., Louzao, M., Markones, N., Martínez-Cedeira, J., Ó Cadhla, O., Perry, S., Pierce, G., Ridoux, V., Robinson, K., Santos, M., Saavedra, C., Skov, H., Stienen, E., Sveegaard, S., Thompson, P., Vanermen, N., Wall, D., Webb, A., Wilson, J., Wanless, S. and Hiddink, J. 2019. Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology* 57/2: 253-269.





Hornsea Four

Figure A1

Waggitt et al., 2019

Guillemot Densities (January-April)

Hornsea 4 Array and Cable Corridor

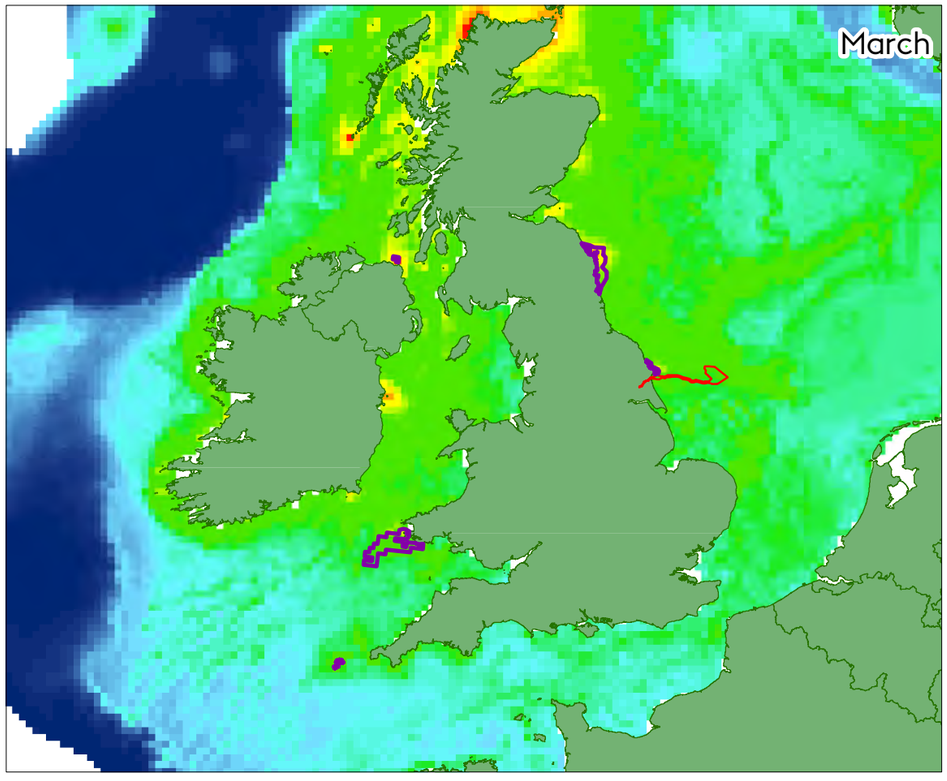
SPA with Common Guillemot Presence

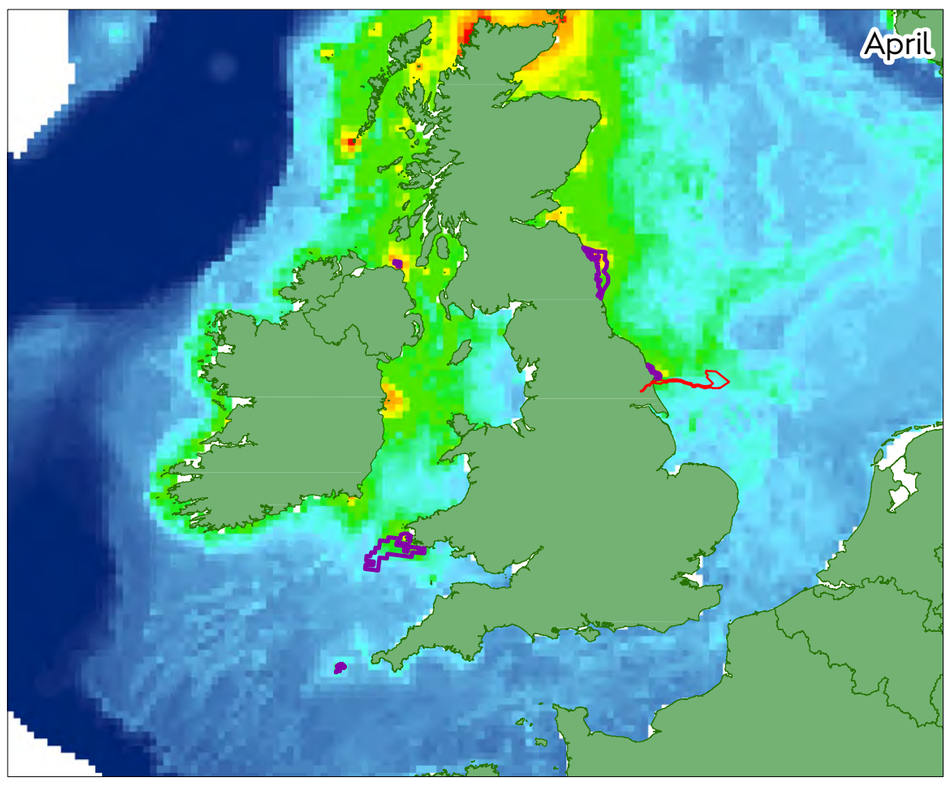
Common Guillemot

High : 6.25

Low : 0

Spatial variation in predicted densities (birds per km) of guillemot, per month, around the UK and Ireland. Values are provided at 10km resolution (Waggitt et al 2019).





Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:9,000,000

0 100 200 400 Kilometres

0 100 200 Nautical Miles

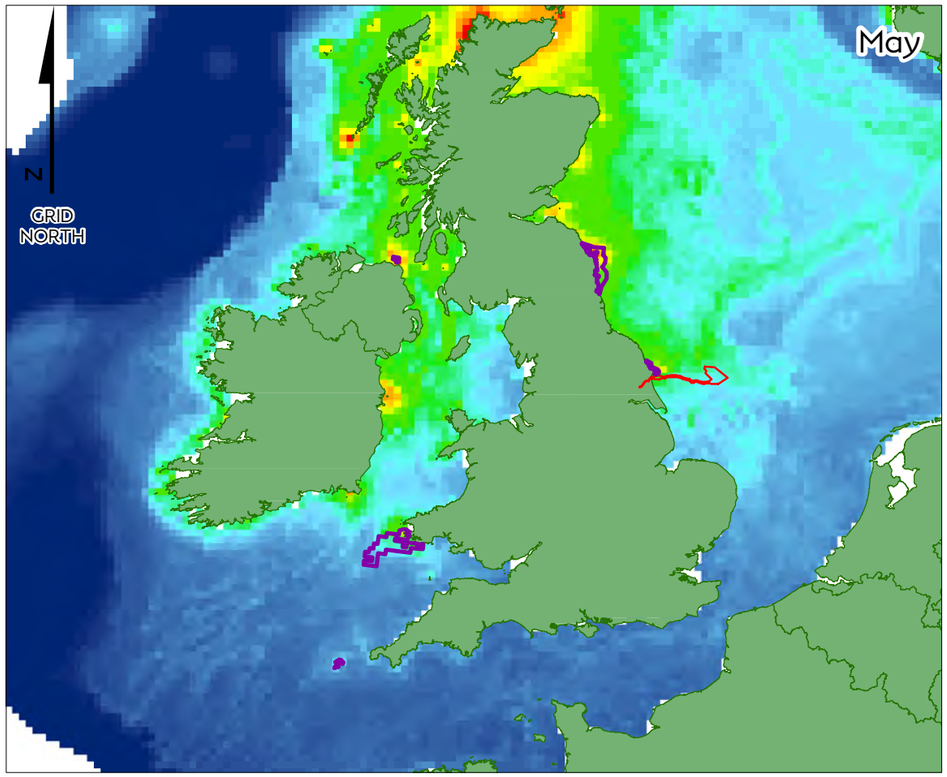
REV	REMARK	DATE
...	First Issue	14/04/2022

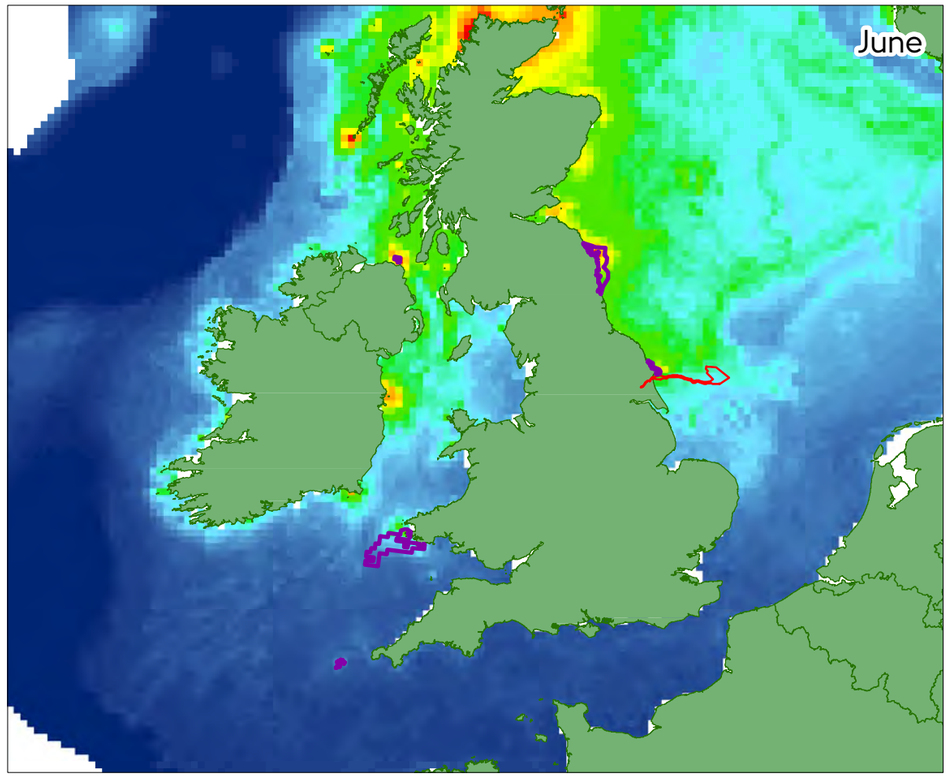
Waggitt et al., 2019
Guillemot Densities
Document no: HOW04GB0014
Created by: BPHB
Checked by: FC
Approved by: NS

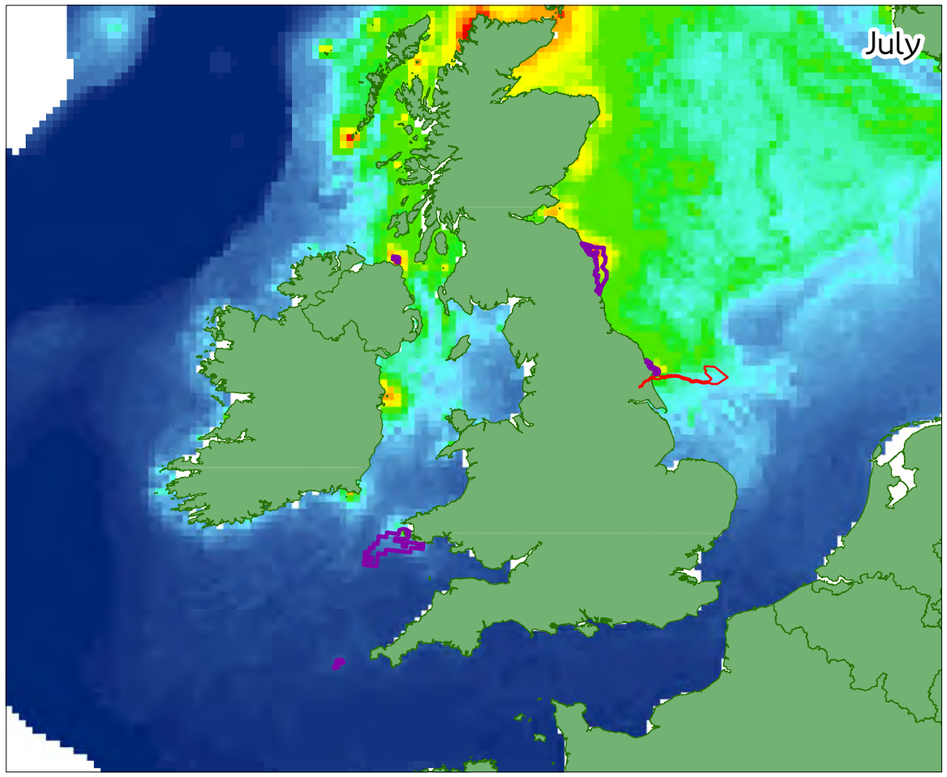
GoBe Ørsted

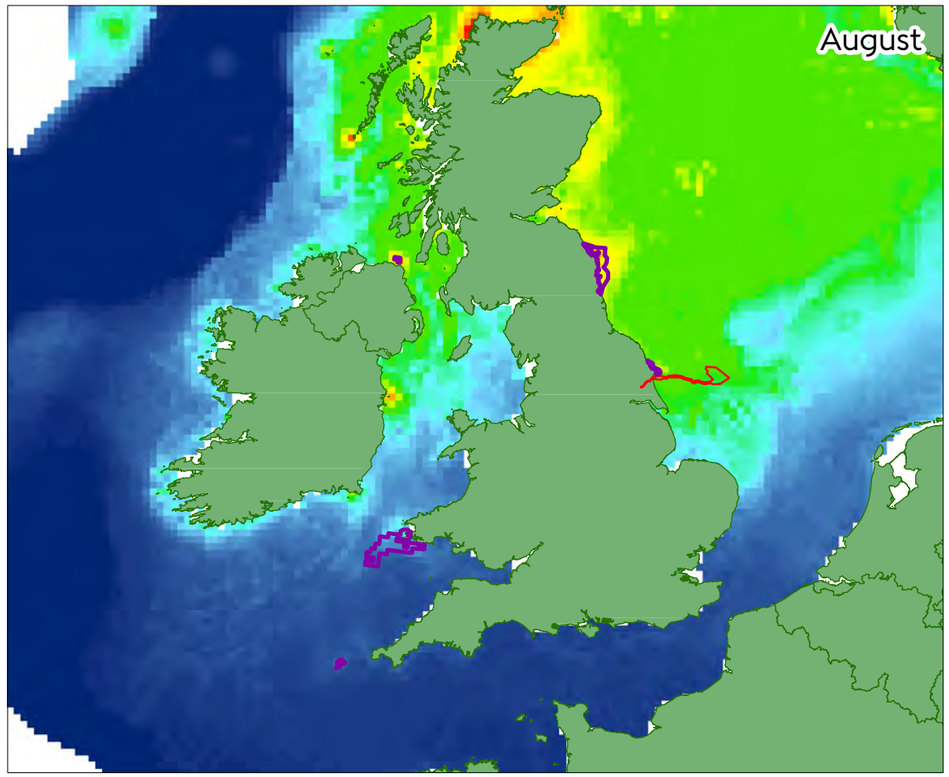
Date: 14/04/2022

Author: BenBlakeman Name: HOW04GB0014_MERP_FigA1_Guillemot_Jan_April









Hornsea Four

Figure A2
Waggitt et al., 2019
Guillemot Densities (May-August)

Hornsea 4 Array and Cable Corridor

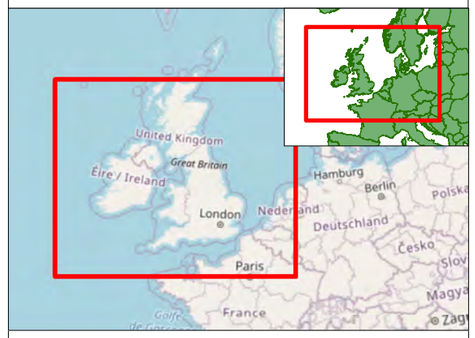
SPA with Common Guillemot Presence

Common Guillemot

High : 6.25

Low : 0

Spatial variation in predicted densities (birds per km) of guillemot, per month, around the UK and Ireland. Values are provided at 10km resolution (Waggitt et al 2019).



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:9,000,000

0 100 200 400 Kilometres

0 100 200 Nautical Miles

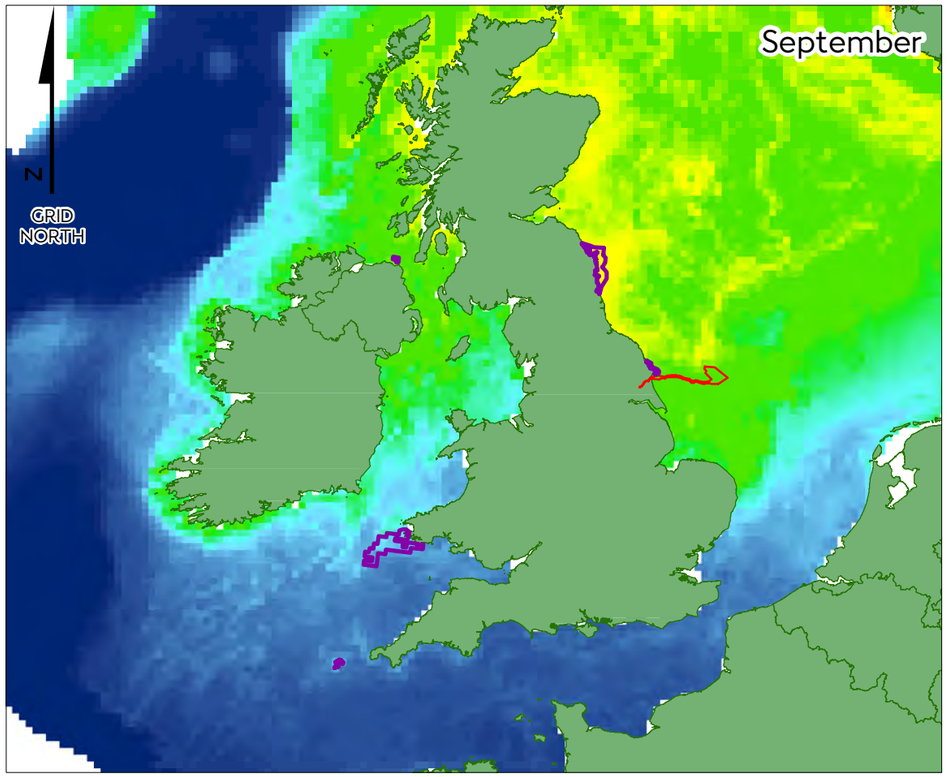
REV	REMARK	DATE
...	First Issue	14/04/2022

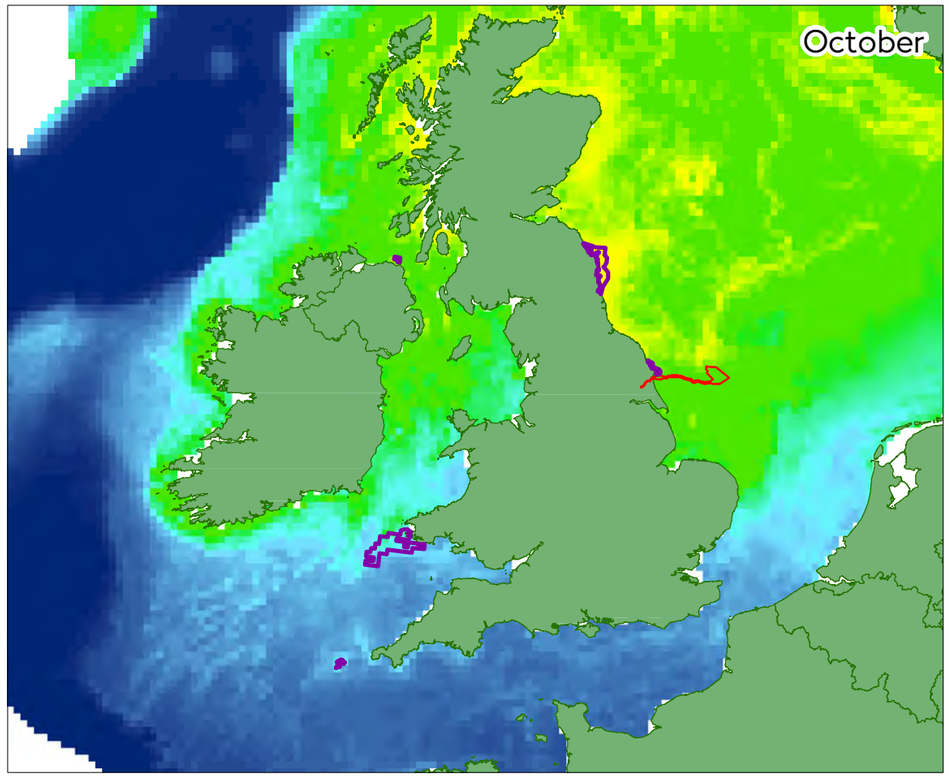
Waggitt et al., 2019
Guillemot Densities
Document no: HOW04GB0015
Created by: BPHB
Checked by: FC
Approved by: NS

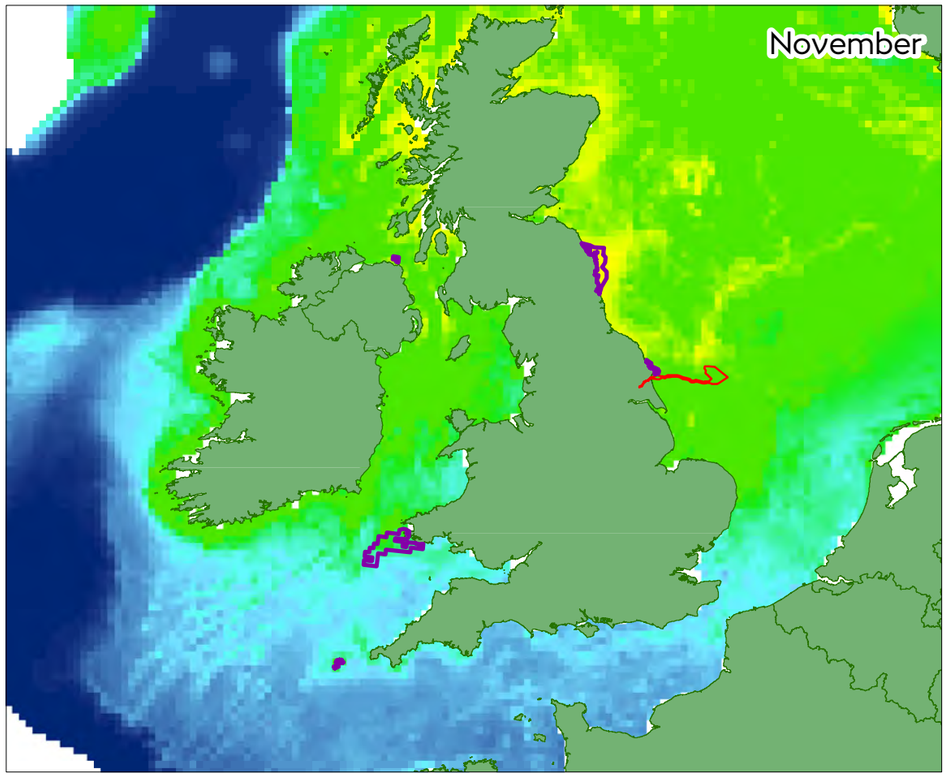
GoBe Ørsted

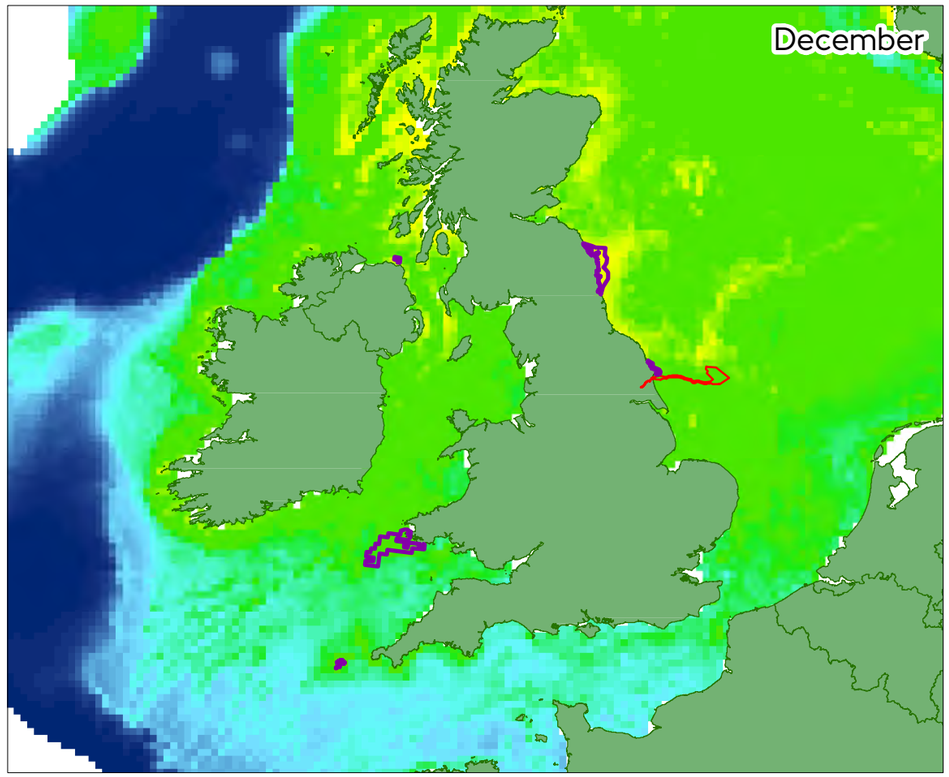
Date: 14/04/2022

Author: BenBlakeman Name: HOW04GB0015_MERP_FigA2_Guillemot_May_August









Hornsea Four

Figure A3

Waggitt et al., 2019

Guillemot Densities (Sept-December)

Hornsea 4 Array and Cable Corridor

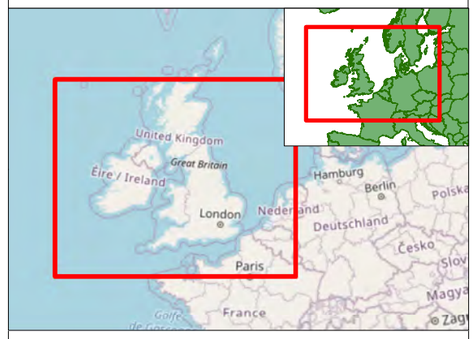
SPA with Common Guillemot Presence

Common Guillemot

High : 6.25

Low : 0

Spatial variation in predicted densities (birds per km) of guillemot, per month, around the UK and Ireland. Values are provided at 10km resolution (Waggitt et al 2019).



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:9,000,000

0 100 200 400 Kilometres

0 100 200 Nautical Miles

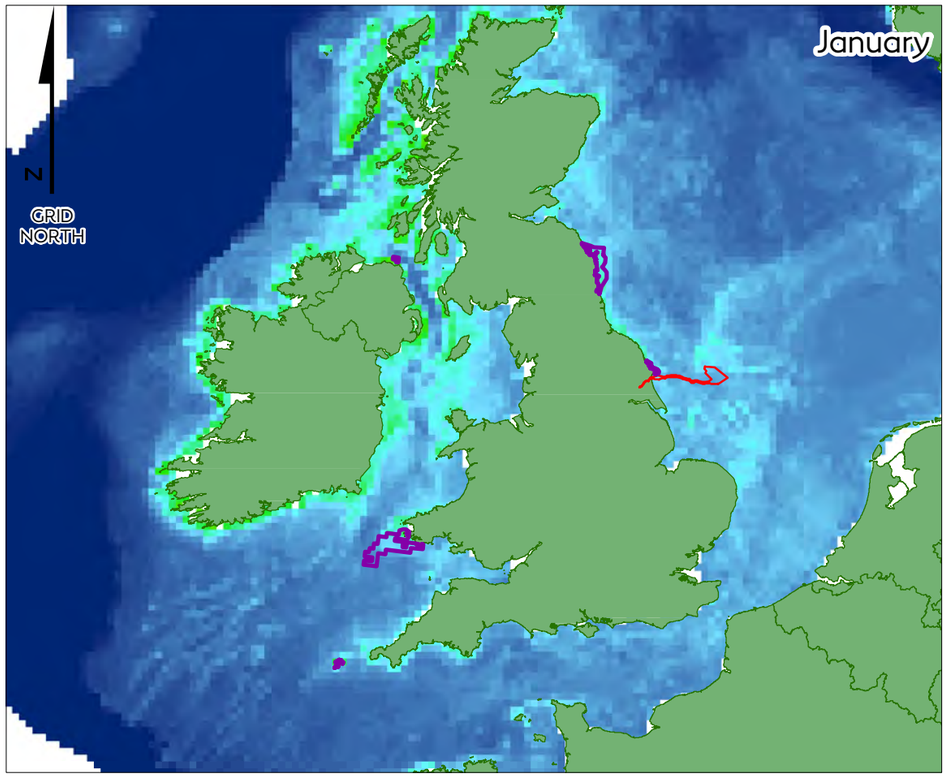
REV	REMARK	DATE
...	First Issue	14/04/2022

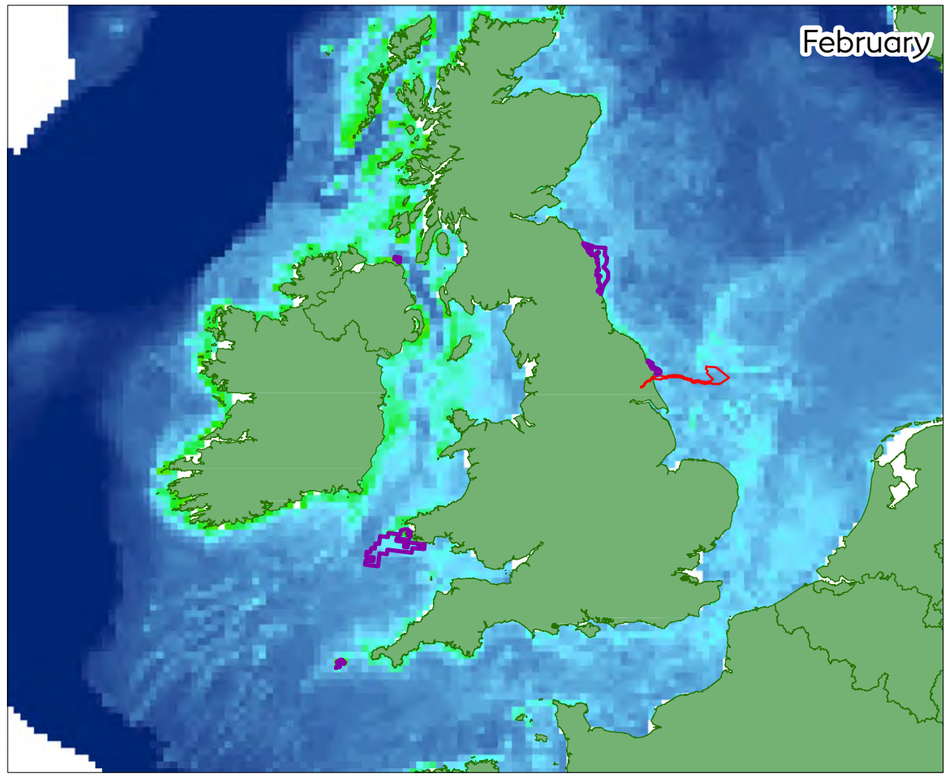
Waggitt et al., 2019
Guillemot Densities
Document no: HOW04GB0016
Created by: BPHB
Checked by: FC
Approved by: NS

GoBe Ørsted

Date: 14/04/2022

Author: BenBlakeman Name: HOW04GB0016_MERP_FigA3_Guillemot_Sept_December





Hornsea Four

Figure A4

Waggitt et al., 2019

Razorbill Densities (January-April)

Hornsea 4 Array and Cable Corridor

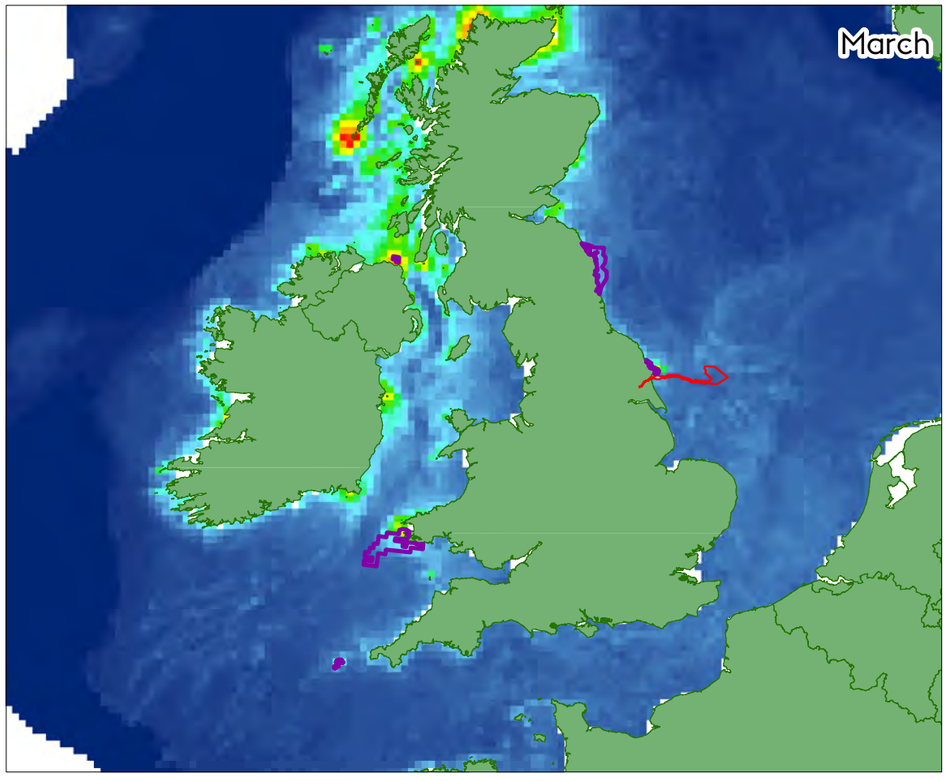
SPA with Razorbill Presence

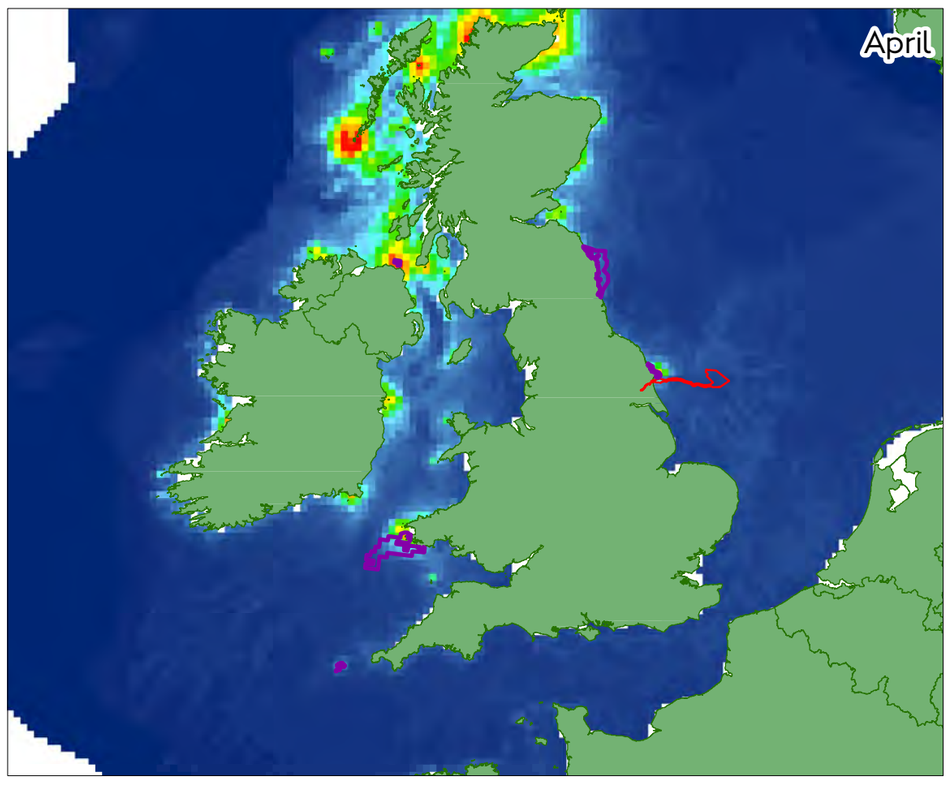
Razorbill

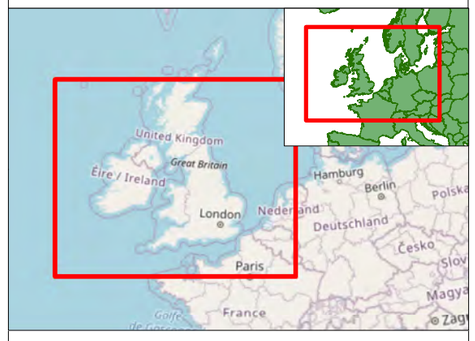
High : 3

Low : 0

Spatial variation in predicted densities (birds per km) of razorbill, per month, around the UK and Ireland. Values are provided at 10km resolution (Waggitt et al 2019).







Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:9,000,000

0 100 200 400 Kilometres

0 100 200 Nautical Miles

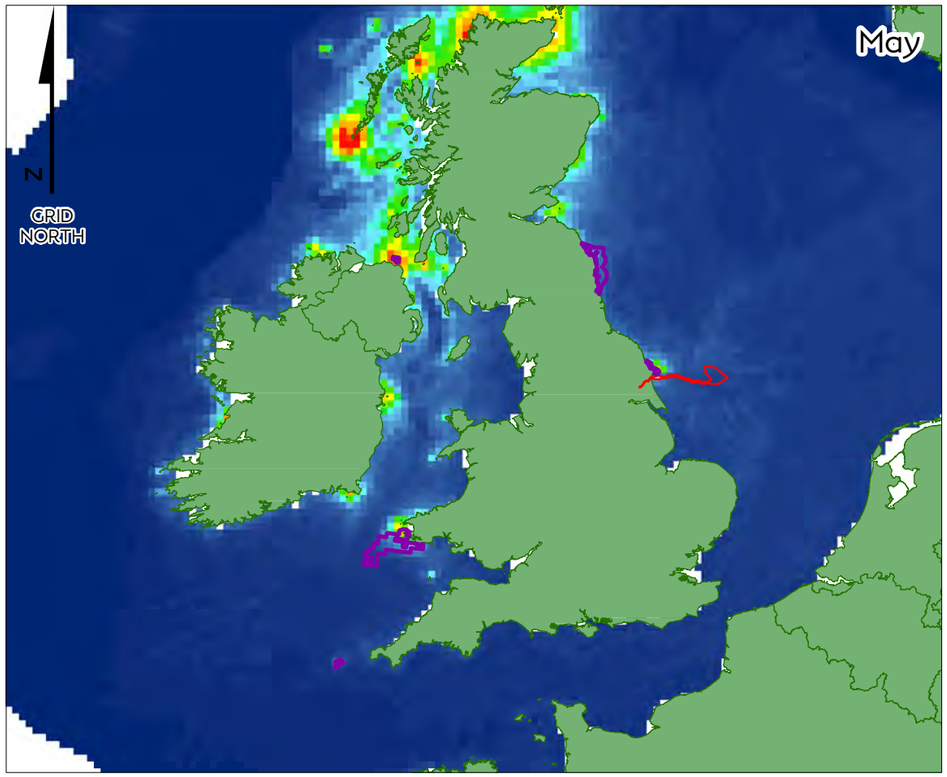
REV	REMARK	DATE
...	First Issue	14/04/2022

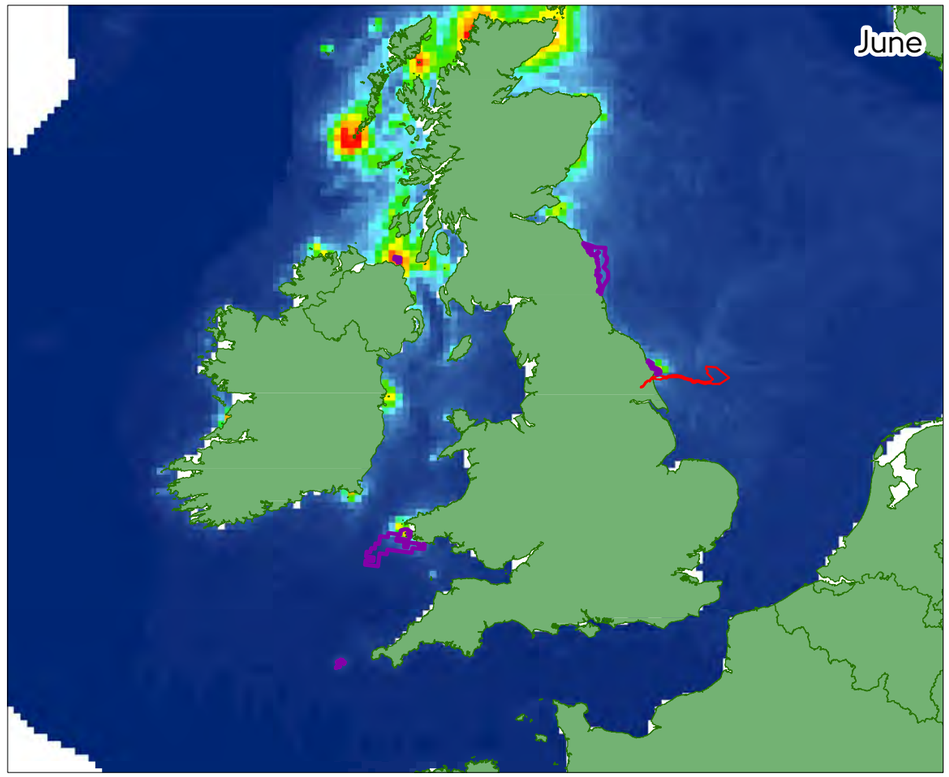
Waggitt et al., 2019
Razorbill Densities
Document no: HOW04GB0017
Created by: BPHB
Checked by: FC
Approved by: NS

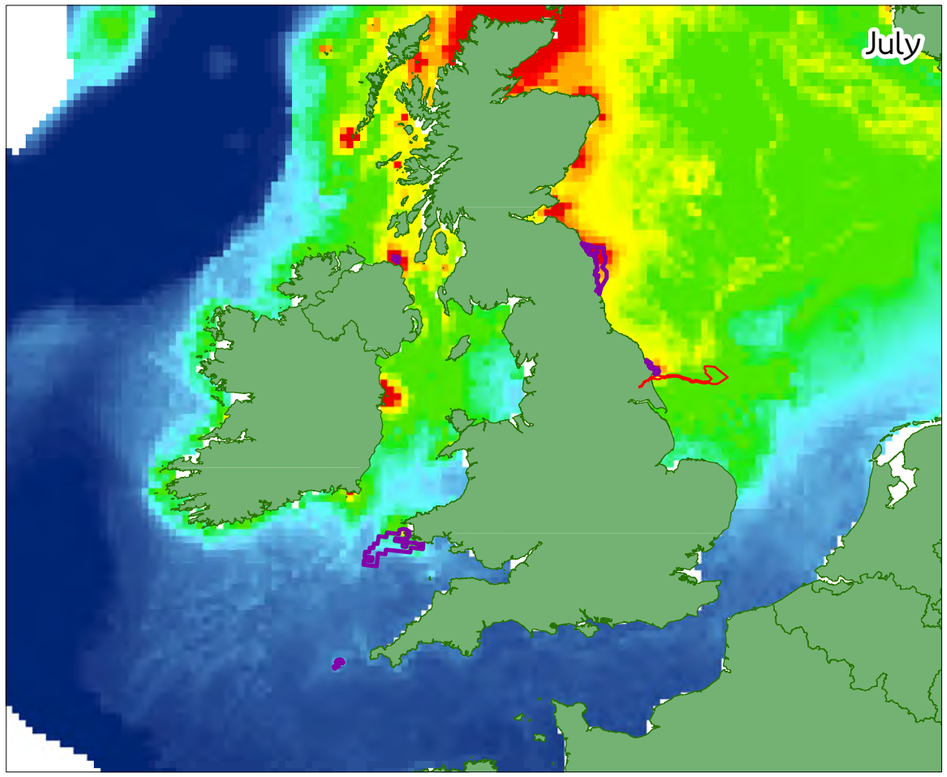
GoBe Ørsted

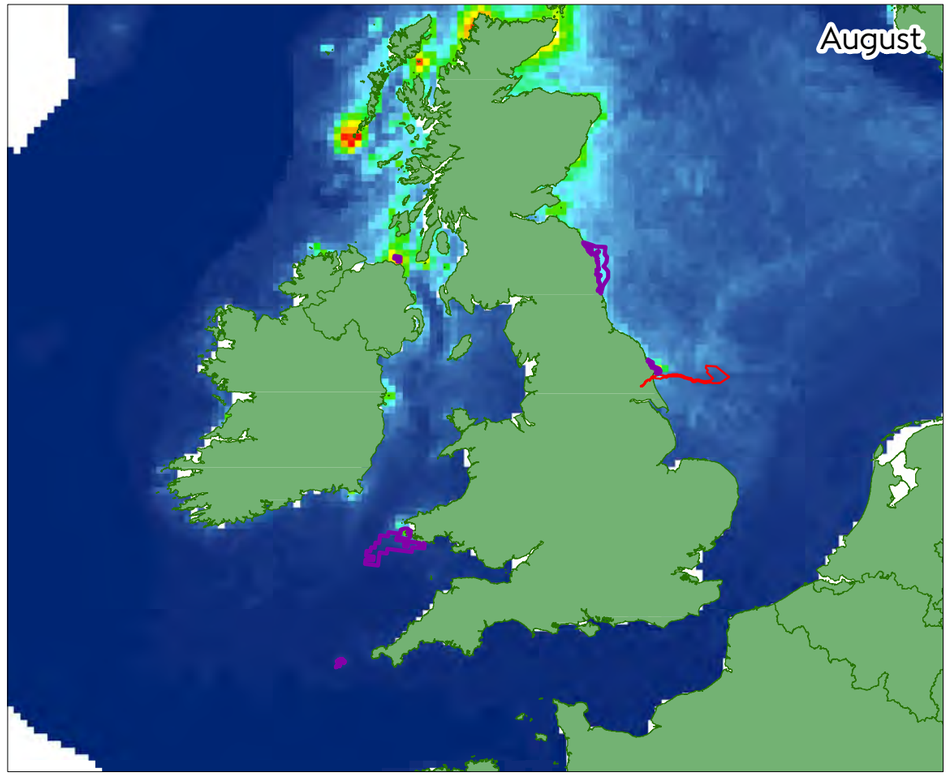
Date: 14/04/2022

Author: BenBlakeman Name: HOW04GB0017_MERP_FigA4_Razorbill_Jan_April









Hornsea Four

Figure A5

Waggitt et al., 2019

Razorbill Densities (May-August)

Hornsea 4 Array and Cable Corridor

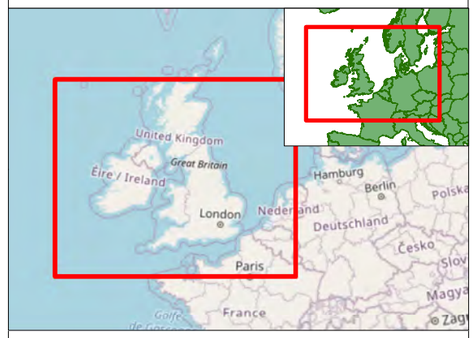
SPA with Razorbill Presence

Razorbill

High : 3

Low : 0

Spatial variation in predicted densities (birds per km) of razorbill, per month, around the UK and Ireland. Values are provided at 10km resolution (Waggitt et al 2019).



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:9,000,000

0 100 200 400 Kilometres

0 100 200 Nautical Miles

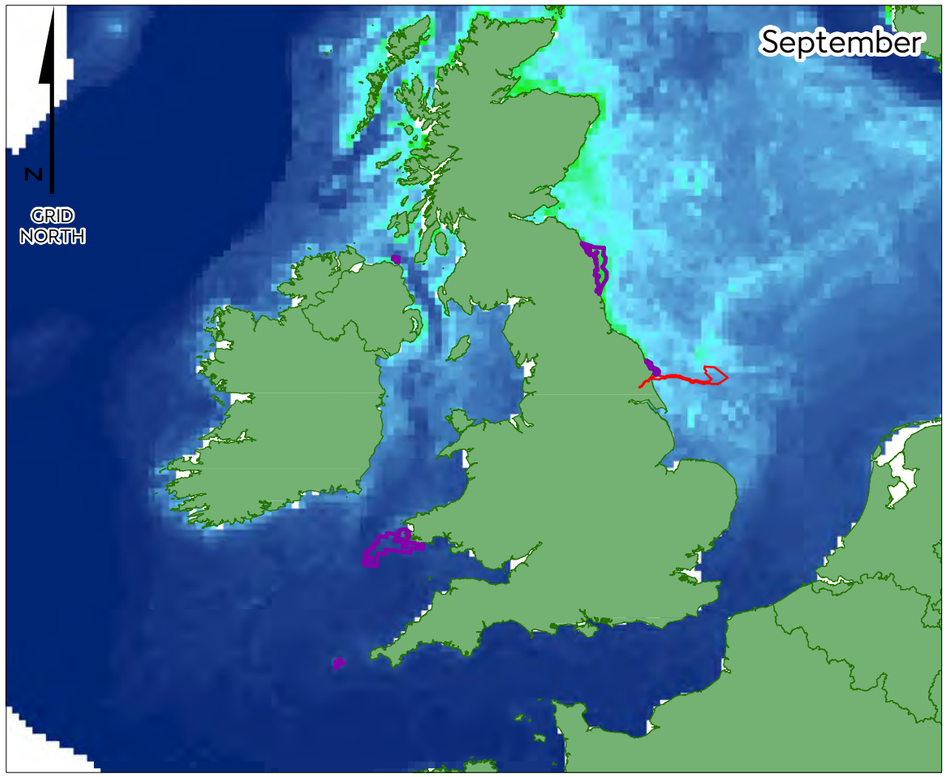
REV	REMARK	DATE
---	First Issue	14/04/2022

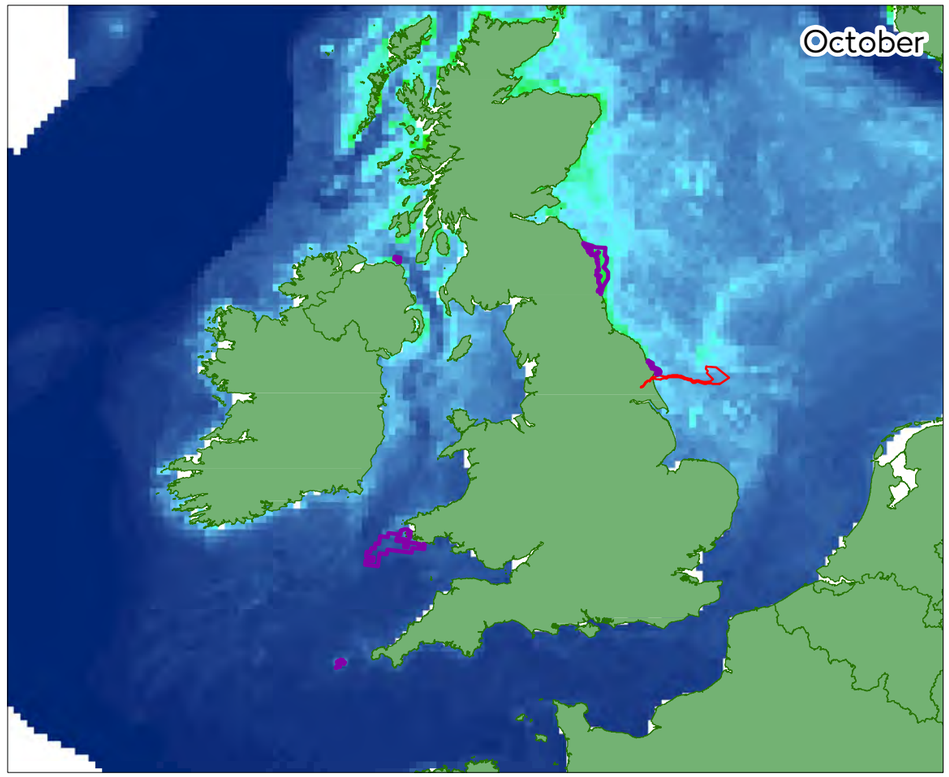
Waggitt et al., 2019
Razorbill Densities
Document no: HOW04GB0018
Created by: BPHB
Checked by: FC
Approved by: NS

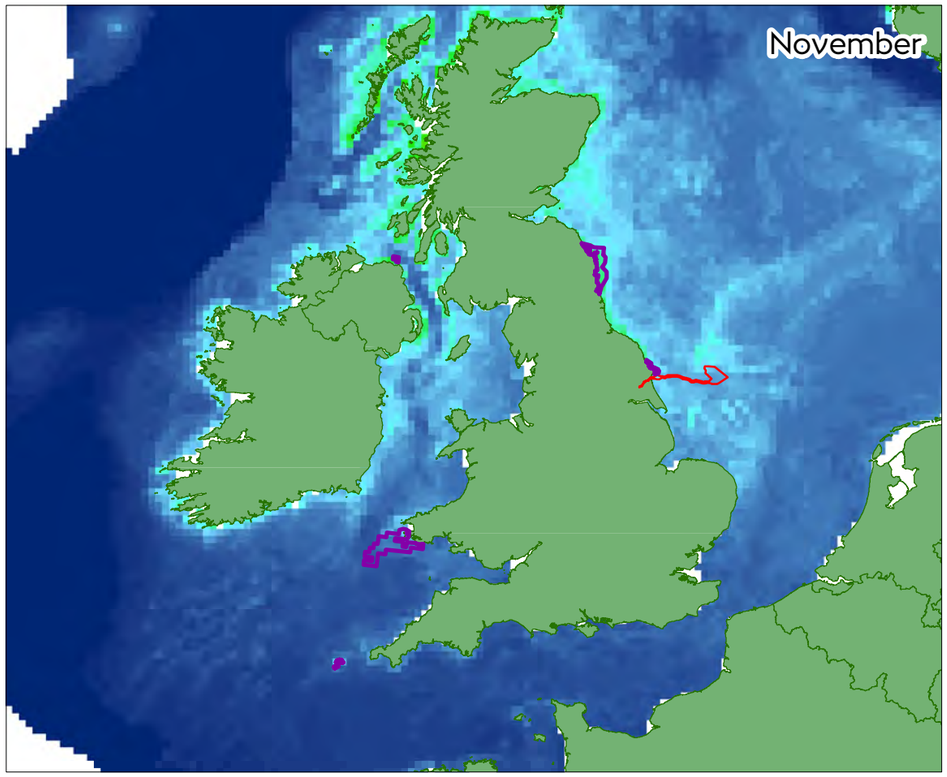
GoBe Ørsted

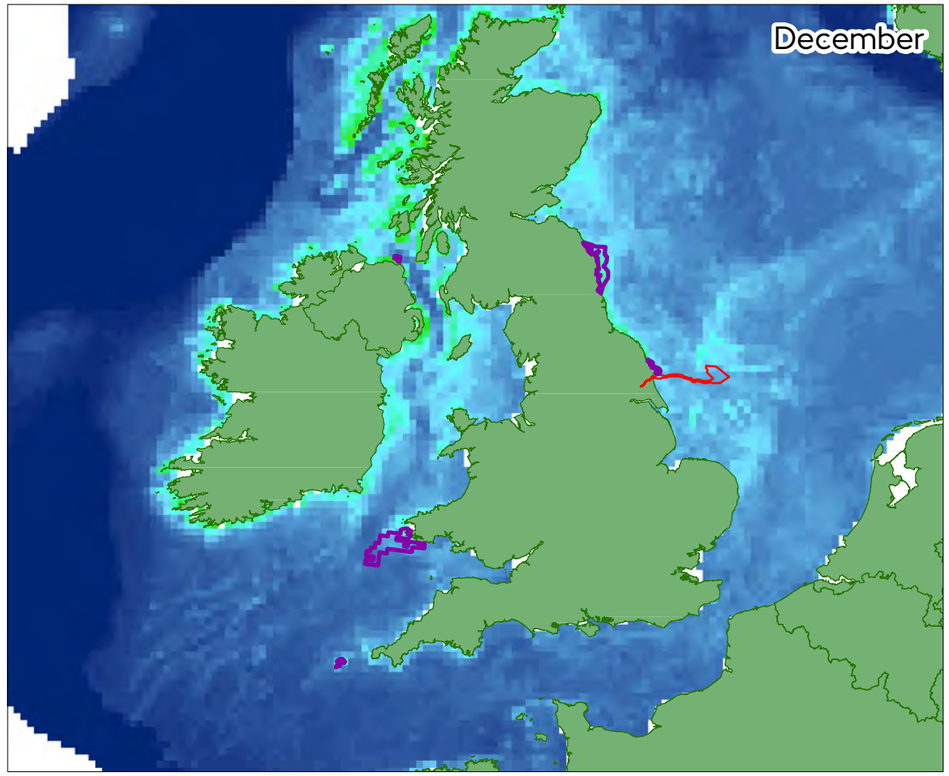
Date: 14/04/2022

Author: BenBlakeman Name: HOW04GB0018_MERP_FigA5_Razorbill_May_August









Hornsea Four

Figure A6

Waggitt et al., 2019

Razorbill Densities (Sept-December)

Hornsea 4 Array and Cable Corridor

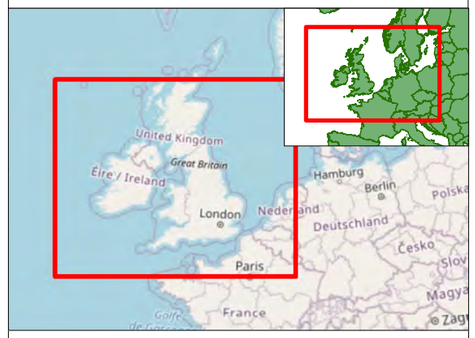
SPA with Razorbill Presence

Razorbill

High : 3

Low : 0

Spatial variation in predicted densities (birds per km) of razorbill, per month, around the UK and Ireland. Values are provided at 10km resolution (Waggitt et al 2019).



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:9,000,000

0 100 200 400 Kilometres

0 100 200 Nautical Miles

REV	REMARK	DATE
...	First Issue	14/04/2022

Waggitt et al., 2019
Razorbill Densities
Document no: HOW04GB0019
Created by: BPHB
Checked by: FC
Approved by: NS

GoBe Ørsted

Date: 14/04/2022

Author: BenBlakeman Name: HOW04GB0019_MERP_FigA6_Razorbill_Sept_December