Addendum to the Seagreen (2018) EIAR

Annex 1

Ornithology Technical Report (revised)

NOTE: This Annex was previously Seagreen (2018) EIAR Appendix 8A. It remains unchanged from that version except for updates to the site populations in Appendix 2

Ornithology Technical Report for Seagreen Alpha & Bravo

Firth of Forth
Offshore Wind Farm Development
2018

From clockwise: © Martin Perrow

commuting Northern Gannets *Morus bassanus*

juvenile Black-legged Kittiwake *Rissa tridactyla*

Common Guillemots *Uria aalge* delivering prey to the colony

Black-legged Kittiwakes attending Razorbills *Alca torda* and Common Guillemots

V1	**27/3/18**	**Technical Report**	[Redacted]		
V2	**07/3/19**	**Appendix 2 revisions**			
Revision	**Date**	**Description**	**Authors**	**Checked By**	**Approved By**

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1. INTRODUCTION

1.1.1 The Firth of Forth constitutes Zone 2 of the original nine Round 3 (R3) of offshore wind licensing arrangements established by The Crown Estate. With an area of 2,855 km^2, the Firth of Forth R3 Zone (hereafter referred to as the Zone) was the fourth largest of the R3 Zones. Seagreen Wind Energy Limited (hereafter referred to as Seagreen) was awarded the rights to develop the Zone in January 2010 under a formal Zone Development Agreement (ZDA) with The Crown Estate. A generation capacity of up to 3,465MW was defined under the ZDA.

1.1.2 For the purpose of the proposed sequence of development, Seagreen split the Zone into three discrete development Phases and excluding an area of generally deeper water in the south of the Zone from development. Phase 1 in the north of the Zone was considered the least constrained for technical reasons such as ease of connection to the grid and was therefore the focus for initial development (Figure 1). Phase 1 is located approximately 27 km offshore east of the Angus coastline at its closest point and extends up to 60 km offshore.

1.1.3 Following the Zonal Assessment Process (ZAP) required by The Crown Estate, Seagreen determined that the western part of Phase 1, incorporating the area around Scalp Bank, was to remain undeveloped (Seagreen 2011). Scalp Bank was previously a focus of the sandeel fishery and was thus thought likely to be a feeding ground for many seabirds targeting sandeels as well as other species (Wanless *et al*. 1998). Harris *et al*. (2012) suggests that breeding Atlantic Puffin *Fratercula arctica* also forage over Scalp Bank as well as other key areas such as the Wee Bankie to the south of Phase 1

1.1.4 The resultant broadly rectangular area of the Phase 1 project area, excluding a few areas of water considered to be of excessive depth (> 60 m**)** for development, was divided into two approximately triangular wind farm sites named Seagreen Alpha and Seagreen Bravo (hereafter Alpha and Bravo respectively) of similar area (197.2 km^2 and 193.7 km^2 respectively). Each site was to contain up to 75 turbines of six to seven megawatt (MW) capacity.

1.1.5 Ornithological and marine mammal data for Alpha and Bravo were provided by a two-year programme of boat-based surveys of the entire zone undertaken from December 2009 to December 2011 inclusive. A baseline technical report analysing the specific data for Alpha and Bravo was produced (Seagreen 2012a), which underpinned the subsequent Environmental Statement required for Environmental Impact Assessment purposes (Seagreen 2012b) and the subsequent report of information to inform Appropriate Assessment (AA) required as part of Habitat Regulations Appraisal (HRA) (Seagreen 2013).

1.1.6 Alpha and Bravo were consented on the 10th October 2014, alongside two Scottish Territorial Waters (STW sites) inshore of the western part of the Zone: Neart na Gaoithe to be developed by Mainstream Renewable Power Ltd and Inch Cape to be developed by Red Rock Power Ltd. (Figure 1).

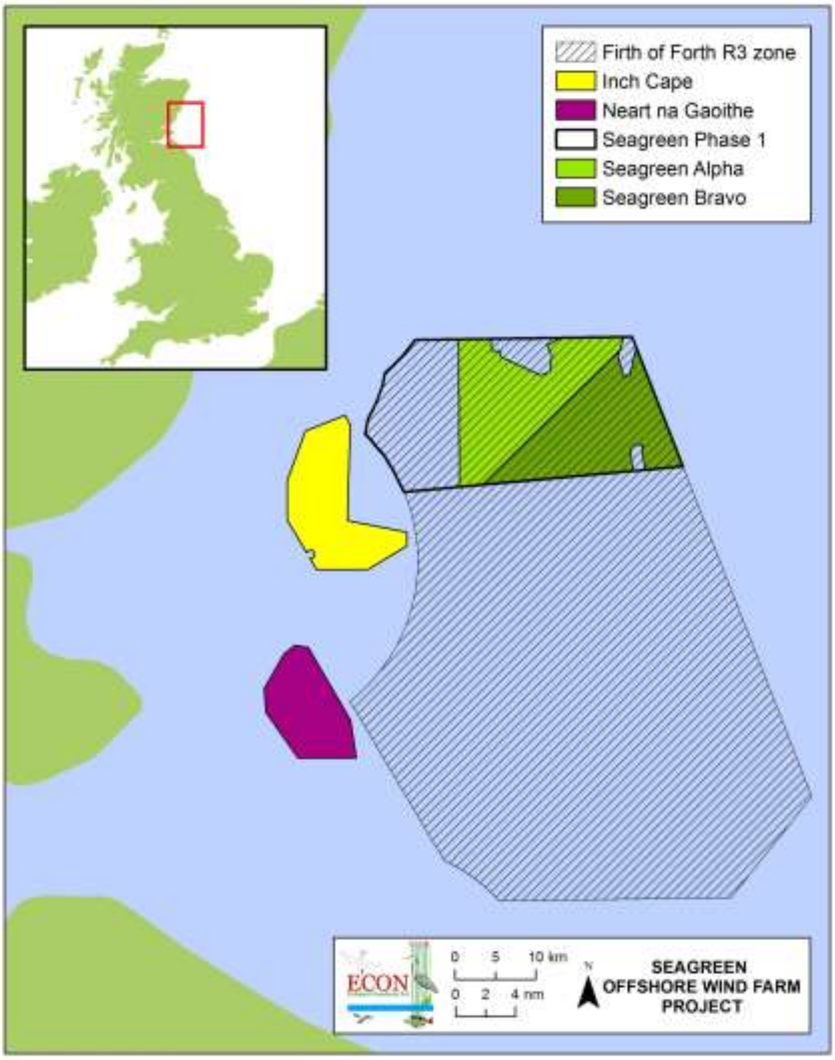

Figure 1. The Seagreen Firth of Forth Round 3 Phase 1 project area containing the Seagreen Alpha and Seagreen Bravo sites relative to the Scottish Territorial Waters sites of Inch Cape and Neart na Gaoithe.

1.1.7 Following consent, the Royal Society for the Protection of Birds (RSPB) appealed the decision and a Judicial Review (JR) process was initiated. The findings of the JR were published in July 2016, finding in favour of the RSPB. As a result the consents for all four sites were overturned. The Scottish Ministers lodged a counter appeal that was subsequently upheld by the Inner House of the Scottish Courts on 16th May 2017, thereby reinstating the consents for all sites. The RSPB applied to the Supreme Court for permission to appeal that decision, but this was denied on 7th November 2017. The original consents for all four sites are therefore active.

1.1.8 Prior to that decision and in light of technological advances within the wind industry all three developers had begun the process of submitting applications for revised sites to the consenting authority Marine Scotland. For all proposed projects, a number of the key parameters of the developments were to change relative to those proposed for the original consented projects. These changes are shown in the scoping report for Inch Cape and the EIA for Neart na Gaoithe (Table 1).

Table 1. Details of the proposed Seagreen Project within Phase 1 in comparison with the Scottish Territorial Waters sites bordering the Zone. Information for STW sites as defined by Mainstream Renewable Power (2017) and Inch Cape Wind (2017).

Key parameter	Seagreen		Inch Cape		Neart na Gaoithe	
	Current combined Alpha and Bravo project	Original combined Alpha and Bravo project	Current	Original	Current	Original
Area	391	391	150	150	105	105
Closest distance from shore (km)	27	27	15	15	15.5	13
Total maximum installed capacity (MW)	TBC	1,050	784	784	450	450
Maximum capacity of turbines	Up to 15	7	8	7	8	6
Number of turbines	70-120	150	Up to 72	110[1]	Up to 54	75[2]
Maximum rotor diameter	220	122-167	250	120-172	167	126-152
Maximum hub height above LAT	140	87.1-126	176	92-129	126	107.5
Maximum tip height above LAT	280	148.1-209.7	301	152-215	208	197
Minimum blade clearance above LAT	29.1-42.7	26.1-42.7			35	30.5
Minimum turbine separation distance (m)	1,000	610-835	1,278	820	800	

1.1.9 The age and thus relevance of the ornithological data underpinning the original consented applications was raised as a concern by the RSPB in particular, in relation to assessment of any revised sites in the Forth and Tay development area (see Marine Scotland 2017). As a result, in their Scoping Report for a revised site

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[1] The initial application was for up to 213 turbines, with consent ultimately awarded for 110.

[2] The initial application was for up to 125 turbines, which was amended to up to 90 in the addendum, although consent was ultimately awarded for 75.

(Seagreen 2017a), Seagreen committed to gathering further boat-based ornithological data on sensitive breeding species in the 2017 breeding season over an area encompassing the entire original Phase 1 area with the addition of a 2 km buffer, thereby incorporating the Phase 1 project area of Alpha and Bravo combined as well as Scalp Bank (shown as current study area in Figure 5).

1.1.10 No further ornithological data was to be gathered at Neart na Gaoithe according to Scoping (Mainstream Renewable Power 2017), although this development was already underpinned by three years of data relative to two for all other developments. At Inch Cape, although further boat-based surveys (at least) were undertaken from late 2016 throughout the breeding season in 2017, this was not mentioned in Scoping (Inch Cape Wind 2017) and thus seems unlikely to be included in EIA/HRA for the revised application.

1.1.11 During the 2017 breeding season surveys, although all birds and marine mammals were recorded in the same manner as in 2009-2011, the focus was on six key species as determined from previous HRA (and EIA) relating to the potential impact of wind farm development particularly in a cumulative context in the Forth and Tay (Marine Scotland 2014). The six species were Northern Gannet *Morus bassanus*, Black-legged Kittiwake *Rissa tridactyla*, European Herring Gull *Larus argentatus*, Common Guillemot *Uria aalge*, Razorbill *Alca torda* and Atlantic Puffin *Fratercula arctica*, with each occurring as a designated feature in one or more Special Protection Area (SPA) colonies of concern (Table 2).

Table 2. **Breeding seabird species originating from specific colonies to be considered in EIA/HRA following the advice of Marine Scotland (2017).**

Species	SPA
Northern Gannet	Forth Islands
Black-legged Kittiwake	Buchan Ness to Collieston Coast, Fowlsheugh, Forth Islands, St Abb's Head to Fast Castle
European Herring Gull	Buchan Ness to Collieston Coast, Fowlsheugh, Forth Islands, St Abb's Head to Fast Castle
Common Guillemot	Buchan Ness to Collieston Coast, Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle
Razorbill	Fowlsheugh, Forth Islands, St Abb's Head to Fast Castle
Atlantic Puffin	Forth Islands

1.1.12 The six species were identified in the Scoping Opinion received from Marine Scotland (2017) with specific input from ornithological specialists within Scottish Natural Heritage (SNH) as statutory advisors to Marine Scotland. The number of species of concern represents a reduction from the eight species considered in the original AA (Marine Scotland 2014), following the removal of Northern Fulmar *Fulmarus glacialis* and Lesser Black-blacked Gull *Larus fuscus graellsii*, which are qualifying features of the Buchan Ness to Collieston Coast, Fowlsheugh and Forth Islands SPAs, and the Forth Islands SPA respectively.

1.1.13 The location of the four SPAs of concern, namely Forth Islands, Fowlsheugh, Buchan Ness Collieston Coast and St Abb’s Head to Fast Castle, is shown in Figure 2. Fowlsheugh SPA is in closest proximity to the Seagreen Phase 1 Project at around 29 km at its closest point, followed by Forth Islands SPA at 53 km, followed by St Abb’s Head to Fast Castle at 68 km, with Buchan Ness to Collieston Coast being considerably more remote at 84 km.

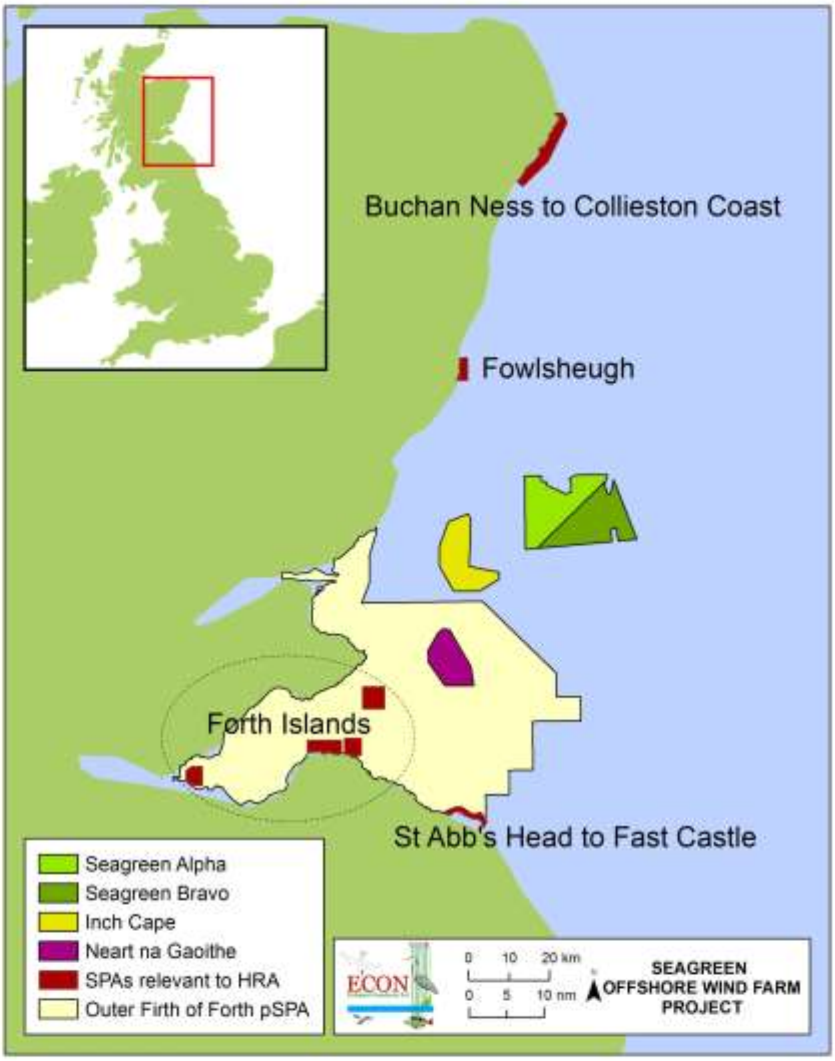

Figure 2. **Location of Seagreen Alpha and Bravo and the Scottish Territorial Waters sites in relation to the SPAs to be included in the EIA/HRA according to Marine Scotland (2017).**

1.1.14 All the SPAs contain large numbers of multiple species of seabirds as qualifying features (Table 3), compared to the relatively few species to be considered in EIA/HRA (Table 2). Thus, many species have been scoped out of further assessment for the proposed new sites, mainly as previous surveys showed these species did not occur in sufficient numbers at the sites to provide the potential for any risk of impacts upon the populations in the respective SPAs.

1.1.15 Moreover, the large numbers of seabirds of concern within colonies reduces the prospects of population-scale impacts of the developments, unless a species that is particularly sensitive to collision or displacement uses the proposed project areas intensively.

1.1.16 In this context, it is of note that there have been considerable changes in the numbers of seabirds present in these SPAs since designation. For example, Fowlsheugh SPA contained the third largest Common Guillemot colony in Britain in Seabird 2000 with 80,280 individuals. In 2015, just 55,507 individuals were present (SMP Online Database). Similarly, Black-legged Kittiwake numbers have declined from 69,740 individuals at designation (Table 4) to 19,310 individuals in 2015 (SMP Online Database).

1.1.17 However, not all seabirds have declined as the Northern Gannet colony on the Bass Rock increased rapidly from 8,077 pairs in 1970 (Cramp *et al.* 1974) to 48,065 pairs in 2004 (Wanless *et al*. 2005a), 55,482 breeding pairs in 2009 (Murray 2011) and 75,290 occupied sites representing 150,580 individuals in 2014 (Murray *et al*. 2014) surpassing St Kilda (60,290 pairs in 2013 - SMP database) as the largest colony in the World.

1.1.18 The size of the seabird colonies underpins the importance of the Firth of Forth within the Aberdeen-Tees area, which is ranked in the top three areas for seabirds in the North Sea (Skov *et al*. 1995). Wee Bankie and Marr Bank encompassed by the Zone, but falling outside the Phase 1 Project, are viewed as particularly important foraging grounds (Wanless *et al*. 1998, Camphuysen 2005).

1.1.19 The analysis of Kober *et al*. (2009) subsequently recognised the Outer Forth/Wee Bankie/Marr Bank as being of international importance for multiple seabird species. Only three other areas of sea around the UK were thought to be capable of achieving this status. Wee Bankie is incorporated in the Outer Firth of Forth and St Andrews Bay Complex pSPA i.e. proposed as a SPA (Figure 2), and as such is also to be considered in relation to the Forth and Tay wind farm developments (Marine Scotland 2017).

Table 3. **Numbers of breeding seabirds (individuals) of each species designated within each SPA bordering the Firth of Forth Phase 1 project, as defined in Natura 2000 or Stroud *et al.* (2001) where Natura was updated (marked with an asterisk*).**

Species	**Fowlsheugh SPA**	**Firth of Forth Islands SPA**	**St. Abb's to Fast Castle SPA**	**Buchan Ness to Collieston Coast SPA**	**Total**
Northern Fulmar	2,340	1,596		3,530	7,466
Northern Gannet		68,800*			68,800
Great Cormorant		400			400
European Shag		5,774	1,120	2,090	8984
Black-legged Kittiwake	69,740*	16,800	42,340	60,904	189,784
Lesser Black-backed Gull		5,840			5,840
European Herring Gull	6,380	13,200	2,320	8,584	30,484
Sandwich Tern		44*			44
Common Tern		1,600			1,600
Roseate Tern		18*			18
Arctic Tern		1,080			1,080
Common Guillemot	80,280*	32,000	31,750	17,280	161,310
Razorbill	5,800	2,800	2,180		10,780
Atlantic Puffin		42,000*			42,000
Total (for designated species)	164,540	191,952	79,710	92,388	528,590

2. AIMS & OBJECTIVES

2.1.1 The primary aim of this technical report is to present an amalgam of information on the distribution, abundance, activity and behaviour of key breeding seabird species identified by Marine Scotland (2017) (see Table 2), within the Seagreen Phase 1 project area comprising a combination of Seagreen Alpha and Seagreen Bravo gathered over all seasons in 2009-2011 (see Seagreen 2012ab, 2013) and during the breeding season in 2017 (Seagreen 2017b).

2.1.2 A key objective of the current document is thus to provide current information in one readily accessible location for use in the EIA/HRA to be undertaken by NIRAS, the lead EIA consultant for Seagreen. In particular, densities of birds in flight coupled with flight height information may be used to assess collision risk and numbers of both birds on the water and in flight will provide the basis of the number of birds subject to potential displacement (Marine Scotland 2017).

2.1.3 During the 2017 breeding season surveys, further information was also to be collected on the accuracy of observer flight height estimates. Accurate flight height measurements are of critical importance when determining flight height distributions for collision risk modelling, but little is yet known of the accuracy of observations taken during surveys relative to bird-borne altimeters (see Cleasby *et al*. 2015). Thus, during the current surveys dedicated measurements were made with a simple rangefinder device throughout the surveys to provide a comparative dataset. More detailed information is provided in Appendix 1, which forms the basis of a submitted manuscript (Harwood *et al*. submitted).

2.1.4 This document also presents population data of birds from colonies within species-specific foraging range of the Phase 1 Project, both in relation to historic data from Seabird 2000 and the latest contemporary counts in the Seabird Monitoring Programme (SMP) database (http://jncc.defra.gov.uk/smp), in order to aid apportioning of the birds recorded on the site to particular colonies during EIA/HRA to be undertaken by NIRAS. In this document, the focus of this is on non-SPA versus SPA and between the SPAs themselves.

3. METHODOLOGY

3.1 Boat-based surveys

3.1.1 Boat-based surveys were selected as the primary method for characterising the ornithological interest of the Alpha and Bravo sites from December 2009 to November 2011 inclusive, as they provide a high degree of species identification as well as providing detailed information on bird behaviour (e.g. foraging, flight directions and interactions).

3.1.2 To ensure consistency with previous survey work, boat-based surveys were also commissioned in 2017, albeit from a smaller vessel (17 m compared to 32.1 m length) that had previously been employed to survey the smaller STW sites.

Survey vessel & logistics

3.1.3 The 2009-2011 surveys of Alpha and Bravo were undertaken as part of the survey of the entire Zone. The extremely large area of the Zone (2,855 km^2) required an extremely long route in excess of 936 km to provide data of sufficient resolution to meet COWRIE guidelines of a transect spacing of 0.5-2 nm (Camphuysen *et al*. 2004). Initial calculations suggested an average of ~8 days effort per month would be required.

3.1.4 To meet the challenging conditions at a distance of up to ~70 km offshore, the *MV Clupea* a high-specification research vessel that previously operated as the Fisheries Research Vessel in the area was chartered (Figure 3)[3]. For the vessel, to be immediately available as soon as weather conditions were suitable, Seagreen committed to long-term charter of the *Clupea*, for a specified time per month over a two-year period. In effect, a standby system ensured the vessel and crew were available when required within 48 hours notice. Surveyors were made available with a maximum of 24 hours notice.

Figure 3. The Clupea in Leith Docks with viewing platforms visible above and in front of the wheelhouse.

3.1.5 At 32.1 m in length the *MV Clupea* exceeds the minimum COWRIE recommendations of > 20 m (Camphuysen *et al*. 2004). In addition, the vessel was specifically modified to provide two survey platforms exceeding the COWRIE recommendation of 5 m minimum eye-height. The lower platform on the boat deck immediately forward on the wheelhouse was fitted with hard wooden bench

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[3] The *Clupea* was out of service for the March and April surveys in 2010 and the *MV Dornoch* (24.34 m in length with an eye-height of 5 m) was used as a replacement.

seating secured to the deck (Figure 3). Similar seating was also installed within a bespoke observation area on top of the wheelhouse, offering a minimum of 6.2 m eye height when sitting (i.e. >7 m when standing).

3.1.6 Given that only a short weather window of two days was needed each month, an *ad hoc* vessel charter was deemed adequate for the surveys in 2017. The *Eileen May,* a 17 m Severn class ex-RNLI lifeboat with experience of ornithological survey work on the nearby STW sites, was used (Figure 4). The vessel operated from either Montrose or Arbroath to allow the shortest possible transit times to and from the site on the day. Whilst Montrose has no tidal restriction for a vessel of the size of the *Eileen May* the tidally restricted Arbroath harbour was used on favourable tides on occasion in order to reduce transit times to and from certain parts of the site. The crew and survey team could be mobilised within 24 hours' notice of a suitable weather window.

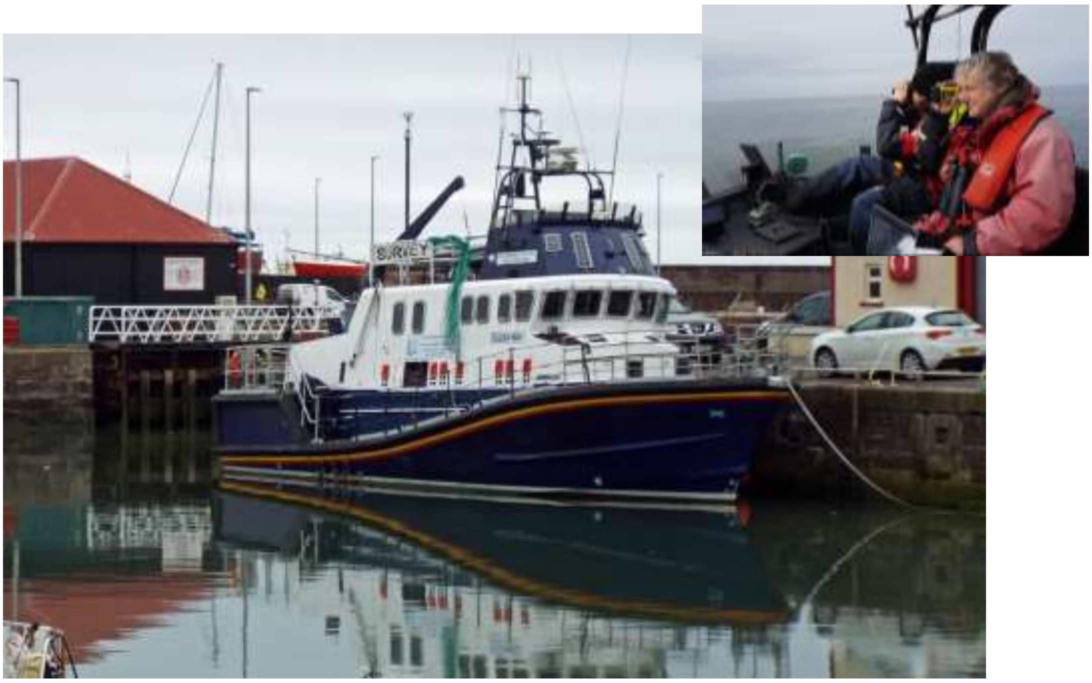

Figure 4. The Eileen May in Arbroath harbour and surveyors on the flying bridge during a survey (inset).

3.1.7 Although the *Eileen May* falls short of the 20 m length recommended by COWRIE (Camphuysen *et al*. 2004) it had previously been approved as a suitable ornithological survey platform by JNCC largely as it exceeds the COWRIE recommendation of >5 m eye-height for surveyors. This was measured at 6.1 or 6.2 m for surveyors either standing or seated on the elevated bench (Figure 4).

Timing of surveys

3.1.8 The basic requirement of both the 2010-11 and 2017 survey programmes was to undertake one survey per month of an area including both Alpha and Bravo. In relation to the former, a total of 24 surveys were attempted in monthly periods from December 2009 to November 2011 inclusive (Table 4). Of these, 23 surveys were used in analysis including 22 that were entirely completed and two begun in adjacent months (January 2010 and February 2010) that were amalgamated to provide 100% coverage within a phenological period (see 3.1.16 below).

3.1.9 In 2017, the plan to complete one survey each month between April and September 2017 inclusive was constrained by a number of issues. For example, survey logistics and weather constraints meant the intended April survey was delayed into early May (Table 4) and the survey scheduled for May undertaken in the latter half of the month two weeks after the first survey. Surveys in June, July and August were undertaken as scheduled thus completing the intended breeding season surveys for most key species including Black-legged Kittiwake, European Herring Gull *Larus argentatus*, Common Guillemot, Razorbill *Alca torda* and Atlantic Puffin (see 3.4 below).

3.1.10 The final survey, due to be carried out in September to fully encompass the breeding season for Northern Gannet, was not conducted. This was initially due to the survey vessel requiring engineering repairs, followed by poor weather that persisted into October. Undertaking this survey in October was not considered to be representative of the breeding season and it was cancelled.

3.1.11 Instead, a one-day survey was mobilised in October with the aim of gathering additional flight height data on any important species present (see 3.1.34 below) and conducting a comparison of radial and box snapshot sampling technique (see 3.1.44 below). To these ends, the vessel only covered a selection of the transect route thought likely to maximise the number of birds encountered. As such, the survey focussed on Scalp Bank and the eastern part of Alpha and a very limited extent of Bravo.

Survey design and route

3.1.12 The variable topography, substrate and oceanographic conditions of the Zone, including in the area around Seagreen Alpha and Bravo was thought likely to provide potential for consistent seabird foraging ‘hotspots’ as a result of the aggregation of fish with particular features. For example, Scott *et al*. (2010) showed primary productivity was concentrated into small areas of a few tens of kilometres in the Firth of Forth with a consequent effect on bird distribution. Thus, in order to detect fine-scale distribution patterns, a high spatial coverage of the survey area was desirable.

Table 4. **Details of transect route used, proportion of survey completed and dates of each boat-based survey of Alpha and Bravo between December 2009 and October 2017 inclusive.**

Phenological period	Survey	Route	Proportion of survey (%) completed	Date
Wintering	1	1	100	11 – 12 December 2009
	2	2	74	23 – 24 January 2010
	-	4	26	21 February 2010
	3	4	100	20 – 21 March 2010
Breeding	4	4	100	3 – 4 April 2010
	5	1	100	19 – 20 May 2010
	6	3	100	16 June 2010
	7	4	100	10 July 2010
Dispersal	8	4	100	5 August 2010
	9	1	100	18 – 19 September 2010
	10	3	100	7 – 8 October 2010
	11	4	100	6 – 7 November 2010
Wintering	12	2	100	3 – 4, 6 December 2010
	13	3	100	13 – 14 January 2011
	14	4	100	10 – 11 February 2011
	15	1	100	1 – 3 March 2011
Breeding	16	2	100	9 April 2011
	17	3	100	4 May 2011
	18	4	100	10 June 2011
	19	1	100	9, 12 July 2011
Dispersal	20	2	100	1 August 2011
	21	3	100	17 – 18 September 2011
	22	1	100	27 – 28 October 2011
	23	2	100	5 – 7 November 2011
Breeding	1	1	100	9 – 10 May 2017
	2	2	100	24 – 25 May 2017
	3	3	100	20 – 21 June 2017
	4	1	100	24 – 25 July 2017
Dispersal	5	3	100	15 – 16 August 2017
	6	N/A	N/A	27 October 2017

3.1.13 At a typical transect spacing of 3 km, as much as 80% of the area would not be surveyed as only a 600 m strip (if both sides of the vessel were sampled) would be covered, thereby greatly diminishing the chances of sampling small important patches. Missing hotspots or continuous re-sampling of hotspots captured by chance would lead to underestimation and overestimation of density respectively, as well as biasing the patterns of seabird distribution. The obvious solution to increase coverage is to simply reduce transect spacing and sample more transects. However, this has considerable cost and resource implications.

3.1.14 An alternative solution was provided by the concept of less frequent rotational sampling of a series of different survey routes offset by a small distance within the framework of 3 km spacing. In 2009-2011, the desired high level of coverage was achieved by sampling four different survey routes 750 m apart (e.g. transect line 1 of route 1 was 750 m apart from transect line 1 of route 2 etc) within the 3 km spacing were selected (Figure 5).

3.1.15 Rotation of transect routes (and therefore not covering exactly the same area each time) could be argued to increase variability between surveys and reduce the prospect of detecting change in the seasonal abundance for any species. However, seasonal change was of lower priority compared to high survey coverage and detection of fine-scale distribution patterns. Moreover, EIA tends to be based on peak and mean populations of birds rather than specifically use any change in seasonal abundance.

3.1.16 The four routes were sampled within each of three four-monthly phenological periods broadly corresponding to breeding (April-July), dispersal (August-November) and wintering (December-March) periods, although this does vary between different species (see 3.4.1 below). Thus, in any one phenological period, the fact that each route was sampled meant that the area covered by the survey amounted to ~80% of the area as survey of 300 m on each side of the vessel leaves only an unsurveyed strip of 150 m between adjacent transect route.

3.1.17 In 2017, with three routes (rather than four in 2009-2011), the offset between transects was 1 km compared to 0.75 km. The intention was then to survey each route twice during the six planned surveys. The differences in transect spacing reduced survey coverage to 58.4% (from a total transect length of all three routes combined of 793 km covering an area of 475.8 km^2). Despite this reduction coverage was still deemed to be very good compared to a typical survey programme along the same relatively widely spaced transects.

3.1.18 Throughout both the 2009-2011 baseline characterisation surveys and 2017 breeding season surveys, the different routes were selected randomly in diminishing rounds (see Table 5), according to the aim of surveying each route the same number of times.

3.1.19 In 2009-2011, there was some imbalance in the number of surveys on each route in the different phenological periods as a result of input errors by the vessel. Thus, in both the breeding and wintering periods there were three surveys on route four and one on route two rather than two surveys on all routes (Table 4). There was a need for this to also be considered when interpreting distribution patterns. In 2017, the missing September survey meant that route 2 was only surveyed once compared to twice for the other two routes.

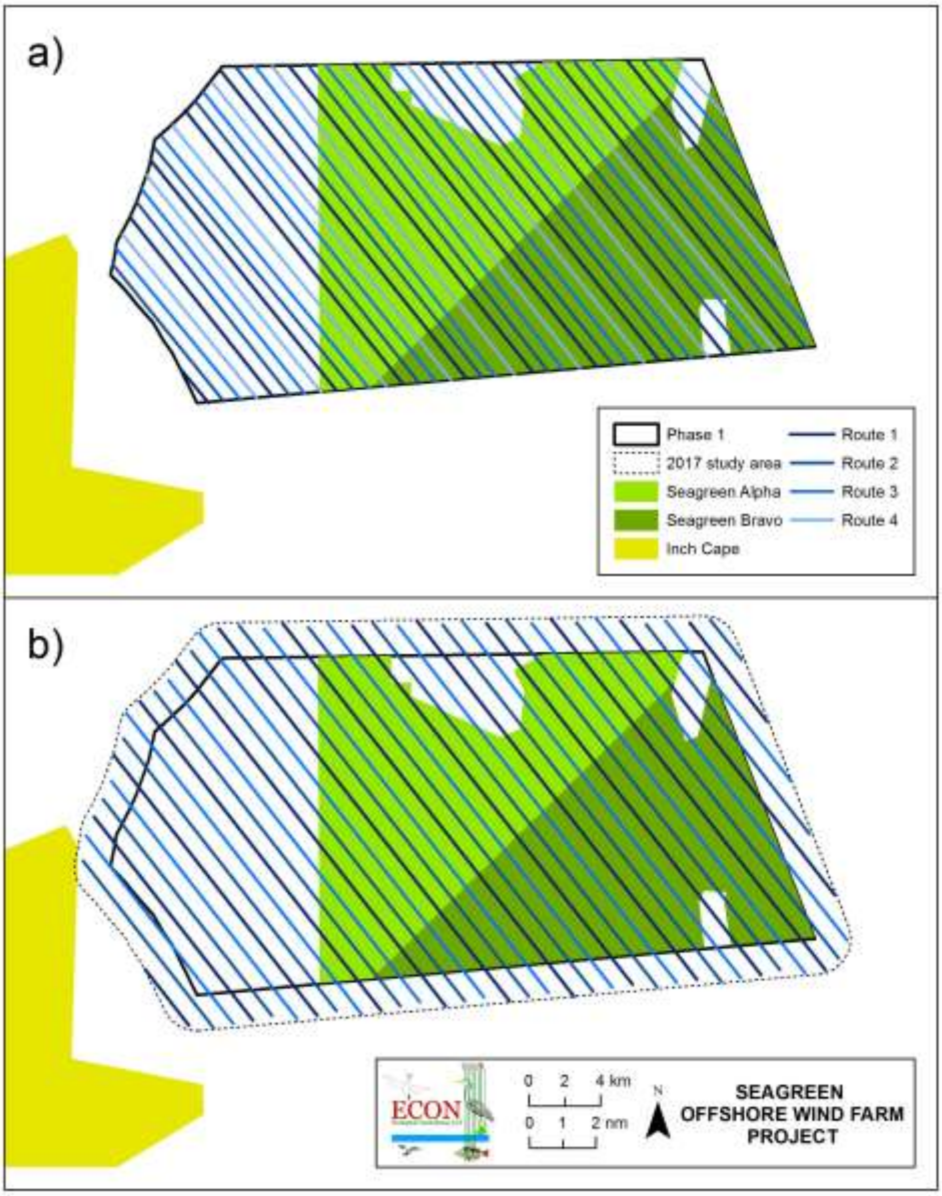

Figure 5. **Boat-based survey transect routes for: a) the baseline characterisation phase (2009-2011) and b) the modified route for the 2017 breeding season across Seagreen Alpha and Bravo. Note the 2 km buffer was not surveyed during the baseline period.**

3.1.20 In both sampling programmes, the orientation of transects was northwest to southeast at an angle of 142^o (Figure 5) in order to intercept the likely main axis of bird movement across the Zone, such as the movement of Gannets to and from Bass Rock, seabirds from colonies within the Firth of Forth SPA especially, and specific southwest or northeast flight lines into the Firth of Forth estuary by geese, other waterfowl, waders and landbirds.

3.1.21 The northwest to southeast axis was preferred to any other potential environmental gradient such as bathymetry, as this does not grade evenly across the area partly as it is highly complex with shallow outcrops such as Scalp Bank that may influence the distribution of birds. In other words, the relationship between birds and bathymetry was predicted to vary between different species as well as being relatively weak compared to general distance from any colony.

Table 5. Details of the number and length of transects for each transect route on Alpha and Bravo during boat-based surveys between December 2009 and November 2011 inclusive.

Parameter	Route	Alpha	Bravo
Number of transects	1	9	8
	2	9	8
	3	9	8
	4	9	9
Range of transect length (km)	1	1.4 – 13.6	1.1 – 14.8
	2	2.4 – 14.6	1.7 – 15.5
	3	4.3 – 14.8	2.7 – 14.9
	4	0.5 – 14.2	0.5 – 14.4
Mean transect length (km)	1	7.2	7.8
	2	7.5	7.9
	3	7.5	8.2
	4	7.1	7.3
Total transect length (km)	1	65.0	62.5
	2	67.1	63.1
	3	67.5	65.7
	4	63.8	65.4

3.1.22 In 2009-2011, eight or nine individual transects were undertaken on any one survey dependent on the route followed (Table 5) with an average surveyed track length of 192.6 km. Individual transect length varied from a minimum of 0.5 km to a maximum of 14.2 km on Alpha and 0.5 km to 14.4 km on Bravo depending on which route was being covered. Mean transect length was similar at a minimum of 7.1 km on Alpha and 8.2 km on Bravo. The total transect length was thus also similar between the two sites with a range of between 63.8 – 67.5 km for Alpha and 62.5 – 65.7 km for Bravo on any one survey (Table 5).

3.1.23 In 2017, a buffer area of 2 km was added around the entire Phase 1 project development area (Figure 6) as determined by Marine Scotland (2017). This increased the survey area from 390.8 km^2 to 814.1 km^2. For the purposes of assessment, 2 km buffer areas were also defined around Alpha and Bravo separately, with part of each site falling within the buffer of the other where the two sites abut each other (Figure 6).

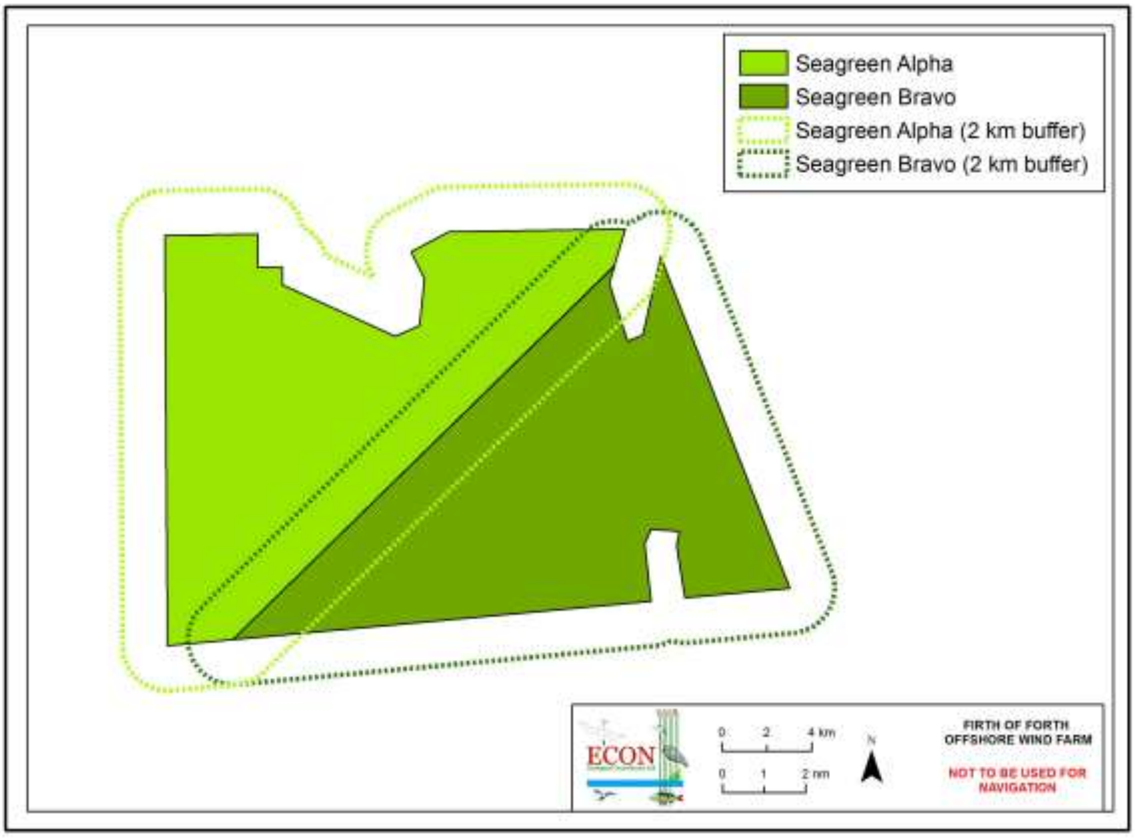

Figure 6. Relationship between Alpha, Bravo and the 2 km buffer areas of each site relative to the 2 km buffer around Alpha and Bravo combined.

3.1.24 As a result of a larger study area than just Alpha and Bravo combined, the average surveyed track length increased to 264.3 km including transits between transects. The number of transects was also larger compared to 2009-2011 at 12-13, with individual transect lengths varying from a minimum of 3.0 km to a maximum of 26.5 km depending on which route was being covered (Table 6). The mean transect length of all routes was 20.9 km. All transects were designed to be divisible into complete 500 m cells rather than strictly adhering to a length determined by the location of the 2 km buffer.

Survey methods

3.1.25 With the exception of flight height monitoring (see *Rangefinder flight height acquisition and verification* below), the survey methods remained consistent throughout. All surveys were carried out by ECON using experienced ornithologists trained to systematically record seabirds and migrant species using the methodological principles established by COWRIE (Camphuysen *et al*. 2004) based on the European Seabirds at Sea team (ESAS) method (see Tasker *et al*. 1984, Webb & Durinck 1992).

3.1.26 During a boat-based survey, two approaches are employed simultaneously to target different components of the ornithological assemblage. Birds on the water are sampled by the continuous line transect and in principle, are assumed to be stationary or at least recorded before any movement is initiated, with birds in flight sampled by regular instantaneous point samples or ‘snapshots’. The latter sampling technique effectively freezes birds in space and time in order to allow density to be calculated, as otherwise the movement of flying birds relative to the survey vessel would bias density estimation. Both sampling approaches typically aim to sample birds ‘within transect’ to a distance of 300 m (but see 3.1.28 below).

Table 6. Details of the number and length of transects for each transect route used during boat-based surveys between April 2017 and September 2017 inclusive.

Parameter	Route	Alpha	Alpha+2km	Bravo	Bravo+2km
Number of transects	1	9	11	8	10
	2	8	10	8	9
	3	8	10	7	9
Range of transect length (km)	1	2.0 – 3.5	1.5 – 18.5	1.0 – 14.5	3.0 – 18.5
	2	3.0 – 10.0	3.5 – 14.0	1.5 – 12.5	4.0 – 17.0
	3	2.0 – 13.0	3.5 – 17.5	2.0 – 13.0	3.0 – 17.0
Mean transect length (km)	1	6.3	9.6	6.6	10.6
	2	5.1	8.3	6.1	9.8
	3	6.9	10.4	7.4	10.8
Total transect length (km)	1	58.5	108.5	55.5	109.0
	2	57.0	109.0	55.5	106.0
	3	57.5	111.5	55.5	106.5

3.1.27 In the 2009-2011 surveys of Phase 1 as part of the Firth of Forth Round 3 zone ECON made a number of specific modifications to the standard methodology for the sole purpose of enhancing the value of the data for the assessment of offshore wind farms. These modifications have been routinely employed by ECON in surveys of a further seven Round 2 sites as well as two other Round 3 zones as noted in a previous review of methods by COWRIE (Maclean *et al*. 2009). The regulators and their advisory bodies in England, Wales and Scotland have previously approved these methods, and to ensure consistency, the same modified methods were also used in the 2017 surveys.

3.1.28 The survey method adopted, with amendments to ESAS methods, can be summarised as follows:

- Line transect surveys were carried out with a strip width of 300 m on both sides of the vessel (90° to port and starboard), rather than the single side advocated by ESAS (Figure 7). This allows effort to be maximised, enhances the probability of detecting rare species and provides more data for density estimation and spatial analysis;

- All birds on the water or in flight observed during line transects were recorded within bands of 0-50 m (A), 50-100 m (B), 100-200 m (C), 200-300 m (D), >300 m (E) width, perpendicular to the vessel;
- Discrete snapshots were taken at specified locations every 500 m, to ensure consistent coverage and sample effort along each survey line. The standard use of timed intervals can lead to variation in the number of snapshots resulting from changes in vessel speed and thus distance between snapshots under different conditions (e.g. tide, wave height);
- Flying birds observed during snapshots were recorded within radial bands of 0-50 m, 50-100 m, 100-200 m, 200-300 m and >300 m on each side of the vessel within a 180^o scan. This differs to the ESAS method of recording all birds within a 300 m^2 box (see 3.1.31 below);
- Flying birds were originally classified within three flight height bands: <20 m, 20-120 m and >120 m in 2009-2011. These divisions were based on the potential to be below, within and above potential strike heights respectively. During the 2017 surveys birds were also assigned to 5 m height bands, and an additional band of >0-1 m, to provide higher resolution flight distribution data;
- Two skilled ornithological surveyors (one for each side of the vessel) and a dedicated data recorder were used throughout.
- In 2017, a further expert seabird surveyor was present acted as a dedicated rangefinder operator. This was to carry out a supplementary survey of flight heights (see 3.1.42 below).
- In 2009-2011, a dedicated separate marine mammal observer (MMO) was employed, whilst in 2017 this role was also fulfilled by the ornithological surveyors;
- All birds were initially detected by eye with identification aided by the use of binoculars;
- Each observation was recorded in real time (hr:min:sec) rather than being assigned to a time bins. The time of each observation coupled with its location on either side of the vessel (port or starboard) and distance band allowed more accurate positioning in a Geographical Information System (GIS);
- Flight directions were recorded using eight compass bearings where appropriate, or as no specific direction (ND) or circling (C), often indicative of foraging activity or association with other individuals or the vessel;
- Additional information regarding, age, sex, plumage and behaviour of birds was recorded wherever possible;
- Ship speed was maintained at 8-10 knots whenever possible;

- Weather, cloud cover, sea state and a visibility score (Table 7) were recorded throughout. The latter may be used as a covariate in Distance analyses accounting for imperfect detection;
- No observations above sea state 5 were used in data analysis;
- Routine overhead and forward scanning was carried out especially for migrant passerines, waterfowl and waders in key migration periods, and

Table 7. Key to the visibility index score based on observer confidence of detection of birds on the water.

Visibility index score	Description of observer confidence
1 (very poor)	Can see all birds on the water in band A
2	Can see all birds on the water in bands A and B
3	Can see all birds on the water in bands A, B and C
4	Can see all birds on the water in bands A, B, C and D
5 (excellent)	Can see all birds on the water in transect and beyond

3.1.29 In addition to birds, the surveyors recorded all sightings of marine mammals. Records were made using the same format as for birds, that is species and sex wherever possible or relevant, side of vessel, distance band and activity. In addition, following JNCC methodology, a bearing to within 10^0 taking the bow of the vessel as 0^0 and estimated distance (m) was also recorded, to allow more accurate positioning of animals using GIS.

3.1.30 All data were entered into a database with quality control (QC) procedures to ensure accuracy of data entry. The QC procedure involved an independent check of the entered data against randomly selected entries on the raw data sheets.

3.1.31 One of the more significant methodological modifications is the employ of a radial snapshot method with radial distance bands, rather than the use of the ESAS ‘box’ assumed to be 300 m x 300 m according to the width of the transect (Tasker *et al*. 1984, Camphuysen *et al*. 2004). In fact, at the time of snapshot, 20% of the box area is actually >300 m from the observers, to a maximum of 424 m at an angle of 45^o (Figure 7). Therefore, during a snapshot scan, the surveyors are required to continually adjust the distance at which they should be scanning in order to place birds within the imaginary box. Moreover, surveyors are required to detect all flying birds irrespective of size and colour, position relative to the observer (perpendicular, flying away) and flight behaviour (high against the sky, low against the sea surface or a combination of the two) to a distance of 424 m.

3.1.32 As Barbraud & Thiebot (2009) illustrate, the detection function by eye may be virtually 1 for a variety of species at a distance of 100 m, but ranges from 0.87 down to 0.69 from large (albatross-sized) to small species (small petrels) at 300 m. In other words, 100% detection of birds of virtually any size is rarely achieved to 300 m, let alone beyond it. Potentially, all birds could be seen beyond 300 m through the use of binoculars, but surveyors would still be required to effectively place birds at different distances.

3.1.33 Therefore, whilst the box method allows estimation of relative measures of flying bird abundance, which may be perfectly adequate for the purposes for which it was designed, there are fundamental conceptual issues with its use to provide accurate density measures of flying birds which is critical in order to assess collision risk. As a result, ECON have routinely used a radial (arc) snapshot with a fixed distance of 300 m as previously adopted in a number of studies (e.g. Spear *et al*. 2004; Parsons *et al*. 2015).

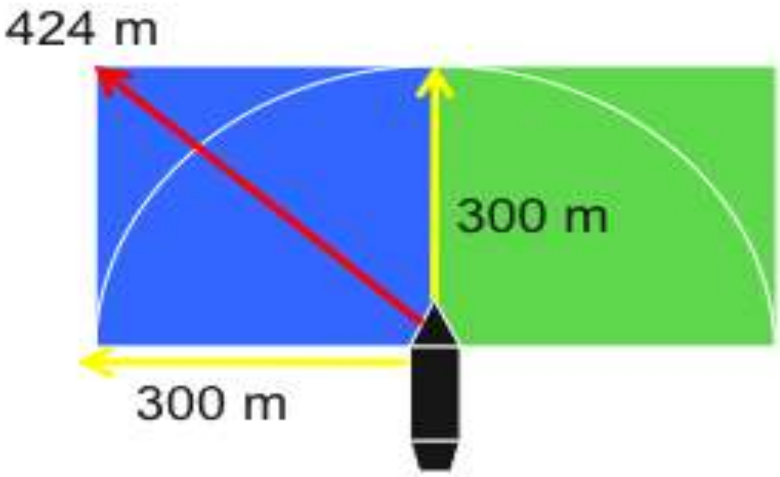

Figure 7. Diagrammatic representation of the area surveyed by the 'radial' method compared to the 'box' method each assuming a detection distance of 300 m. Birds are actually recorded to a distance of 424 m in the latter. The blue area represents survey of one side of the vessel often adopted by ESAS, whereas both sides of the vessel (blue and green areas) within radial bands were surveyed in the current surveys.

3.1.34 Whilst the radial snapshot method is intuitively likely to be less likely to underestimate flying bird density than the box method, to the best of knowledge there had been no test of the counts and densities supplied by the two different techniques. As a result, a preliminary comparison was undertaken on the additional survey of 27 October 2017 (Table 4). In this, a transect length of 148 km was surveyed using only 283 snapshots at fixed 500 m intervals adopting both box and radial snapshot methods simultaneously. Two surveyors accustomed to the box method (one exclusively so) each surveyed one side of the boat, which were combined to produce counts and according density estimates for a 600 x 300 m box with an area of 0.18 km^2. A single surveyor accustomed only to the radial method sampled both sides of the boat using a radial distance of 300 m giving a snapshot area of 0.141 km^2.

3.1.35 Only pairs of snapshots in which at least one flying bird was recorded by either technique were taken forward for analysis comprising *n*=120 for all birds combined, *n*=63 for Black-legged Kittiwake, *n*=35 for Razorbill, *n*=21 for Common Guillemot and *n*=13 for Common Gull *Larus canus*. Too few records of European

Storm Petrel *Hydrobates pelagicus*, Northern Fulmar *Fulmarus glacialis*, Northern Gannet, Great Black-backed Gull *Larus marinus*, European Herring Gull, Little Gull *Hydrocoloeus minutus*, Little Auk *Alle alle* and Atlantic Puffin were obtained to enable species-specific comparison, but were all included in the 'all birds' comparison.

3.1.36 Shapiro-Wilk tests showed both count and density data were not normally distributed and thus non-parametric methods were used. Wilcoxon signed rank tests for paired data with continuity correction in R software (R Core Team 2017) revealed no significant differences in counts between the two techniques (Figure 8, Table 8) despite the difference in the area being surveyed.

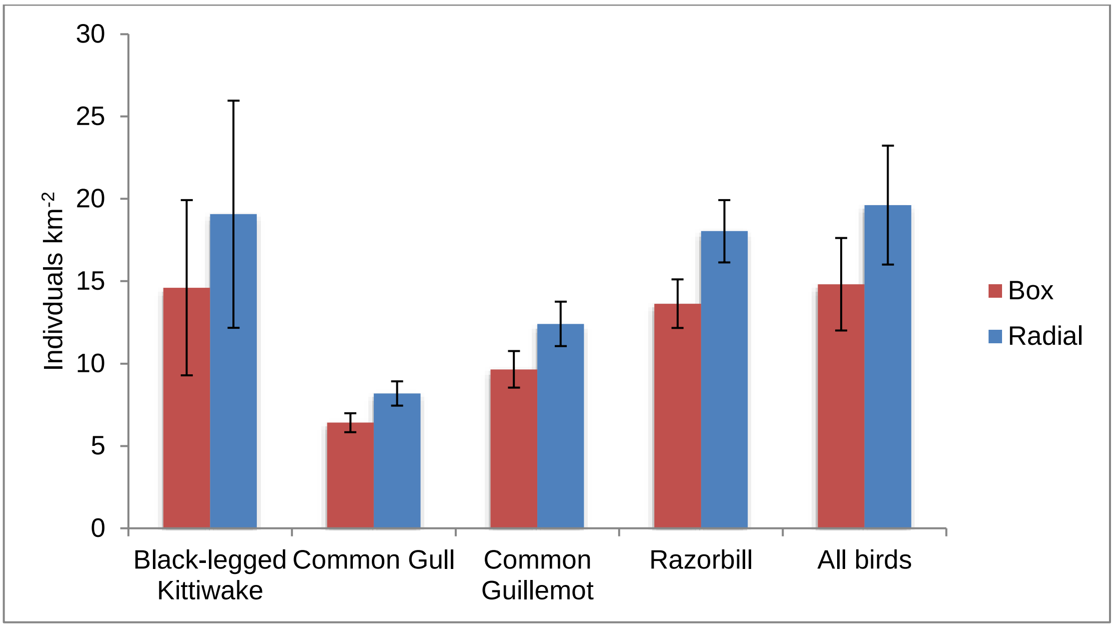

Figure 8. **Mean density (± 1 standard error) derived using the box and radial snapshot methods for the variety of medium-sized seabirds sampled as well as 'all birds' comprising a range of large to small species.**

Table 8. **Results of Wilcoxon signed rank tests for paired data derived from box and radial snapshots for each species and all birds combined. Data on wingspan and length from https://www.bto.org/about-birds/birdfacts**

Species	**Wingspan (m)**	**Body length (m)**	***n***	**Count**	**Densities**
Black-legged Kittiwake	1.08	0.39	63	V=30.5 p =0.527	V=54 p<0.001
Common Gull	1.20	0.41	13	V=0 p=NA	V=0 p<0.001
Common Guillemot	0.67	0.40	21	V=9.5 p=0.916	V=18 p<0.001
Razorbill	0.66	0.38	35	V=63 p=0.517	V=0 p<0.001
All birds			120	V=86.5 p=0.190	V=653 p<0.001

3.1.37 A closer investigation of the data revealed that there were only three occasions on which additional single birds were recorded in a box relative to a radial snapshot, strongly suggesting that surveyors did not generally see birds at distances greater than 300 m. As a result, significantly higher densities of all species (and group) considered were recorded in radial compared to box snapshots (Table 8, Figure 8), simply because of the greater area used in the latter relative to the similar number of birds seen.

3.1.38 Notwithstanding that further comparison is required for both small and large species such as Northern Gannet or large *Larus* gulls, and under different conditions (including vessels), it is concluded that the box method is likely to significantly underestimate the density of (at least medium-sized) flying birds simply because the larger sample area of the box is not effectively sampled. As such, the previous comment in the Seagreen (2012) paragraph 10.3.25 that *"To ensure comparability between densities of flying birds generated from the ESAS method gathered at other sites and to allow assessment in a cumulative context, it is recommended that any density derived from the latter be corrected by a factor of 1.28 to account for the likely area sampled (0.141 km^2) compared to the area assumed (0.18 km^2)"* is upheld. The alternative for comparison with data gathered from other sites is to adjust the densities derived by the snapshot method at Seagreen Alpha and Bravo by a factor of 0.78.

Rangefinder flight height acquisition and verification

3.1.39 The development of collision risk modelling (CRM), particularly the use of various options in Band (2012), has highlighted the importance of flight height estimation to more accurately determine the numbers of birds at risk (Johnston *et al*. 2014), which may be critical to consent. Accordingly, many offshore wind farm surveys now confidently place birds into 5 m height bands, although the ability of surveyors to estimate flight height of birds accurately remains in question (Cleasby *et al*. 2015).

3.1.40 During the 2009-2011 surveys, the height of flying birds was recorded in three coarse bands: 1 = < 20 m, 2 = 20-120 m and 3 > 120 m, broadly in line with potential collision risk and accepting that flight height may be difficult to estimate with no reference structures (Seagreen 2012ab). However, during the 2017 surveys the aim was to place birds within 5 m bands and to assess the reliability of the surveyors to do so.

3.1.41 Accurate determination of flight height can be achieved using rangefinders (Skov *et al*. 2012). Moreover, Recent work on Sandwich Tern *Thalasseus sandvicensis* by Perrow *et al*. (2017) has shown that a low-cost laser rangefinder (Nikon Forestry Pro) can be reliably used to verify flight heights of birds from boats even in difficult circumstances such as from a rigid-hulled inflatable travelling at high speed, although this requires a high degree of user aptitude. Comparing flight height estimates made by surveyors and by rangefinder measurements provides a means of judging accuracy and therefore confidence in derived flight height distributions.

3.1.42 A fourth surveyor was therefore employed on all surveys to undertake a dedicated, simultaneous survey of flight heights using a Nikon Forestry Pro laser rangefinder (see Figure 4 inset). This surveyor occasionally swapped roles with the main data recorder and thus two rangefinder operators were used. During surveys, the operator attempted to acquire targets and obtain readings from all species of birds encountered at a variety of distances and flight heights. The species, flock size, and a specific ID number assigned to location recorded as a waypoint on a hand-held GPS.

3.1.43 Where a successful reading was achieved, the vertical height and lateral distance relative to the rangefinder unit were recorded alongside the flight height assigned by a surveyor at the same time as part of the survey. The specific ID number was also translated to the data recorder. Where the rangefinder reading was obtained at a different time to the initial observation, a further updated flight height estimate was requested and recorded to ensure direct comparison. For some records, a target bird was not part of the survey, for example when encountered during transit. In this circumstance, one or more surveyors were asked to estimate the height of the bird. In all cases, the surveyor estimating the height of the target bird was not informed of the reading from the rangefinder, so in general, only the two rangefinder operators had the opportunity to learn and subsequently improve their performance in estimating flight height.

3.1.44 Records of flight heights were obtained over all parts of the study area including on transit to and from and within the study area, over the six surveys from May to October (Figure 9). In total, 1,423 records were obtained from 17 species, with a focus on the six key species, contributing 90% of records. Of these, most records were obtained from Black-legged Kittiwake (*n* = 634), followed by Northern Gannet (*n* = 411), Common Guillemot (*n* = 157), European Herring Gull (*n* = 47), Razorbill (*n* = 26) and Atlantic Puffin (*n* = 5). Records also included birds on the sea surface as a check of rangefinder ability and accuracy. The bulk of the records of birds on the sea surface (*n* = 177) were from auks (72%).

3.1.45 The data for each species are discussed briefly in each species account, with a full account of the methodology, the use of the rangefinder, calibration of the accuracy of the rangefinder and variation between surveyors undertaken in Appendix 1. Suffice it to say here that in general terms the rangefinder appeared to perform satisfactorily, but with the key limitation of being able to sample birds at relatively close distance, which is also a function of bird size. This is clear from the plots of cumulative records of Black-legged Kittiwake and Northern Gannet with maximum distances of records being around 150 and 200 m respectively (Figure 10[4]). Accordingly, some 50% of the records for the smaller Black-legged Kittiwake (wingspan of 108 cm and body weight of 410 g) were obtained at ~60 m from the observer, with those of the much larger Northern Gannet (wingspan of 172 cm and body weight of 3 kg) at ~95 m.

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[4] Note a few individuals of each species, comprising two Northern Gannets and three Black-legged Kittiwakes did not have a measurement of horizontal distance from the observer.

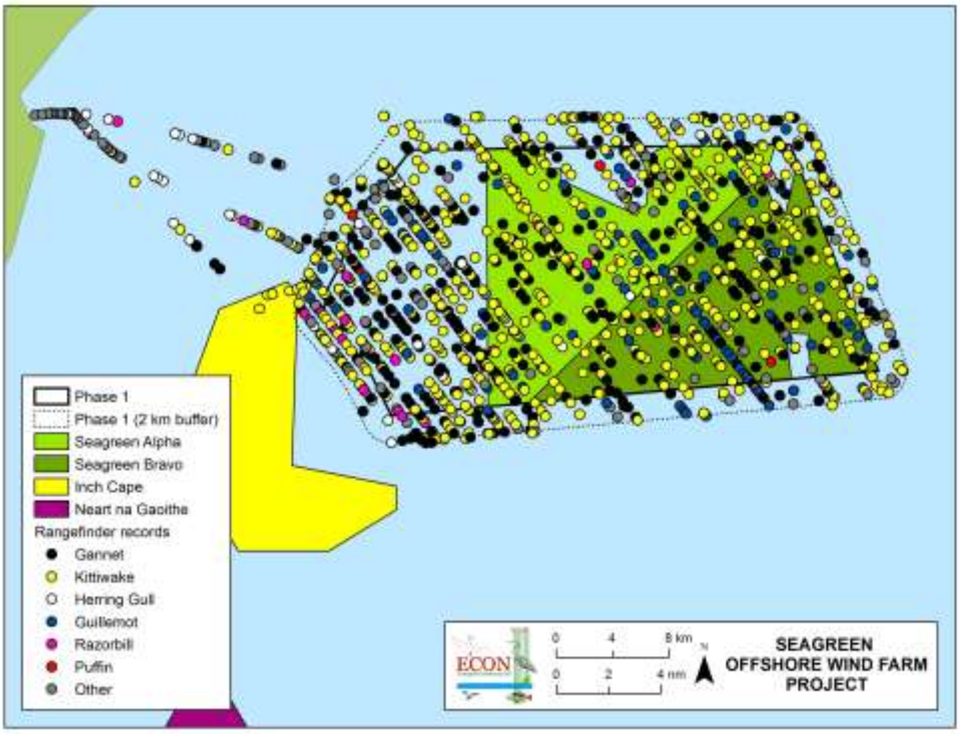


Figure 9. **Location of all 1,423 rangefinder flight height records assigned to different species during all surveys from May to October 2017 inclusive.**

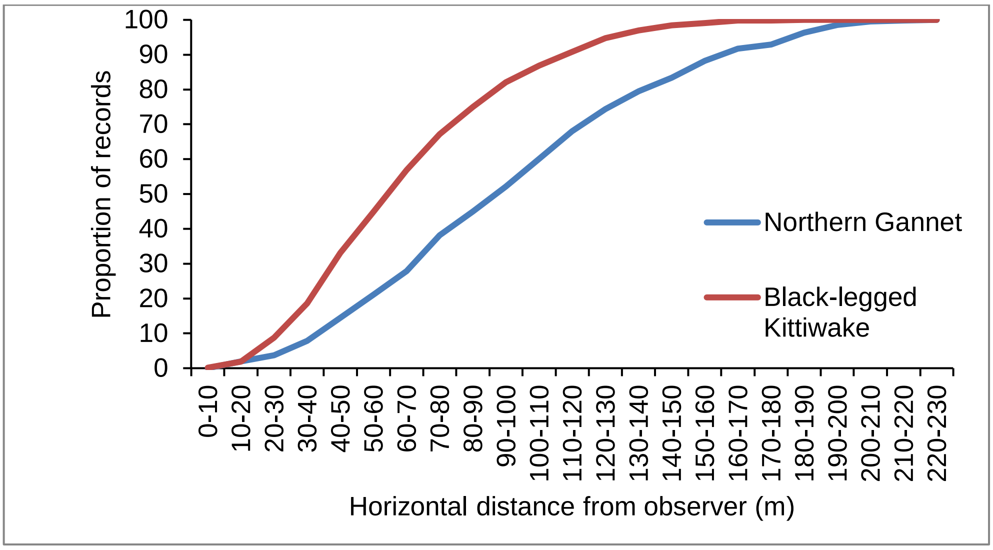


Figure 10. **Cumulative frequency curves of the proportion of records obtained for Black-legged Kittiwake (*n* = 631) and Northern Gannet (*n* = 409) at increasing horizontal distance (m) from the observer. Records are assigned to 10 m distance categories.**

3.2 Density & population estimation

3.2.1 Data from the two sets of surveys (2009-2011 and 2017) were analysed separately due to differences in surveys routes, surveyors and survey vessels. The methods described below were applied to both datasets with any differences in approach described where necessary.

3.2.2 In both survey periods, for the purpose of analysis, the area covered by each transect (Figure 5) was divided into a linear series of abutting 500 x 600 m cells, that incorporated a 500m length sampled by the continuous transect for birds on the water to 300 m either side of the vessel, and a radial snapshot of 600 wide (300 m either side of the vessel) extending in an arc 300 m from the observers. The area sampled by each snapshot (0.141 km^2) conducted at 500 m intervals was taken to be representative of each cell even though the entire area of each cell was not sampled in a snapshot.

3.2.3 In 2009-2011, the length of transect was determined by the area of the sites to be sampled and was thus not necessarily divisible by 500 m (see Table 5). As a result, it was judged by eye whether the majority of a cell or snapshot fell within a particular part of the area to be calculated (e.g. the Alpha site) and whether the data contained therein was to be included in density calculations.

3.2.4 In 2017, transects were set up to be divisible by 500 m (see Table 6) and only cells or snapshots that were entirely within each area of interest (e.g. the Alpha site) were considered during calculations. Thus, there were some cells which fell on the boundary between the adjacent project that were not included in the estimates for the individual projects but were used for the combined site. Other cells fell into both the individual Alpha and Bravo sites when the 2 km buffer was included due to the overlap in the buffers for the sites (Figure 6).

3.2.5 Standard simple densities of birds on the water were calculated from the number of birds in transect (300 m either side of the vessel) divided by the entire line transect survey area, that is the transect length multiplied by the transect width of 600 m.

3.2.6 Densities of flying birds were derived from the total numbers seen in radial snapshots, divided by the total area surveyed by snapshots (survey effort); that is the number of snapshots multiplied by the snapshot area of 0.141 km^2.

3.2.7 In 2017, confidence intervals were also estimated for simple density estimates of birds on the water and for birds in flight using survey cell and snapshots as repeat sample units. This allowed mean survey densities and upper and lower 95% confidence intervals (2SE) to be calculated for the species or importance to the assessment.

3.2.8 Species-specific densities (ind. km^{-2}) of birds on the water and flying birds were then combined in two ways: 1) adding standard ESAS density calculations for birds on the water to the density of birds in flight assuming all birds were seen, and 2) using a Distance sampling correction for birds on the water (Buckland *et al*. 2001, 2004, Thomas *et al*. 2010) added to the (standard) density for birds in flight.

3.2.9 Surveying animals by eye carries the potential for decreases in detectability with distance, resulting in negatively biased population estimates (e.g. Skov *et al*. 1995, Ronconi & Burger 2009). This is especially likely for relatively small species on the water, such as auks. Detection is also likely to change according to sea state amongst other factors. Distance analysis, employing Distance software v6.2 (Thomas *et al*. 2010) is be used to analyse variations in the detectability of birds and correct density estimates accordingly. Buckland *et al*. (2001) define the central concept of Distance analysis as the modelling of the detection function, $g(x)$, which is the probability of detecting an object (a bird or group of birds), given that it is at distance x from a transect line or point. For further details of the application of Distance analysis see Buckland *et al*. (2001, 2004).

3.2.10 Distance correction analysis makes several important assumptions about the nature of the data: 1) the distribution of birds is random with respect to the transect line, 2) birds are non-aggregated and are evenly distributed across all distance bands and 3) all birds on the transect line at distance 0 (band A in this case) are detected (Thomas *et al*. 2010). Given Distance analysis was only applied to birds on the water, there was limited scope for birds to be attracted to, or be associated, with the vessel. However, where this did occur, or where birds were associated with other vessels (e.g. fishing boats), observations were excluded from the analyses. It was also assumed that birds were identified and located in distance bands prior to any response (flushing, swimming or diving) to the vessel, which might violate the assumptions of Distance correction (Buckland *et al*. 2001).

3.2.11 Models were fitted using various key functions (uniform, half-normal, hazard-rate or negative exponential), with or without adjustment terms (e.g. cosine, simple polynomial or hermite polynomial). Sea state was also investigated as a model covariate. The ‘best’ model was selected based on evaluation of the shape of the detection functions, Akaike Information Criterion (AIC) values and Chi-squared test results for grouped data and coefficients of variation (*cv*). Density estimates were then derived for each area component using either a size-biased regression of log cluster size against estimated $g(\mathrm{x})$ where significant or a mean cluster size where it was not.

3.2.12 Distance analysis was carried out in slightly different ways using the two sets of survey data from 2009-2011 and 2017 (see Seagreen 2012ab and Seagreen 2017b respectively for further detail on the analyses carried out). The original analyses used survey and site-specific detection functions to generate density estimates given sufficient data, with data pooled across surveys where this was not possible. In contrast in 2017, given the small number of surveys over a single breeding season, all data were pooled to maximise the data informing the detection functions. Data from the whole survey area was also used in 2017 to inform the models, producing a single detection function for each species, with post-stratification used to produce site specific estimates.

3.2.13 For the key species to be considered in EIA/HRA (Table 2), Distance corrections for birds on the water could be derived for Black-legged Kittiwake, Common Guillemot, Razorbill and Puffin on the water across all surveys. Too few records were obtained for European Herring Gull, and for Northern Gannet, models suggested that Distance correction was not required (see Figure 11 for examples from 2017).

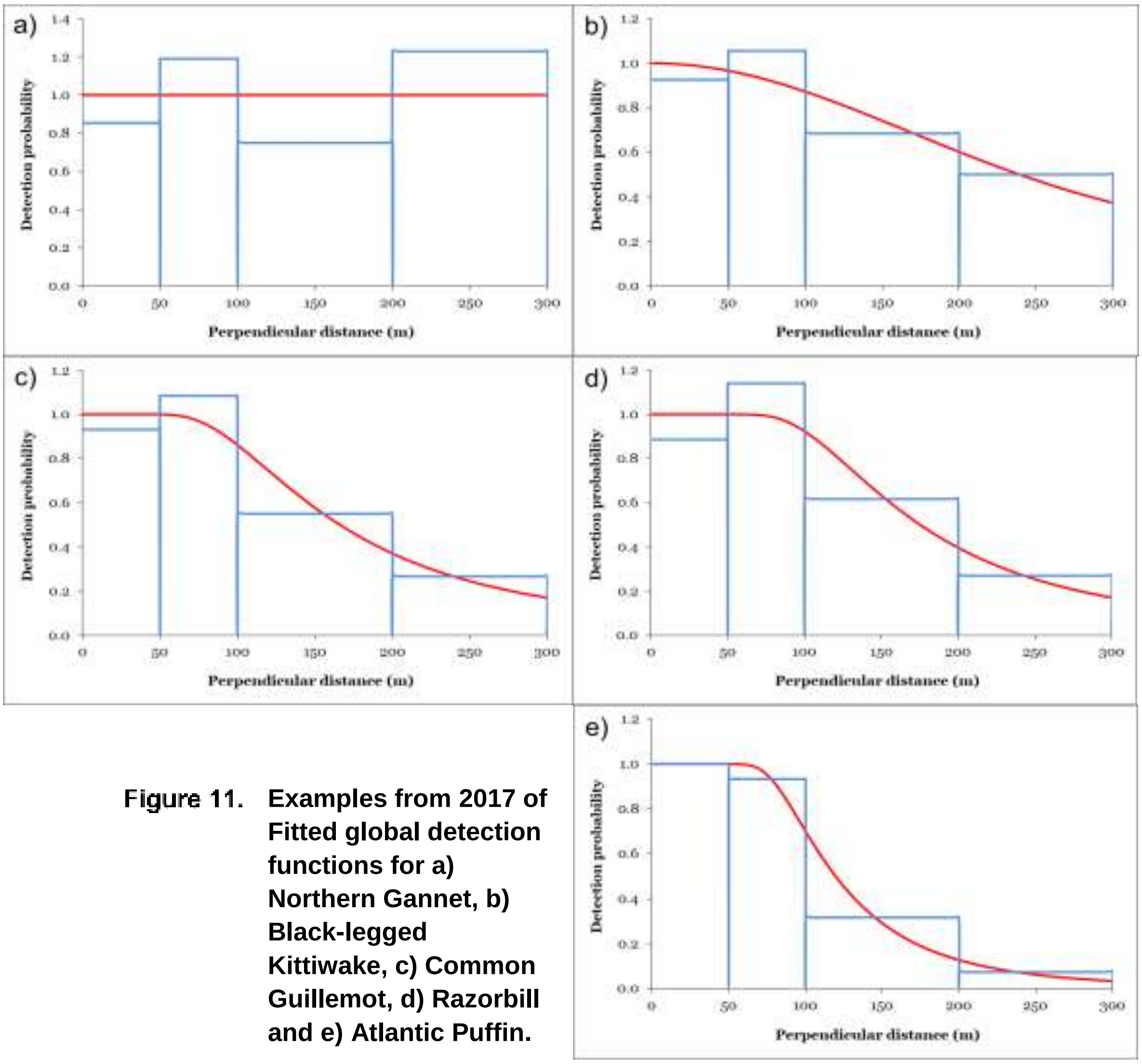


Figure 11. Examples from 2017 of Fitted global detection functions for a) Northern Gannet, b) Black-legged Kittiwake, c) Common Guillemot, d) Razorbill and e) Atlantic Puffin.

3.2.14 A summary of the results of distance correction models in 2017 is provided in Table 9. Global correction factors (CFs) were derived from the surveyed transect distance for one side of the vessel (i.e. 300 m) divided by the estimated strip width (ESW). The ESW represents the area under the detection function curve, or the distance to which the expected number of birds matches the observed numbers (Buckland *et al*. 2001). In the case of Northern Gannet, a model derived ESW of 300 m, reflects the lack of any drop-off in detection with distance and the resultant CF of 1.00.

Table 9. **Summary of Distance analyses for relevant species. The number (n) of observations (obs) used, description of the 'best' models, associated coefficients of variation (% CV), effective strip widths (ESWs) and resulting correction factors (CFs) are provided for each species.**

Species	Selected model	N obs	% CV	ESW (±SE)	CF
Northern Gannet	Uniform with no adjustment	232	14.2	300.00 (0)	1
Black-legged Kittiwake	Half-normal with no adjustment + factor sea state	569	14.7	217.57 (5.10)	1.38
Common Guillemot	Hazard rate with no adjustment + factor sea state	3,388	7.26	182.23 (2.02)	1.65
Razorbill	Hazard rate with no adjustment + factor sea state	1,063	9.61	189.96 (3.60)	1.58
Atlantic Puffin	Hazard rate with no adjustment + factor sea state	643	9.71	135.73 (4.04)	2.21

3.2.15 For the other species, there was a decrease in detectability of birds with distance, with the inclusion of sea state in all models, illustrating the importance of environmental conditions on detectability (Table 9). In more detail, the fitted model for Black-legged Kittiwake showed there was some decline in detections at greater than 100 m, with this being even steeper for Common Guillemot and Razorbill consistent with their size and colouration, which led to lower ESW's and increased CF's. The even smaller Atlantic Puffin showed the steepest drop-off in detectability, lowest ESW and thus the highest CF the species sampled (Table 9).

3.2.16 Population sizes were estimated by multiplying combined densities (of birds on the water and in flight) by the relevant area (e.g. of the site). For some species where density could not be derived, a crude population estimate was derived by extrapolating the number of individuals of a species seen within the estimated area surveyed (a maximum detectability to 500 m either side of vessel was assumed) and scaling this to the area of the site in question (i.e. total study site area / transect area × total counts).

3.2.17 Density and population estimates were derived for the different project areas incorporating Alpha, Bravo and Alpha and Bravo combined. The densities for Alpha and Bravo for 2009-2011 were taken from the original ES for the consented sites (Seagreen 2012b), with some corrections made to values in the Seagreen (2013) document that provided information to inform AA.

3.2.18 As the revised new project envelope considers a specific combined site for Alpha and Bravo that contains a specific number of turbines and is not simply Alpha and Bravo added together, densities were required for the combined site for the purposes of assessment. However, an Alpha and Bravo combined area was not considered as a separate entity in the historic assessments (Seagreen 2012b, 2013). Therefore, to produce density estimates for the combined site scenario, populations of birds in Alpha and Bravo derived in 2009-2011 were summed and divided by the combined area.

3.2.19 The current assessment methodology (see Marine Scotland 2017) also requires the inclusion of estimates for the project areas with associated 2 km buffers. As information was only available to inform estimates including the buffers in 2017, a pragmatic approach to scaling densities for the respective project areas in 2009-2011 without 2 km buffers had to be adopted and agreed with the SNCBs (at a technical meeting held with MS and SNH on 6 March 2018). The approach was to calculate scaling factors based on the densities in each project area relative to the densities for the project area including a 2 km buffer using the 2017 data (Figure 6). This was undertaken for each of the species considered for displacement; namely Black-legged Kittiwake, Common Guillemot, Razorbill and Atlantic Puffin, although for completeness scaling factors were also produced for Northern Gannet and European Herring Gull.

3.2.20 The mean proportional differences (Table 10), based on the five 2017 surveys, were used to adjust the historic survey densities for the project areas alone accordingly. The results suggested that Atlantic Puffin (and Northern Gannet) densities were very similar when including the buffers, likely due to the species being relatively evenly distributed across the area.

Table 10. Density scaling factors (±1SD) for each project + 2 km buffer relative to each project area alone.

Species	Alpha	Bravo	Alpha + Bravo
Puffin	1.004 (0.099)	1.068 (0.347)	1.023 (0.122)
Razorbill	1.339 (0.437)	1.125 (0.649)	1.228 (0.509)
Guillemot	1.214 (0.286)	0.959 (0.180)	1.098 (0.235)
Kittiwake	1.489 (0.620)	1.126 (0.234)	1.381 (0.377)
Gannet	1.007 (0.213)	0.967 (0.126)	0.963 (0.165)
Herring Gull	1.290 (1.548)	0.397 (0.265)	1.971 (1.795)

3.2.21 Razorbill and Black-legged Kittiwake, two species that are often associated with each other, showed similar patterns, with the greatest increases as a result of the inclusion of the 2 km buffer in relation to Alpha compared to Bravo and Alpha and Bravo combined. This is in accordance with the buffer area on the western edge of Alpha including an area near Scalp Bank. A similar pattern was noted for Common Guillemot.

3.2.22 Very low densities of European Herring Gull were generally recorded resulting in the species sometimes being included in a 2 km buffer area when not present in a project area. This led to more extreme and diverse scaling factors that are seen to be unreliable and not recommended for use.

3.2.23 It is important to note that the final density estimates may need to be adjusted for the purposes of cumulative assessment to account for discrepancies between box and radial snapshot methods, according to the principles set out in 3.1.38 above.

3.3 Spatial distribution

3.3.1 In both 2009-2011 and 2017, actual observations of all birds, including the group size, were plotted in ESRI ArcGIS v.10/10.1 for each species by positioning each record relative to the location of the vessel at ten second intervals and then calculating an offset based on the side of the vessel and assigning the midpoint of the distance band in which the observation had been made (i.e. at 75 m from the vessel in band B which occupies the area 50–100 m from the vessel). On the few occasions birds were recorded outside of transect, they were assigned a distance of 400 m for the offset.

3.3.2 In 2009-2011 basic maps (as ‘bubble plots’) were produced for each survey in a standalone survey report but were not reproduced as a compilation of data in the subsequent Technical Report (Seagreen 2012a) or subsequent ES (Seagreen 2012b) or information to inform AA (Seagreen 2013). Bubble plots for each survey and for all data were however produced for the Technical report of the 2017 data (Seagreen 2017b). There was no scope for reinvestigation of the data in relation to this report and as a result, only previously available maps of spatial distribution are provided.

3.3.3 In 2009-2011, in order to allow meaningful interpretation of spatial patterns of bird abundance across the Alpha and Bravo sites and to fit with the basic design of surveying different routes that ultimately provided more or less equivalent survey effort over ~80% of the entire area of Alpha and Bravo (see 3.1.13 above), a grid-based design was adopted as has been used in many previous studies (Stone *et al*. 1995, Ford *et al*. 2004, Camphuysen 2005, 2011). This involved overlaying a grid of 1 km^2 cells over the sites within GIS, with the aim of expressing the abundance of birds within each 1 km^2 cell.

3.3.4 With no ready means of pooling records of birds in the different modes of activity i.e. either on the water or flying, these were treated separately, and plots produced for each species according to their principal mode of activity. In relation to the species in this report, Northern Gannet, Black-legged Kittiwake and Herring Gull, tend to be recorded in flight whereas Common Guillemot, Razorbill and Atlantic Puffin are pursuit divers and tend to be recorded on the sea surface.

3.3.5 A key component of the analysis conducted was to compensate for both any differences in survey effort within each 1 km^2 cell and any differences in detectability of any species according to the conditions encountered between surveys. To begin the process, each survey route area covering Alpha and Bravo was plotted in ArcGIS v.10 and the areas of each of the 444 cells surveyed by each route calculated. Each geo-referenced bird observation (with count) was then also assigned to a cell for each survey. This resulted in both a measure of the area of each cell surveyed and the numbers of birds seen in that cell. For each survey and each cell the numbers of birds were divided by the area surveyed by the respective route.

3.3.6 According to the methods of Ford *et al*. (2004), a weighted mean of estimated abundance was then calculated for a period of interest to take into account the proportion of each cell covered by each survey route. The results were then plotted using coloured cells to represent variations in abundance across the sites.

3.3.7 To eliminate the need for differential distance buffer of birds on the water between surveys, which may change radically according to sea state, only records from distance bands A and B were used as these did not show any apparent drop-off in detection. In effect therefore, it was assumed that 100% of birds were detected up to 100 m from the vessel as a natural extension to the assumption in DISTANCE of detection of all birds in distance 0 (usually band A).

3.3.8 The strip transect for each survey route was therefore 200 m over both sides of the vessel compared to the 300 m standard for one side. Areas of each cell surveyed by the adjusted strip transects were recalculated and again the numbers of birds seen in each cell were extracted in GIS. The same calculations were then performed to provide weighted mean abundance estimates for each cell and the results were plotted to allow interrogation of potential patterns in distribution. As it was assumed that all birds were detected within the line transect, the results for each cell could be expressed as absolute density (individuals km^{-2}).

3.3.9 For flying birds, snapshot data was seen to be spatially restricted and thus of limited value in assessing patterns of distribution. Therefore, records of all individuals encountered in flight in the line transect of distance bands A to D inclusive was used as an expression of relative abundance. For the purposes of analysis it was assumed that there was no decline in detectability over 300 m (even though this may not be true for at least some species – see 3.1.32 above), and thus records from the full strip transect width of 600 m (300 m either side of the vessel) could be used.

3.3.10 In 2017, a different approach to describing patterns of distribution and in particular to indicate areas of intense use was adopted using Kernel Density Estimation (KDE). KDE produces a smoothed surface of relative density by placing weighted Gaussian curves (the kernels) over observations within a given bandwidth (Worton 1989, O'Brien *et al*. 2012).

3.3.11 As for 2009-2011 data, only the records relating to the primary mode in which each species was encountered was used for KDE analysis i.e. Northern Gannet, in flight (86% of the total records) and birds on the water for Common Guillemot Razorbill and Atlantic Puffin (82%, 84% and 89% of records respectively). For Black-legged Kittiwake, the division between observations of birds on the water (21%) and birds (79%) was less biased to one mode or the other and on one of the surveys the proportion of birds on the water increased to 38%. Thus, for the KDE on this species the estimates of birds on the water were combined with those of birds in flight. Due to the very low numbers of observations, no KDE surface could be generated for European Herring Gull. To generate an overview of the distribution of all bird species a KDE surface was generated by combining simple densities derived from the respective methods for birds on the water and for birds in flight.

3.3.12 Prior to the application of KDE (apart from for European Herring Gull), counts of birds on the water in each survey cell measuring 600 m width by 500 m length were corrected using the same Distance models described in 3.2.12 above. The counts of birds on the water were then standardised as densities (ind. km^{-2}) and, in the case of Black-legged Kittiwake, added to densities of flying birds derived from snaps for the corresponding cells. If a snapshot had been missed, the cell was excluded from the analysis.

3.3.13 The cell centroids (midponts) were used for the geographic location of each abundance estimate for each survey. As three different routes were surveyed, with two of them being repeated during the programme, the survey coverage and effort varied spatially. Thus, an average cell value was derived from the repeated surveys and the single values from the route that was not repeated.

3.3.14 Using the ESRI ArcGIS v10.1 Spatial Analyst package, KDE analysis was then applied to the combined data from the three routes to generate a single surface of relative abundance. In this context, KDE estimates the density of point features (birds in this case), around each raster cell comprising a surface over the study area. A curved surface is fitted over each point with the value decreasing with distance from each point to zero at the extent of the search radius or ‘bandwidth’ within a circular neighbourhood. The volume under the surface equals the bird density value for the point. The final density for each raster cell is estimated by summing the values of all the kernel surfaces that intersect the raster cell centre. The kernel function is based on the quartic kernel function described in Silverman (1986).

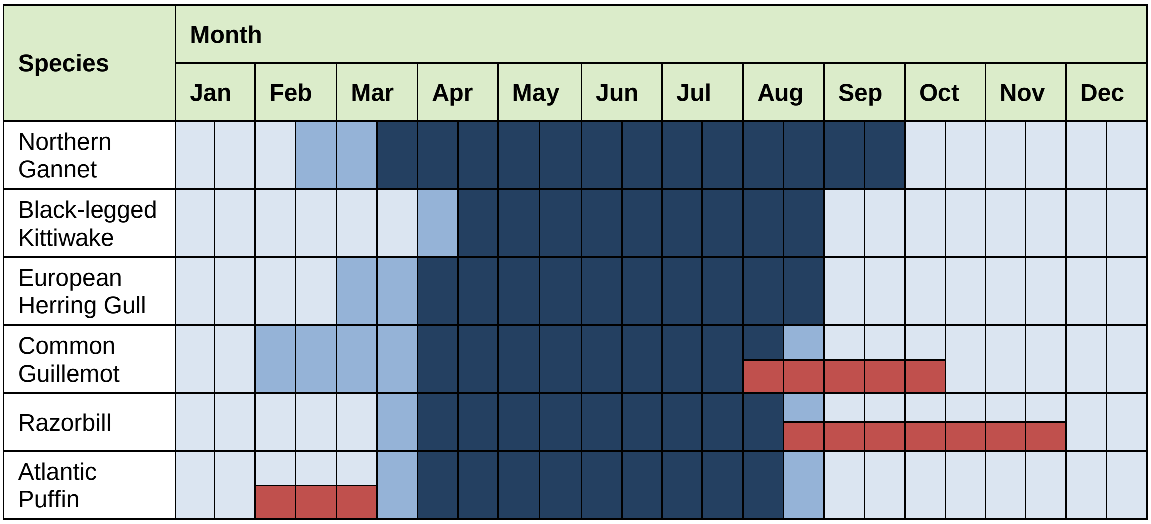
3.3.15 A smoothing factor or ‘bandwidth’ of 3 km was used. This was the distance between transect lines on the same routes and ensured data from individual transect lines were not conspicuous, that is, there was no ‘banding’ as a result of data from individual lines receiving the greatest weight. The raster cell size was selected as 500 m^2, in accordance with the distance between consecutive cell centroids on any given line and in order to retain detail in the derived surfaces.

3.3.16 The output of the KDE was a surface of relative density, with a grid resolution of 500 m^2 as the smoothing factor, covering the entire study area. The resultant surfaces were clipped (limited) to the boundaries of the study area so that only relevant estimates were included in the maps.

3.4 Breeding and non-breeding seasons

3.4.1 The breeding seasons for each species are identified in the individual species accounts, according to that specified by SNH in the Scoping opinion of Marine Scotland (2017), as shown in Table 11. The different species have subtly different phenological periods in relation to breeding and non-breeding as well as the moult period in relation to auks when birds are flightless (Table 11). These periods as defined form the basis of assessment of impacts upon breeding species, particularly for HRA as well as combined impacts across breeding and non-breeding seasons, of particular relevance to EIA. In this report, the relevant breeding periods are recognised in relevant text and tables.

Table 11. Key seasonal periods for important seabirds in the Scottish Marine Environment (adapted from Tyler 2017).



Species	Month																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Northern Gannet	□	□	□	▨	▨	■	■	■	■	■	■	■	■	■	■	■	■	■	□	□	□	□	□	□
Black-legged Kittiwake	□	□	□	□	□	□	▨	■	■	■	■	■	■	■	■	■	□	□	□	□	□	□	□	□
European Herring Gull	□	□	□	□	▨	▨	■	■	■	■	■	■	■	■	■	■	□	□	□	□	□	□	□	□
Common Guillemot	□	□	▨	▨	▨	▨	■	■	■	■	■	■	■	■	■ 🟥	▨ 🟥	□ 🟥	□ 🟥	□ 🟥	□	□	□	□	□
Razorbill	□	□	□	□	□	▨	■	■	■	■	■	■	■	■	■	▨ 🟥	□ 🟥	□ 🟥	□ 🟥	□ 🟥	□ 🟥	□ 🟥	□	□
Atlantic Puffin	□	□	□ 🟥	□ 🟥	□ 🟥	▨	■	■	■	■	■	■	■	■	■	▨	□	□	□	□	□	□	□	□

Breeding phase	Colour
Breeding period (strongly associated with nest site)	■
Breeding site attendance (not closely associated with nest site)	▨
Flightless moult period	🟥
Winter period (non-breeding)	□

3.4.2 For most of the species of concern, April-August inclusive encapsulates the breeding period, although only for European Herring Gull is this seen to be entirely definitive. For Black-legged Kittiwake, the first half of April is defined as one of attendance at the breeding site, whereas for the auks, Common Guillemot, Razorbill and Atlantic Puffin, only the first half of August is strictly associated with breeding, with this merging into a period of colony attendance and/or the flightless moult period for the Common Guillemot and Razorbill. Moreover, this period is also likely to broadly coincide with the time which chicks are encountered at sea with their male parent. Northern Gannet has an extended breeding period beginning in the latter half of March and extending into September.

3.5 Reference ranges & population sizes

3.5.1 Marine Scotland (2017) suggested the most applicable foraging range criterion for use in assessment was the mean maximum foraging range as derived by Thaxter *et al*. (2012). This value is shown for the six breeding species of most concern in Table 12. In order to determine which colonies of each species may be in range of the Phase 1 project area, this value for each species was applied as a contour around the area within GIS and compared with the location of all recorded colonies downloaded from the online SMP database (http://jncc.defra.gov.uk/smp/) for each species within this area of overlap. An example is shown for Black-legged Kittiwake in Figure 12.

Table 12. **Mean maximum foraging range (km) as determined by Thaxter *et al.* (2012) of the breeding seabirds subject to EIA/HRA with the potential to occur or are known to occur within the Phase 1 project area.**

Species	Mean maximum foraging range (km)
Northern Gannet	229.4
Black-legged Kittiwake	60.0
European Herring Gull	61.1
Common Guillemot	84.2
Razorbill	48.5
Atlantic Puffin	105.4

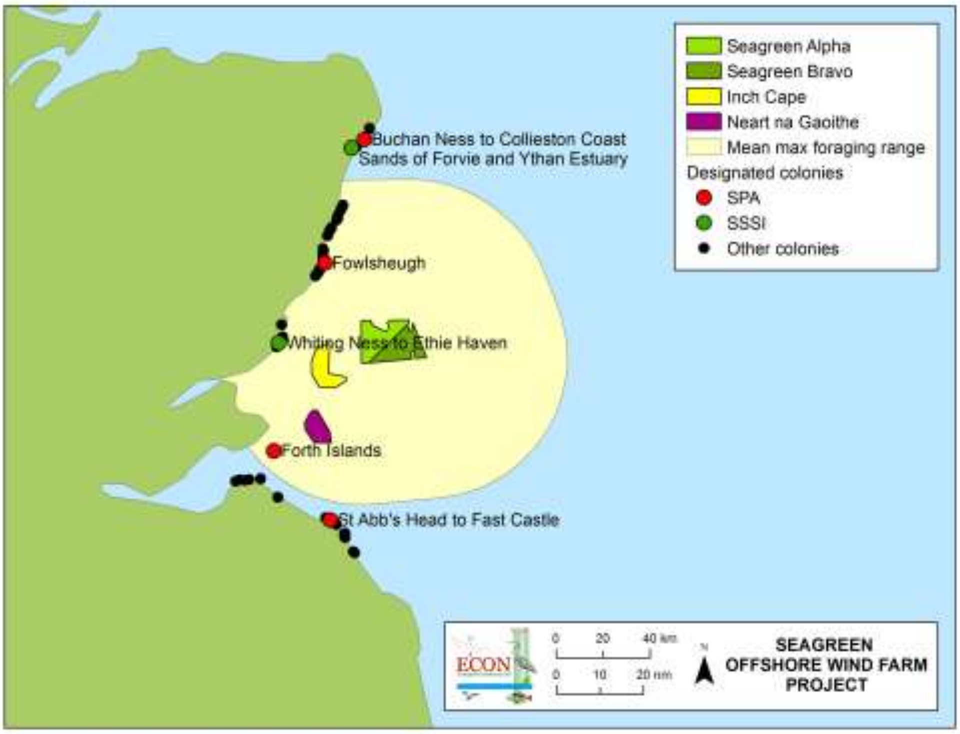


Figure 12. **Distribution of Black-legged Kittiwake breeding colonies including SPAs and SSSIs contained within the mean maximum foraging range relative to the Alpha and Bravo combined.**

3.5.2 It is immediately apparent from Figure 12 that two of the four SPAs for which assessment is required in relation to Black-legged Kittiwake (see Table 2), namely Buchan Ness and Collieston Coast and St Abb's to Fast Castle, fall outwith the boundary of the mean maximum foraging range implying that these colonies are not relevant to the proposed Seagreen Phase 1 project. For EIA and HRA, further clarification is required from Marine Scotland and their advisors on this issue especially as this also influences potential apportioning of the birds between different colonies within range.

3.5.3 The approach to apportioning is described in the as yet unpublished NIRAS apportioning document associated with the Seagreen submission. Suffice to say here that apportioning is complicated by the availability of data on the population size at each colony, with only Seabird 2000 supplying comparative data across all colonies. For this reason, Marine Scotland (2017) advised that Seabird 2000 data available for all colonies was to be used to allocate the proportion of birds to SPA and non-SPA colonies within range. Following this step the proportion of birds attributed to each colony was then to be allocated according to the latest count information for that SPA.

3.5.4 In relation to the issue outlined for Black-legged Kittiwake outline above, whether Buchan Ness and Collieston Coast and St Abb's to Fast Castle SPAs are included or excluded makes a considerable difference to the outcome. In effect, the inclusion of these large, more remote colonies effectively dilutes the proportion of birds attributed to closer colonies, including Fowlsheugh SPA and Forth Islands SPA. With a lower proportion of birds attributed to these SPAs, the predicted effect on these colonies will also be diluted.

3.5.5 Notwithstanding any issues relating to how information on population sizes for all colonies within species-specific foraging range is to be used, this document tabulates the latest information on population sizes for all SPA/non SPA colonies within range of Alpha and Bravo (Table 12) as well those SPA colonies outwith foraging range, but required to be included within assessment, for prospective use in EIA/HRA. This species-specific information derived from The Seabird Monitoring Programme (SMP) database is presented within the individual species accounts.

3.5.6 Species and colony-specific tracking data are particularly useful to confirm whether birds routinely reach the project area of developments. Results from available studies were therefore plotted to illustrate this point and to describe general foraging patterns. These included tracks of a number of species from different colonies around the Firth of Forth in 2010 and 2011 (see Daunt *et al*. 2011ab). These studies by the Centre for Ecology and Hydrology (CEH) were commissioned by the Forth and Tay Offshore Wind Developers Group (FTOWDG) comprised of Seagreen, Mainstream Renewable Power and Repsol (former owners of Inch Cape) facilitated by The Crown Estate. A literature review of foraging ecology of several key species was also commissioned from CEH (Daunt *et al*. 2011c) alongside another on Northern Gannet from the research group at the University of Leeds (Hamer *et al*. 2011).

4. ORNITHOLOGICAL OVERVIEW

4.1 Species composition & patterns of abundance

4.1.1 During the 23 boat-based surveys between December 2009 and November 2011 inclusive (Table 4), a total of 44,435 individual birds of 49 species and 12 unidentified taxa were recorded during surveys of Alpha and Bravo combined (Table 13). In Alpha alone, the equivalent totals were 24,501 birds of 40 species and 10 unidentified taxa (Table 14), with 19,934 birds of 40 species and 7 unidentified taxa within Bravo (Table 15).

4.1.2 During the five boat-based surveys between May and September 2017 (Table 17), a total of 14,907 individual birds of 20 species and 3 unidentified taxa were recorded during boat-based surveys of Alpha and Bravo combined (Table 13). In Alpha alone, the equivalent totals were 7,642 individual birds of 17 species and 3 unidentified taxa (Table 14), with 6,950 birds of 16 species and 1 unidentified taxon within Bravo (Table 15).

4.1.3 Thus, overall, a total of 59,342 birds of 53 species and 12 unidentified taxa were recorded during all boat-based surveys of Alpha and Bravo combined (Tables 13-15). In Alpha alone, the equivalent totals were 32,143 birds of 42 species and 10 unidentified taxa (Table 14), with 26,884 birds of 42 species and 8 unidentified taxa within Bravo (Table 15).

4.1.4 General abundance is broadly indicated by the numbers of individuals recorded, and a few locally breeding seabirds dominated the records of Alpha and Bravo combined, with Common Guillemot (32%), Black-legged Kittiwake (23%), Northern Gannet (16%) Razorbill (9%) and Atlantic Puffin (7%) comprising 87% of all birds recorded. Unidentified auks (5%), Northern Fulmar (3%) and Arctic Tern (2%) were the next most numerous taxa meaning 97% of the ornithological assemblage was accounted for by seven species and one unidentified taxon (auks).

4.1.5 The patterns were similar for Alpha and Bravo separately. In Alpha, the proportions were Common Guillemot (32%), Black-legged Kittiwake (26%), Northern Gannet (15%) Razorbill (9%), Atlantic Puffin (6%), Unidentified auks (6%), Northern Fulmar (2%) and Arctic Tern (2%) comprising 98% of all birds recorded. Whereas in Bravo, the proportions were Common Guillemot (31%), Black-legged Kittiwake (21%), Northern Gannet (16%) Razorbill (9%), Atlantic Puffin (9%), Unidentified auks (5%), Northern Fulmar (3%) and Arctic Tern (3%) comprising 97% of all birds recorded.

4.1.6 Differences were largely restricted to the reduced proportion of Black-legged Kittiwakes of Bravo (21%) compared to Alpha (26%) and the increase in the proportion of Atlantic Puffin in Bravo (9%) compared to Alpha (6%), which could reflect the relative proximity of each site to the major colony of each species in the area, which is Fowlsheugh SPA in the case of Black-legged Kittiwake and the Isle of May with the Forth Islands SPA in the case of Atlantic Puffin (Table 3).

Table 13. **Total count from all surveys, maximum density (individuals km^{-2}) and maximum population size (individuals) in any single survey, of all bird species (and unidentified taxa) recorded in monthly boat-based surveys of Alpha and Bravo combined in the survey programme from 2009-2011 inclusive and the breeding season surveys of 2017.**

Species	**Scientific name**	**Alpha + Bravo 2009-2011**			**Alpha + Bravo 2017**		
		Total count	**Maximum density**	**Maximum population**	**Total count**	**Maximum density**	**Maximum population**
Mallard	*Anas platyrhynchos*	2	0.060	23			
Common Eider	*Somateria mollissima*	3	-	15			
Long-tailed Duck	*Clangula hyemalis*				1	-	6
Unidentified duck		1	-	5			
Red-throated Diver	*Gavia stellata*	3	0.013	5			
Unidentified diver	*Gavia* sp.	1	-	5	2	-	6
European Storm Petrel	*Hydrobates pelagicus*	29	0.236	92			
Unidentified petrel	*Oceanodroma sp.*	1	-	5			
Northern Fulmar	*Fulmarus glacialis*	1437	2.562	1001	98	0.442	173
Sooty Shearwater	*Puffinus griseus*	26	0.201	78	1	0.014	6
Great Shearwater	*Ardenna gravis*	1	-	5			
Manx Shearwater	*Ardenna puffinus*	28	0.064	25	5	0.014	6
Grey Heron	*Ardea cinera*				2	0.062	24
Northern Gannet	*Morus bassanus*	7243	9.499	3712	1936	9.913	3,972
European Shag	*Phalacrocorax aristotelis*	2	-	10			
Great Cormorant	*Phalacrocorax carbo*	2	-	10			
Eurasian Oystercatcher	*Haematopus ostralegus*	3	-	15			
Northern Lapwing	*Vanellus vanellus*	4	0.053	21			

Species	Scientific name	Alpha + Bravo 2009-2011			Alpha + Bravo 2017		
		Total count	**Maximum density**	**Maximum population**	**Total count**	**Maximum density**	**Maximum population**
European Golden Plover	*Pluvialis apricaria*	12	0.233	91			
Eurasian Curlew	*Numenius arquata*	14	0.271	106			
Ruddy Turnstone	*Arenaria interpres*	4	-	20	1		
Dunlin	*Calidris alpina*				1	0.031	12
Common Snipe	*Gallinago gallinago*	2	0.052	21			
Grey Phalarope	*Phalaropus fulicarius*	10	0.079	31			
Unidentified wader		18	0.026	10	1	-	6
Black-legged Kittiwake	*Rissa tridactyla*	10305	42.181	16485	3459	39.786	15,549
Black-headed Gull	*Chroicocephalus ridibundus*	4	0.245	96			
Little Gull	*Hydrocoloeus minutus*	9	0.054	21			
Common Gull	*Larus canus*	30	0.116	45	4	0.044	17
Great Black-backed Gull	*Larus marinus*	360	1.284	502	10	0.184	72
European Herring Gull	*Larus argentatus*	297	0.559	218	18	0.092	36
Lesser Black-backed Gull	*Larus fuscus*	78	0.597	233	10	0.137	54
Unidentified small gull		21	-	91			
Unidentified large gull	*Larus* sp.	158	0.086	34			
Sandwich Tern	*Thalasseus sandvicensis*	1	-	5			
Common Tern	*Sterna hirundo*	32	0.169	66			
Arctic Tern	*Sterna paradisaea*	315	2.621	1024	731	11.305	4,418
Unidentified tern		127	-	608			
Great Skua	*Stercorarius skua*	19	0.042	16	2	0.031	12
Pomarine Skua	*Stercorarius pomarinus*	2	0.029	11			

Species	**Scientific name**	**Alpha + Bravo 2009-2011**			**Alpha + Bravo 2017**		
		Total count	**Maximum density**	**Maximum population**	**Total count**	**Maximum density**	**Maximum population**
Arctic Skua	*Stercorarius parasiticus*	9	0.028	11	2	0.014	6
Unidentified skua	*Stercorarius* sp.	1	-	5			
Little Auk	*Alle alle*	511	2.254	881			
Common Guillemot	*Uria aalge*	12760	47.373	18514	5973	59.919	23,418
Razorbill	*Alca torda*	3219	7.215	2820	2183	30.533	11,933
Atlantic Puffin	*Fratercula arctica*	4075	19.976	7807	465	7.775	3,039
Unidentified auk		3182	6.782	2651			
Feral Pigeon	*Columba livia*	2	0.013	5			
Common Swift	*Apus apus*	8	-	31			
Merlin	*Falco columbarius*	1	-	5			
Eurasian Skylark	*Alauda arvensis*	1	0.137	54			
Sand Martin	*Riparia riparia*				1	-	6
Barn Swallow	*Hirundo rustica*	2	-	5			
Goldcrest	*Regulus regulus*	1	0.029	11			
Common Starling	*Sturna vulgaris*	5	0.056	22			
Common Blackbird	*Turdus merula*	3	-	10			
Fieldfare	*Turdus pilaris*	4	0.027	11			
Redwing	*Turdus iliacus*	17	0.029	11			
Song Thrush	*Turdus philomelos*	1	0.027	10			
Unidentified thrush	*Turdus* sp.	2	0.026	10			
Spotted Flycatcher	*Muscicapa striata*	1	0.026	10			
Meadow Pipit	*Anthus pratensis*	12	0.028	11			

Species	Scientific name	Alpha + Bravo 2009-2011			Alpha + Bravo 2017		
		Total count	Maximum density	Maximum population	Total count	Maximum density	Maximum population
Unidentified pipit	*Anthus* sp.	1	0.028	11			
Brambling	*Fringilla montifringilla*	1	0.042	16			
Unidentified passerine		12	0.029	11	1	-	6

Table 14. **Total count from all surveys, maximum density (individuals km^{-2}) and maximum population size (individuals) in any single survey, of all bird species (and unidentified taxa) recorded in monthly boat-based surveys of Alpha in the survey programme from 2009-2011 inclusive and the breeding season surveys of 2017.**

Species	Scientific name	Alpha 2009-2011			Alpha 2017		
		Total count	Maximum density	Maximum population	Total count	Maximum density	Maximum population
Common Eider	*Somateria mollissima*	3	-	9			
Long-tailed Duck	*Clangula hyemalis*				1	-	6
Red-throated Diver	*Gavia stellata*	1	-	3			
Unidentified diver	*Gavia* sp.	1	-	3	1	-	6
European Storm Petrel	*Hydrobates pelagicus*	22	0.468	92			
Unidentified petrel	*Oceanodroma sp.*	1	-	3			
Northern Fulmar	*Fulmarus glacialis*	627	2.519	497	51	0.611	121
Sooty Shearwater	*Ardenna griseus*	19	0.398	78	1	0.029	6
Great Shearwater	*Ardenna gravis*	1	-	3			
Manx Shearwater	*Puffinus puffinus*	14	0.053	10	3	0.029	6
Grey Heron	*Ardea cinerea*				2	0.128	25
Northern Gannet	*Morus bassanus*	3,951	13.776	2,716	968	9.448	1863

Species	Scientific name	Alpha 2009-2011			Alpha 2017		
		Total count	Maximum density	Maximum population	Total count	Maximum density	Maximum population
European Shag	*Phalacrocorax aristotelis*	2	-	6			
Great Cormorant	*Phalacrocorax carbo*	2	-	6			
Eurasian Oystercatcher	*Haematopus ostralegus*	3	-	9			
Northern Lapwing	*Vanellus vanellus*	2	0.050	10			
European Golden Plover	*Pluvialis apricaria*	8	0.461	91			
Eurasian Curlew	*Numenius arquata*	13	0.537	106			
Grey Phalarope	*Phalaropus fulicarius*	1	-	3			
Unidentified wader		17	-	50	1	-	6
Black-legged Kittiwake	*Rissa tridactyla*	5,837	22.875	4,510	2362	61.527	12,132
Black-headed Gull	*Chroicocephalus ridibundus*	2	0.430	85			
Little Gull	*Hydrocoloeus minutus*	3	0.051	10			
Common Gull	*Larus canus*	21	0.231	45	2	0.062	12
Great Black-backed Gull	*Larus marinus*	185	1.301	257	10	0.367	72
European Herring Gull	*Larus argentatus*	181	0.614	121	15	0.171	34
Lesser Black-backed Gull	*Larus fuscus*	42	0.498	98	5	0.090	18
Unidentified small gull		2	-	3			
Unidentified large gull	*Larus* sp.	97	0.170	34			
Sandwich Tern	*Thalasseus sandvicensis*	1	-	3			
Common Tern	*Sterna hirundo*	31	0.335	66			
Arctic Tern	*Sterna paradisaea*	186	1.810	357	102	2.773	547
Unidentified tern		127	-	361			
Great Skua	*Stercorarius skua*	13	0.081	16	1	-	6

Species	**Scientific name**	**Alpha 2009-2011**			**Alpha 2017**		
		Total count	**Maximum density**	**Maximum population**	**Total count**	**Maximum density**	**Maximum population**
Pomarine Skua	*Stercorarius pomarinus*	1	0.055	11			
Arctic Skua	*Stercorarius parasiticus*	5	0.056	11	1	0.029	6
Little Auk	*Alle alle*	295	12.530	2,471			
Common Guillemot	*Uria aalge*	7,307	54.827	10,811	2844	56.920	11,221
Razorbill	*Alca torda*	1,796	10.660	2,102	1058	31.151	6,142
Atlantic Puffin	*Fratercula arctica*	1,734	14.134	2,7	213	7.560	1,491
Unidentified auk		1,911	5.905	1,164			
Feral Pigeon	*Columba livia*	1	0.025	5			
Common Swift	*Apus apus*	8	-	18			
Barn Swallow	*Hirundo rustica*	1	-	3			
Common Starling	*Sturna vulgaris*	2	0.026	5			
Redwing	*Turdus iliacus*	1	0.058	11			
Song Thrush	*Turdus philomelos*	1	0.053	10			
Unidentified thrush	*Turdus* sp.	1	-	3			
Meadow Pipit	*Anthus pratensis*	7	0.056	11			
Unidentified pipit	*Anthus* sp.	1	0.055	11			
Brambling	*Fringilla montifringilla*	1	0.082	16			
Unidentified passerine		12	0.058	11	1	-	6

Table 15. **Total count from all surveys, maximum density (individuals km^{-2}) and maximum population size (individuals) in any single survey, of all bird species (and unidentified taxa) recorded in monthly boat-based surveys of Bravo in the survey programme from 2009-2011 inclusive and the breeding season surveys of 2017.**

Species	Scientific name	Bravo 2009-2011			Bravo 2017		
		Total count	Maximum density	Maximum population	Total count	Maximum density	Maximum population
Mallard	*Anas platyrhynchos*	2	0.12	23			
Unidentified duck		1	-	3			
Red-throated Diver	*Gavia stellata*	2	0.025	5			
Unidentified diver	*Gavia* sp.				1	-	6
European Storm Petrel	*Hydrobates pelagicus*	7	0.078	15			
Northern Fulmar	*Fulmarus glacialis*	810	2.606	505	43	0.319	62
Sooty Shearwater	*Ardenna griseus*	7	0.143	28			
Manx Shearwater	*Puffinus puffinus*	14	0.079	15	2	-	6
Northern Gannet	*Morus bassanus*	3,292	5.890[1]	1,141[1]	945	10.888	2,108
Northern Lapwing	*Vanellus vanellus*	2	0.056	11			
European Golden Plover	*Pluvialis apricaria*	4	-	12			
Eurasian Curlew	*Numenius arquata*	1	0.056	11			
Ruddy Turnstone	*Arenaria interpres*	4	-	12	1	-	6
Dunlin	*Calidris alpina*				1	0.066	13
Common Snipe	*Gallinago gallinago*	2	0.106	21			
Grey Phalarope	*Phalaropus fulicarius*	9	0.159	31			
Unidentified wader		1	0.053	10			
Black-legged Kittiwake	*Rissa tridactyla*	4,468	14.527[1]	2,813[1]	1067	18.878	3,655

Species	Scientific name	Bravo 2009-2011			Bravo 2017		
		Total count	Maximum density	Maximum population	Total count	Maximum density	Maximum population
Black-headed Gull	*Chroicocephalus ridibundus*	2	0.056	11			
Little Gull	*Hydrocoloeus minutus*	6	0.108	21			
Common Gull	*Larus canus*	9	0.056	11	2	0.064	12
Great Black-backed Gull	*Larus marinus*	175	1.266	245			
European Herring Gull	*Larus argentatus*	116	0.841	163	3	0.197	38
Lesser Black-backed Gull	*Larus fuscus*	36	0.698	135	5	0.197	38
Unidentified small gull		19	-	53			
Unidentified large gull	*Larus* sp.	61	0.116	23			
Common Tern	*Sterna hirundo*	1	0.056	11			
Arctic Tern	*Sterna paradisaea*	129	4.132	800	612	21.042	4075
Great Skua	*Stercorarius skua*	6	0.058	11	1	0.064	12
Pomarine Skua	*Stercorarius pomarinus*	1	0.053	10			
Arctic Skua	*Stercorarius parasiticus*	4	-	6	1	0.030	6
Unidentified skua	*Stercorarius* sp.	1	-	3			
Little Auk	*Alle alle*	216	5.749	1,113			
Common Guillemot	*Uria aalge*	5,453	54.571	10,567	2970	64.740	12,536
Razorbill	*Alca torda*	1,423	6.605	1,279	1064	31.323	6,065
Atlantic Puffin	*Fratercula arctica*	2,341	28.082	5,439	231	8.013	1,552
Unidentified auk		1,271	7.674	1,486			
Feral Pigeon	*Columba livia*	1	-	3			
Merlin	*Falco columbarius*	1	-	3			
Eurasian Skylark	*Alauda arvensis*	1	-	3			

Species	**Scientific name**	**Bravo 2009-2011**			**Bravo 2017**		
		Total count	**Maximum density**	**Maximum population**	**Total count**	**Maximum density**	**Maximum population**
Sand Martin	*Riparia riparia*				1	-	6
Barn Swallow	*Hirundo rustica*	1	-	3			
Goldcrest	*Regulus regulus*	1	0.058	11			
Common Starling	*Sturna vulgaris*	3	0.113	22			
Common Blackbird	*Turdus merula*	3	-	6			
Fieldfare	*Turdus pilaris*	4	0.055	11			
Redwing	*Turdus iliacus*	16	-	47			
Unidentified thrush	*Turdus* sp.	1	0.053	10			
Spotted Flycatcher	*Muscicapa striata*	1	0.053	10			
Meadow Pipit	*Anthus pratensis*	5	0.051	10			

4.1.7 A similar analysis of breeding season data from 2017 only, bears out the difference in the proportion of Black-legged Kittiwakes in the assemblage in Alpha (31%) compared to Bravo (15%), although the proportion of Atlantic Puffin remains the same at 3%. The proportion of Common Guillemot then shows the largest proportional increase of any species (43% cf. 37% in Alpha) to compensate for the proportional reduction in the proportion of Black-legged Kittiwakes in the assemblage.

4.1.8 For Alpha and Bravo combined, Common Guillemot (39%), Black-legged Kittiwake (23%), Razorbill (14%), Northern Gannet (13%), Atlantic Puffin (3%) comprised 92% of all birds recorded. The addition of passage Arctic Terns (5%) accounted for 97% of the ornithological assemblage.

4.1.9 The dominance of breeding seabirds in the assemblage is in keeping with the location of Alpha and Bravo relatively close to shore (beginning at 27 km). Nevertheless, a diverse range of other seabirds such as petrels, shearwaters, skuas, gulls and terns were recorded alongside small numbers of a range of migrant waders, waterfowl and passerines.

4.2 Density

4.2.1 Density values of all species in each survey of Alpha and Bravo in all years are supplied in Appendix 2. These are shown separately for key species and pooled under generic groups in Figures 13 & 14.

4.2.2 In 2009-2011, peak bird densities of 90-100 ind. km^{-2} were recorded in Alpha and Bravo equating to around 17,000-19,000 individuals. Peak densities may be considered to be high as they rival the peaks recorded by Skov *et al*. (1995) for particular species in important areas for seabirds in the North Sea and are generally higher than the values reported by Stone *et al*. (1995) and Camphuysen (2005) for larger (and different) areas of the northwest North Sea, albeit both incorporating the Firth of Forth. It is important to note however that high density can be readily created in relatively small areas as a result of aggregation of birds, perhaps with particular features or resources. Thus, although the close proximity of Alpha and Bravo meant that they shared similar trends in density even if values were not exactly consistent on each monthly survey (Figures 13 & 14). For example, a density of ~60 ind. km^{-2} in Alpha in July 2011 was over three-fold higher than that in Bravo at the same time.

4.2.3 Moreover, in 2017, concomitant high densities of Common Guillemot (54.98 ind. km^{-2}), Black-legged Kittiwake (36.13 ind. km^{-2}) and Razorbill (27.61 ind. km^{-2}) in July over the whole area incorporating both Alpha and Bravo area made a significant contribution to extremely high densities of around 140-160 ind. km^{-2} (Figures 13 & 14). This was thought to coincide with an abundance of prey attracting birds from the surrounding area, in combination with the beginnings of post breeding dispersal and passage. This idea was supported by an increase in observed foraging behaviour and a simultaneous peak in marine mammal records at this time (Seagreen 2017b).

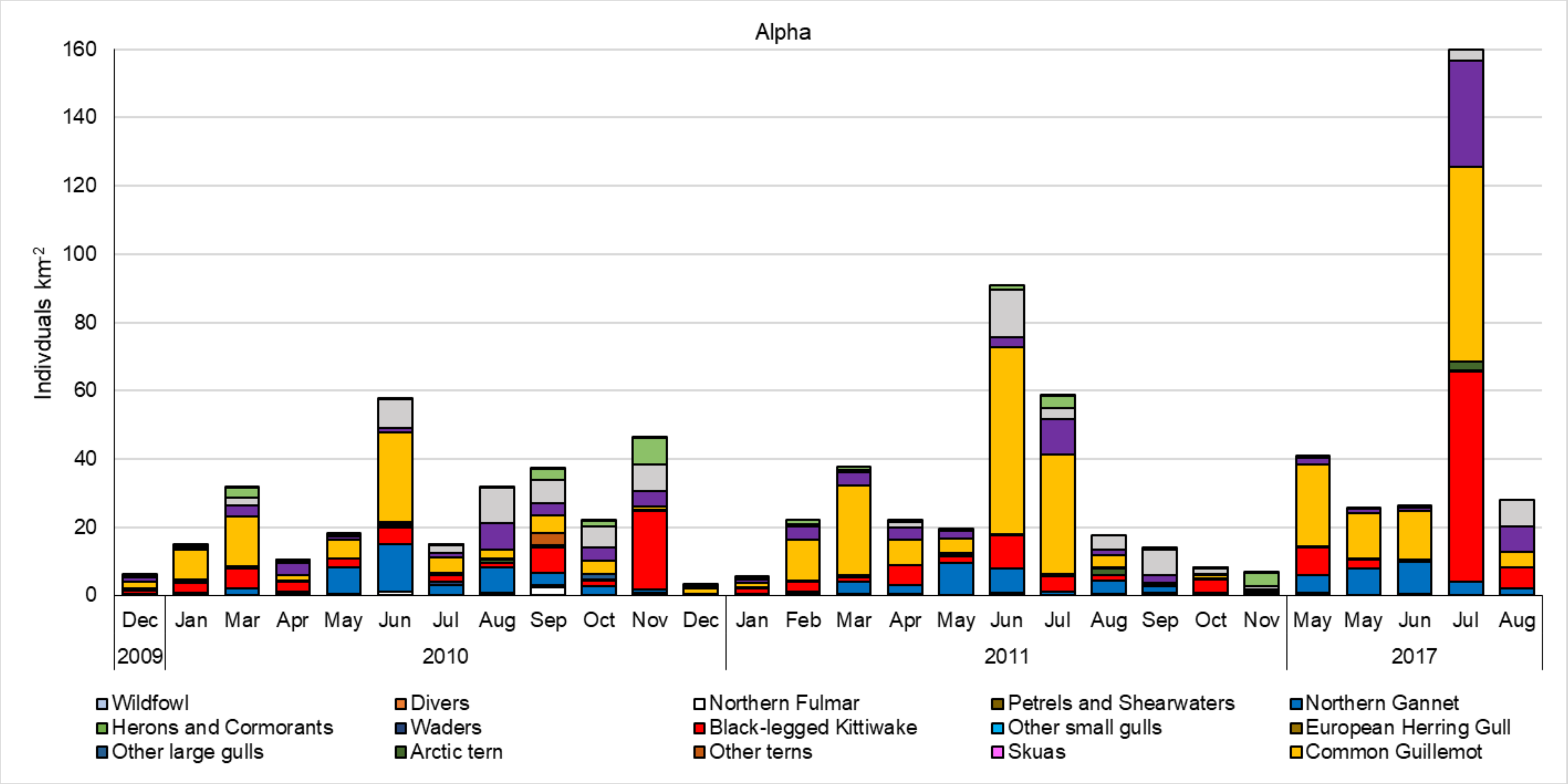


Figure 13. Density (individuals km^{-2}) of all birds recorded in monthly surveys from 2009-2011 and in the breeding season in 2017 in Alpha. Density is calculated from a combination of birds in flight and birds on the water, with Distance-correction of the latter where possible. Extrapolated estimates are included for some rare species only recorded in flight and out of snapshot (see 3.2 above for methods).

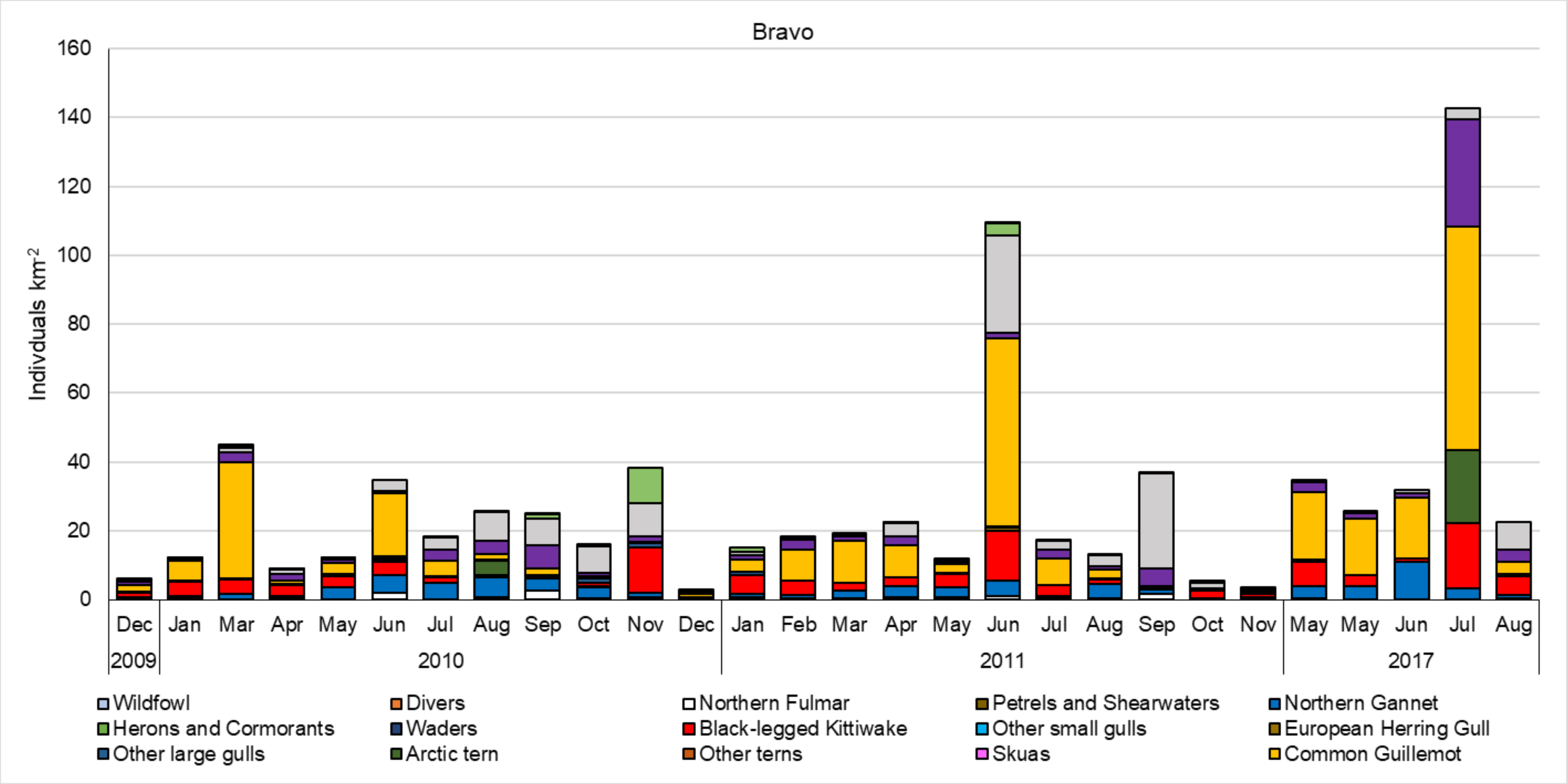


Figure 14. **Density (individuals km^{-2}) of all birds recorded in monthly surveys from 2009-2011 and in the breeding season in 2017 in Alpha. Density is calculated from a combination of birds in flight and birds on the water, with Distance-correction of the latter where possible. Extrapolated estimates are included for some rare species only recorded in flight and out of snapshot (see 3.2 above for methods)**

4.2.4 As a result of the presence of several key breeding species such as Common Guillemot, Razorbill Black-legged Kittiwake, Atlantic Puffin and Northern Gannet, in general, density tended to be higher in the summer months (May to August) with combined density totals in the region of 15-40 ind. km^{-2}. Whilst total density in the breeding season varied considerably between surveys in 2009-2011, the values for 2017 tended to be more consistent.

4.2.5 The passage of the aforementioned breeding species, perhaps including from other colonies outside the immediate area, as well as wildfowl, waders, large gulls and species such as Arctic Tern and Northern Fulmar, led to occasional higher density values in autumn. Otherwise, densities of birds reduced to low levels of 5-10 ind. km^{-2} in the winter months before building again in late winter and spring towards the breeding season.

4.3 Distribution

4.3.1 In Seagreen (2012a), the relative abundance of birds in flight and birds on the water across Alpha and Bravo were presented separately. In relation to the former which feature Black-legged Kittiwake and Northern Gannet in particular, the majority of 1 km^2 grid cells supporting on average between 5-25 flying birds per km^2 surveyed, with a few 'hotspots' of >50 per km^2 (Figure 15). The relatively low number of hotspots was thought likely to indicate feeding aggregations in particular surveys rather than representing a consistent pattern of selection for one area over another linked to the presence of a particular habitat feature. The potential for individual species and seasonal trends was acknowledged however (Seagreen 2012a).

4.3.2 In contrast to birds in flight, the distribution of birds on the water (which are mainly composed of auks) over all surveys and seasons showed much greater patchiness (Figure 15). In general, there was some suggestion of parts of Alpha including the central portion and areas closer to shore on the western side supporting higher relative abundance, with hotspots of >50 and even >100 individuals km^{-2}. Whilst the eastern parts of Alpha and Bravo, generally showed lower abundance, there were some patches containing 25-100 individuals km^{-2} over a series of adjacent cells in the southeastern part of Bravo that were suggestive of consistent association with a particular habitat feature.

4.3.3 In 2017, the KDE derived from the mean cell simple density estimates from birds both in flight and on the water, and across a larger area than just Alpha and Bravo highlighted the importance of the area around Scalp Bank, relative to Alpha and Bravo (Figure 16). This may account for the higher abundance of birds on the water noted on the western edge of the sites in 2009-2011 noted above (see 4.3.2). Other hotspots correspond with the deeper area to the northwest of Alpha as well as other patches mostly likely linked to the large local aggregations of birds recorded in the July survey.

4.3.4 The variation in distribution between surveys was neatly demonstrated by the individual plots of bird records for each survey in 2017 (Figure 17), although interpretation must be undertaken with care as these data are simply all observations of single or groups of birds and do not represent densities. Nevertheless, some general patterns can be seen with some areas favoured more than others, with preferences changing across the course of the surveys.

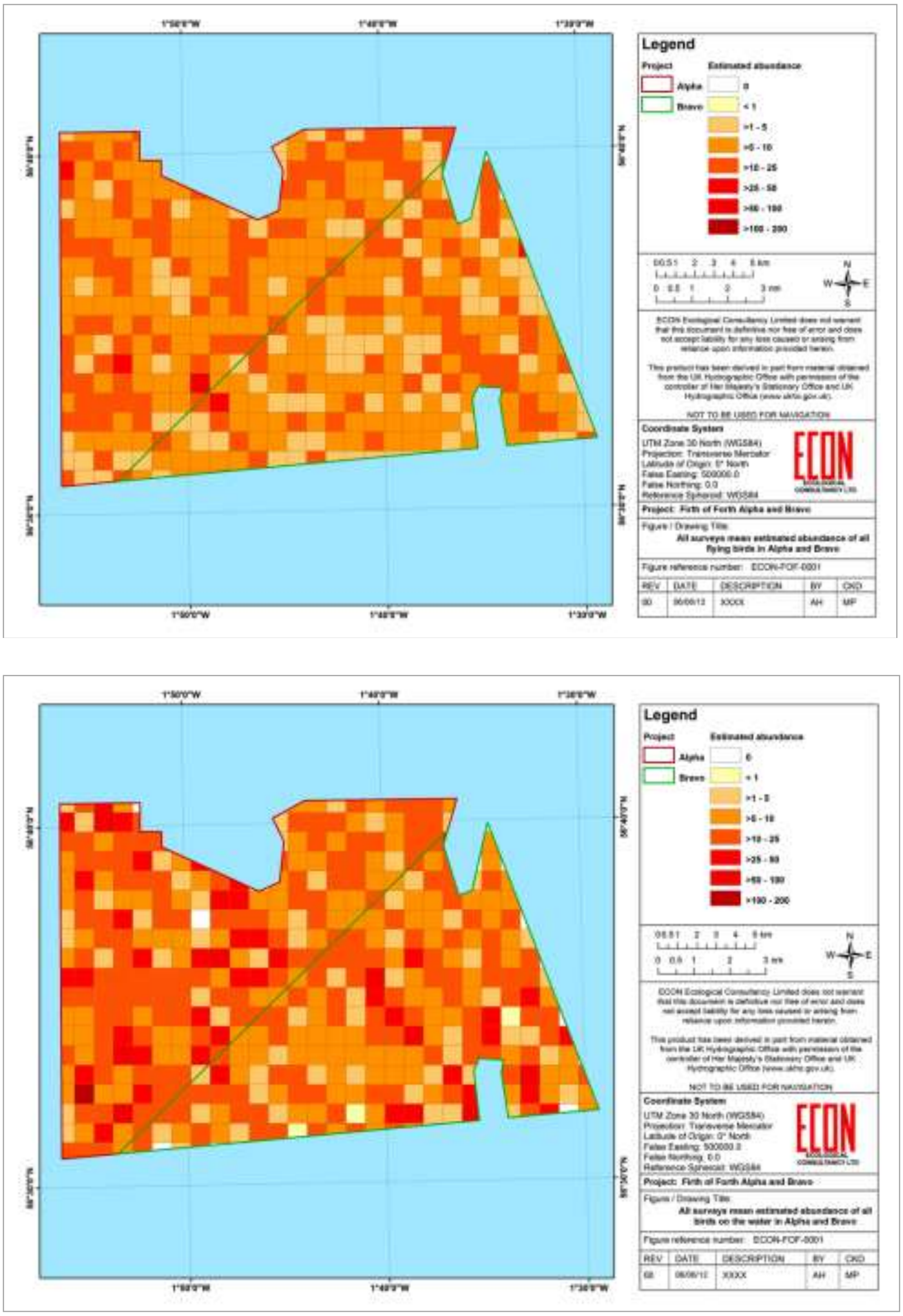


Figure 15. Relative abundance (individuals recorded km^{-2}) of birds in flight (above) and density (individuals km^{-2}) of birds on the water (below) in 1 km^{2} grid cells across Alpha and Bravo in all surveys in all seasons.

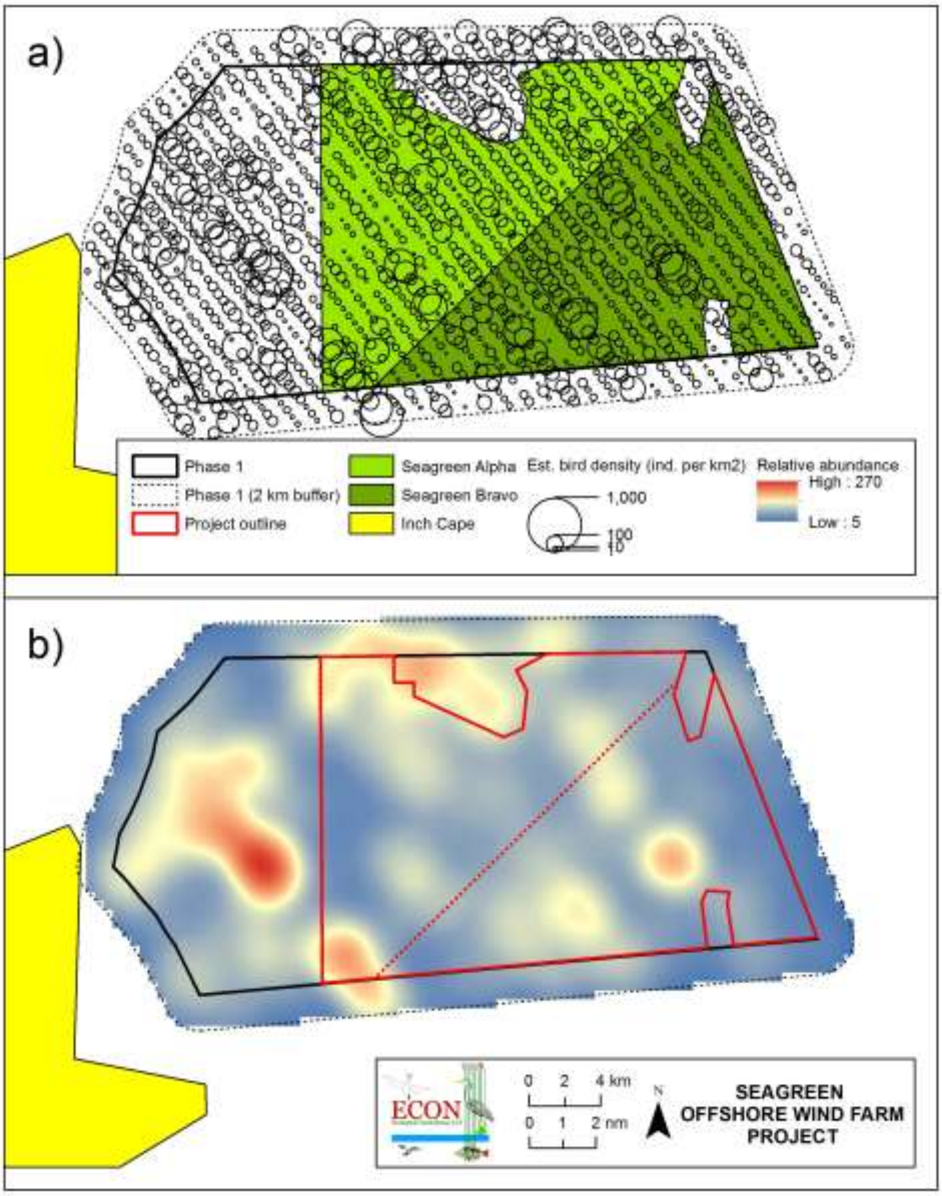


Figure 16. Density distribution of all birds in 2017 as shown by a) mean density of all birds (combined flying and sitting on the water) in each survey cell on each of the three survey routes (route two was only surveyed once) and b) the relative abundance surface derived using KDE applied to these data.

4.3.5 At the beginning of May, there appeared to be some preference for parts of the southerly edge of Scalp Bank and the northwesterly part of Alpha (Figure 17a). Towards the end of May however the pattern was less distinct (Figure 17b), although there was still a hint of higher relative abundance over parts of Scalp Bank.

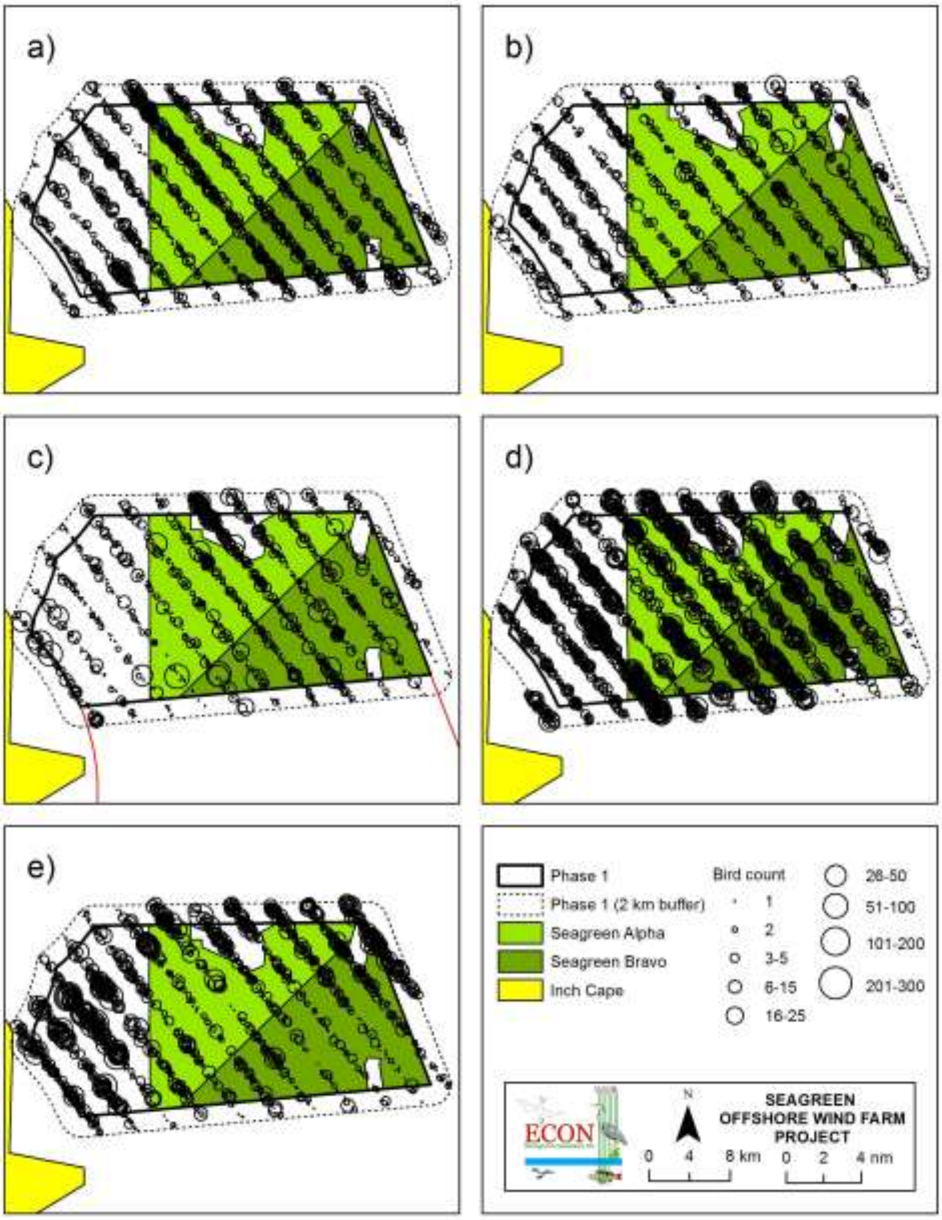


Figure 17. **All observations of all birds (on the water and in flight) recorded during the 2017 breeding season surveys conducted on a) 9th to 10th May, b) 24th to 25th May, c) 20th to 21st June, d) 24th to 25th July and e) 15th to 16th August.**

4.3.6 In June, there was a clear hotspot of activity to the northwest of Alpha in the area of deeper water that had been excluded from development as a result of excessive depth (Figure 17c). The area of activity could represent a bathymetric feature related to the depth change that could lead to upwelling or perhaps indicate particular local currents, both of which may increase prey availability higher in the water column.

4.3.7 In July, during the period of a marked increase in bird abundance and the highest densities recorded in Alpha and Bravo in the three-year period (see 4.2.3 above) increased markedly, primarily due to the presence of large numbers of auks, it was difficult to discern any underlying patterns of distribution, although the southeastern and northeastern parts were perhaps less favoured (Figure 17d).

4.3.8 By August, densities had reduced considerably (Figures 13 & 14) and Alpha and Bravo appeared to be avoided as the birds present heavily favoured the area around Scalp Bank and buffer area on the northern edge of Alpha across to the northeast in the locality of Montrose Bank.

4.3.9 Overall the patterns shown are consistent with the presence of particular features that may consistently aggregate prey resources, although that does not mean that such resources are always present or available. For example, some species such as Black-legged Kittiwake, which are unable to penetrate far into the water column and have to snatch prey from at or near the surface, may be dependent on the presence of other species such as diving auks to drive prey within reach (Camphuysen 2005). Otherwise, Black-legged Kittiwake may require particular states of tide and upwellings to bring prey to the surface (Embling *et al*. 2012), meaning their occurrence and relative abundance will also vary accordingly, even within the breeding season.

4.3.10 Further details of the spatial distribution of birds encountered on the surveys are provided in individual species accounts that follow below.

5. SENSITIVE SPECIES ACCOUNTS

5.1 Background information

5.1.1 In the Technical Report of the baseline characterisation data gathered in 2009-2011, Seagreen (2012a) identified 13 and 11 species of seabird as being potentially sensitive to the development of Alpha and Bravo respectively. Sensitivity was primarily as a result of the occurrence of at least regionally important numbers in at least one period of the year (breeding, passage or winter). In taxonomic order these species were Northern Fulmar, Sooty Shearwater *Ardenna griseus* (Alpha only), Northern Gannet, Black-legged Kittiwake, Lesser Black-backed Gull, European Herring Gull, Great Black-backed Gull *Larus marinus*, Common Tern *Sterna hirundo* (Alpha only), Arctic Tern *Sterna paradisaea*, Common Guillemot, Razorbill, Little Auk *Alle alle* and Atlantic Puffin.

5.1.2 The HRA screening report (Seagreen 2011) guided by the statutory conservation agencies also identified 16 species of migratory waterfowl (geese and wading birds) designated at risk of likely significant effect through links with SPAs. This resulted in initial consideration of 29 species in relation to Project Alpha and 27 species in relation to Project Bravo. Assessment using the principles established by the IEEM (2010) subsequently screened out all migratory waterfowl and Northern Fulmar, Sooty Shearwater, Common Tern and Little Auk for consideration in the Environmental Statement during EIA. Nine species were therefore considered (Seagreen 2012b) including Northern Gannet, Black-legged Kittiwake, Lesser Black-backed Gull, European Herring Gull, Common Guillemot, Razorbill and Atlantic Puffin as breeding birds, Arctic Tern on passage and Great Black-backed Gull as a wintering species.

5.1.3 In the HRA process (Seagreen 2013) connectivity of breeding birds with particular SPAs included Northern Fulmar with the other breeding species, but excluded Arctic Tern and Great Black-backed Gull that were not connected with local SPAs as breeding species.

5.1.4 The scoping opinion in relation to the revised Seagreen sites provided by Marine Scotland (2017) further confirmed the exclusion of Northern Fulmar and Lesser Black-backed Gull in the EIA/HRA. This is because they were not expected to experience significant population level impacts at any of the identified SPAs (Marine Scotland 2017).

5.1.5 Thus, only six species breeding in nearby SPA colonies, namely Northern Gannet, Black-legged Kittiwake, European Herring Gull, Common Guillemot, Razorbill and Atlantic Puffin are to be considered in EIA/HRA and these are considered in turn in this report. Details for each species are considered under the following subheadings:

- Populations & connectivity
- Density & population size
- Spatial distribution
- Population structure
- Flight behaviour
- Foraging & feeding

5.1.6 The theme of *Populations & connectivity* introduces the conservation status of the species and provides information on populations at the national and regional level while using foraging ranges to detail connectivity to the SPA breeding colonies of relevance to the project. The information provided aims to set the context of any potential effect by the proposed development.

5.1.7 *Density & population size* presents density and population data for Alpha and Bravo and discusses temporal/seasonal patterns. Comparative reference to surveys of Alpha and Bravo as well as other studies where appropriate and available, is made to help frame the importance of the populations recorded. Population sizes as numbers of individuals of both birds in flight and birds on the water in each survey for each species are shown in Appendix 3.

5.1.8 Although linked to density and seasonal changes, information on *Spatial distribution* is presented separately and especially in a visual manner to help contextualise the relative importance of different areas, which is of direct relevance in shaping the definition of the project, particularly in relation to other constraints especially depth and ground conditions.

5.1.9 *Population structure* is described from the ages of birds encountered, particularly in relation to Northern Gannet, Black-legged Kittiwake and European Herring Gull, which are readily aged, but also in relation to the occurrence of juveniles in the case of auks.

5.1.10 *Flight behaviour* presents data on transit flight directions that may then be related to breeding colony origin, as well on flight height for species mainly encountered in flight, which is of key importance in assessing collision risk.

5.1.11 *Foraging & feeding* presents data on the frequency and location of observations of foraging behaviour in which birds are apparently looking for food, as compared to feeding when birds are in the act of attempting to seize prey, are seizing prey or have captured prey perhaps immediately before return to the colony. These data provide insight into the importance of Alpha and Bravo as foraging grounds for the different species, which in turn is of importance in relation to potential displacement.

5.2 Northern Gannet

Populations & connectivity

5.2.1 The global breeding population of Northern Gannet has shown a long-term increase and range expansion (BirdLife International 2015). The recent estimate of ~1,500,000-1,800,000 mature individuals (BirdLife International 2015) shows a huge increase compared to the 526,000 individuals reported by del Hoyo *et al*. (1992). The great majority of both the global range (75%-94%) and population (with an estimated 1,370,000 mature individuals) of the species lies within Europe (BirdLife International 2015).

5.2.2 Changes in Northern Gannet populations have been documented by a long history of monitoring, dating back to the early 1900s (Mitchell *et al.* 2004). During the last decade, Northern Gannet numbers have continued to rise in the UK, with JNCC (2016) reporting a 34% increase in the population from 2003 to 2014. Nonetheless, Northern Gannet is ‘Amber’ listed of conservation concern as a result of the UK containing an internationally important breeding population (at least 20% of the European population) and having at least 50% of breeding birds present in 10 or fewer colonies (Eaton *et al.* 2015).

5.2.3 The UK supports 55.6% of the world population (Murray *et al.* 2015) with the majority of Northern Gannets breeding at a few major colonies on remote islands and sea cliffs (Cramp *et al.* 1974). During the Seabird 2000 census, the 16 Northern Gannet colonies in the UK surveyed supported a breeding population estimate of 226,553 breeding pairs (Mitchell *et al.* 2004). The latest UK population estimate, from a 2013-14 census is 293,161 pairs (JNCC 2016).

5.2.4 Northern Gannet has a mean maximum foraging range of 229.4 km, resulting in the combined Alpha and Bravo area falling within the foraging range of 158,212 breeding individuals (Table 16) distributed between two colonies (Figure 18). Of these, the colony on Bass Rock within the Forth Islands SPA at <70 km from Alpha and Bravo is of most relevance as it supports 75,259 breeding pairs and is now the largest colony in the world (Murray *et al*. 2015). Troup Head, incorporated within the Gamrie & Pennan Coast SSSI, supports a much lower population at a greater distance. The Bass Rock colony thus accounts for 95.1% of birds breeding within the mean maximum foraging range from Alpha and Bravo, suggesting just 4.9% of breeding birds within the mean foraging range are not contained within a SPA population.

Table 16. **Details of Northern Gannet breeding colonies within mean maximum foraging range (229.4 km) of Alpha and Bravo at increasing distance (km). Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count in the year specified are shown.**

Site and designation	Distance (km)	Natura 2000	Seabird 2000	Latest count	
				Number	Year
Forth Islands SPA (Bass Rock)	65.15	43,200	88,220	150,518	2014
Gamrie and Pennan Coast SSSI	112.92		2,170	7694	2016
	Total	43,200	90,390	158,212	

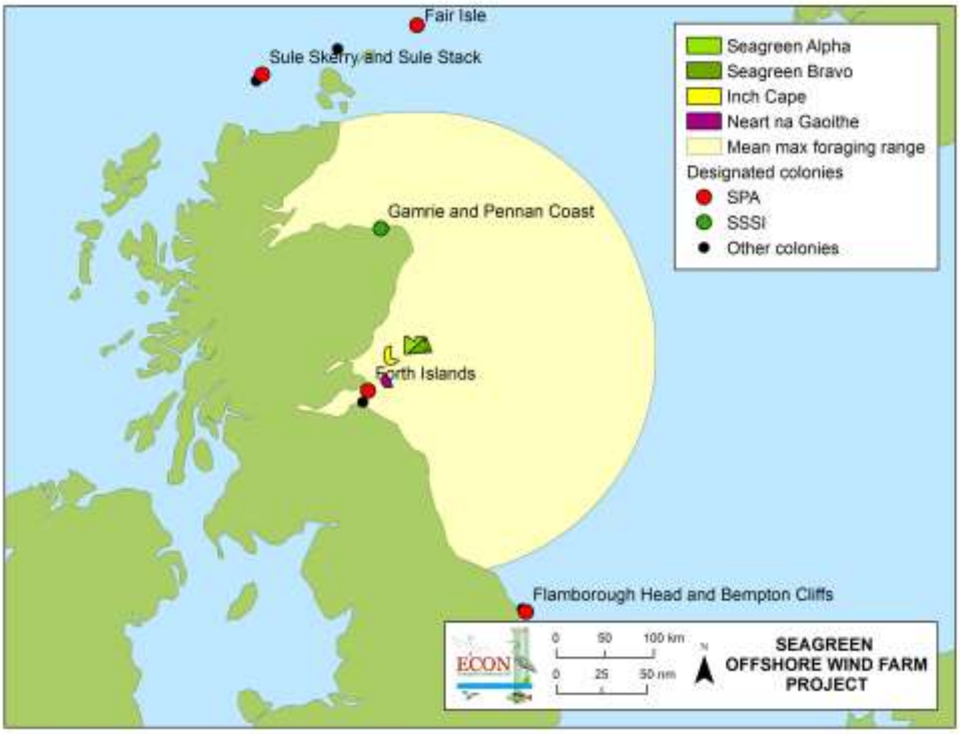


Figure 18. **Distribution of Northern Gannet breeding colonies within mean maximum foraging range (229.4 km) of Seagreen Alpha and Bravo.**

5.2.5 Data from satellite-telemetry studies of chick-rearing adults in 1998, 2002 and 2003 showed that at least Alpha is within the core foraging area of all Northern Gannets in all years studied (Hamer *et al.* 2011). Modelling of habitat suitability for Northern Gannet also supports this view (Skov *et al*. 2008).

Density & population size

5.2.6 Northern Gannets were present throughout the survey period, which covered three breeding seasons from incubation to the fledging period and two migration and winter periods. In 2017, when surveys were restricted to the breeding season, egg laying was likely to have taken place prior to the first survey in May and the majority of fledging would have occurred after the final survey in August.

5.2.7 Within the sites, the seasonal pattern is of low numbers of birds over winter (Figure 19), as most birds migrate to wintering grounds off the coasts of West Africa especially (Kubetzi *et al*. 2009). A pronounced increase in March relates to the return of breeding birds, although some may return as early as January (Forrester *et al.* 2007). A drop in April may indicate increased colony attendance when both sexes take an equal role in incubating the egg laid in April/early May (Cramp *et al.* 1974). Densities then rise in May and June through the incubation and early provisioning period. With a few exceptions (e.g. 2011 in Alpha and Bravo combined and Bravo in 2010), the breeding season peak tended to occur in June (Figure 19).

5.2.8 A lesser secondary peak then often occurred in August. Indeed, the peak population in Bravo in 2010 was achieved at this time (Figure 19), which may relate to late provisioning or early fledging, most of which occurs in September (Forrester *et al.* 2007), with adults reducing attendance at the colony. Dispersing failed breeders at this time may also bolster numbers. A late secondary peak did not occur in 2017, but it is unclear if this was a result of a poor and possibly delayed breeding season, or simply a result of the exploitation of foraging opportunities elsewhere.

5.2.9 Peak population estimates were recorded in June in all sites; being 2,716 individuals in 2010 in Alpha and 2,180 in 2017 for Bravo (Figure 19). During the 2009-2011 surveys, population estimates within Bravo tended to be lower and less variable than those recorded in Alpha, but this trend was reversed in 2017 when numbers in Bravo were more variable and a higher peak population was observed (Figure 19). The peak population estimates in Alpha and Bravo combined were 3,712 and 3,874 in 2010 and 2017 respectively

5.2.10 Densities were generally higher within Alpha when the 2 km buffer was also considered, as may be expected due to the increased area in closer proximity to the Bass Rock colony. Conversely, the inclusion of a 2 km buffer tended to reduce the densities calculated in Bravo and Alpha and Bravo combined (Table 17).

5.2.11 The breeding season peak density calculated within Alpha of 10.11 individuals km^{-2} accords closely with the range to >10 individuals km^{-2} presented by Camphuysen (2011) for the Firth of Forth (Table 17). Peak densities of this magnitude are substantially higher than several other areas of importance in the North Sea such as North Shetland (1.8 individuals km^{-2}) and West Orkney (1.5 individuals km^{-2}) (Skov *et al.* 1995), but this is not unexpected given the proximity of the Bass Rock colony.

5.2.12 The peak density of 6.81 individuals km^{-2} in Bravo was lower than that within Alpha during the breeding season, in keeping with its more offshore location. Interestingly through the winter period of October to February densities were greater in Bravo, though this was always the case when the 2 km buffers were also considered (Table 17).

5.2.13 The densities during the winter months following the passage period in October, of up to 1.03 individuals km^{-2} (in Bravo) is within the range of other North Sea areas during the winter (Skov *et al.* 1995) but is lower than important wintering areas reported such as areas off the coast of Norway (3.6 individuals km^{-2}) or areas of the Channel (14.21 individuals km^{-2}).

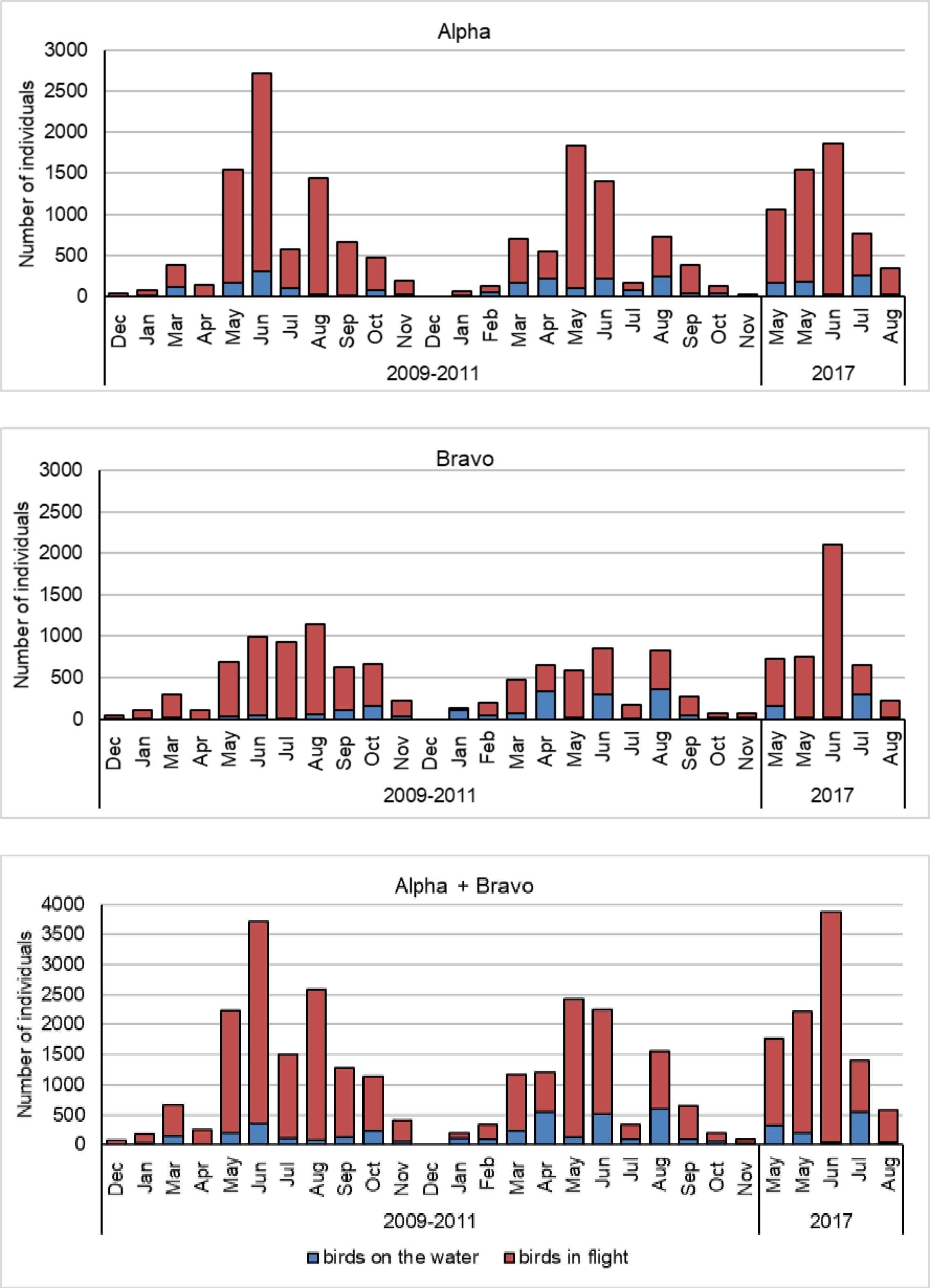


Figure 19. **Northern Gannet population estimates (number of indivduals) in Alpha, Bravo and Alpha and Bravo combined by month from boat-based surveys. Estimates are derived from density from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect.**

Table 17. **Monthly mean density (ind. km^{-2}) and standard deviation (SD) of Northern Gannets in Alpha, Bravo and Alpha and Bravo combined with and without a 2 km buffer. The number of surveys completed in each month is also shown. Densities in all cases were derived from a combination of uncorrected line transect data for birds on the water and snapshot data for flying birds.**

Project		**Month and number of surveys completed**											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
		2	**1**	**2**	**2**	**4**	**3**	**3**	**3**	**2**	**2**	**2**	**2**
Alpha	Mean	0.36	0.66	2.74	1.75	7.60	10.11	2.55	4.27	2.65	1.52	0.54	0.08
	SD	0.04	-	1.16	1.43	1.64	3.38	1.55	2.81	0.97	1.27	0.57	0.12
Alpha + 2km	Mean	0.36	0.67	2.76	1.76	7.01	10.17	2.64	4.47	2.67	1.53	0.54	0.09
	SD	0.04	-	1.17	1.44	1.99	3.41	1.65	2.61	0.98	1.28	0.58	0.12
Bravo	Mean	0.63	1.03	1.99	1.98	3.55	6.81	3.00	3.78	2.30	1.90	0.74	0.11
	SD	0.13	-	0.67	1.98	0.37	3.55	1.98	2.39	1.32	2.17	0.54	0.15
Bravo + 2km	Mean	0.61	1.00	1.93	1.91	3.58	6.32	3.02	3.58	2.23	1.83	0.71	0.11
	SD	0.12	-	0.65	1.92	0.54	2.97	1.96	2.43	1.27	2.10	0.52	0.15
Alpha + Bravo	Mean	0.49	0.85	2.37	1.86	5.52	8.39	2.75	4.02	2.48	1.71	0.64	0.10
	SD	0.04	-	0.92	1.70	0.72	2.28	1.64	2.57	1.14	1.71	0.56	0.14
Alpha + Bravo + 2km	Mean	0.47	0.81	2.28	1.79	5.00	7.90	2.76	3.95	2.39	1.64	0.61	0.09
	SD	0.04	-	0.88	1.64	0.90	2.03	1.68	2.35	1.10	1.65	0.54	0.13

Spatial distribution

5.2.14 Birds were typically encountered in groups commuting between Bass Rock and foraging grounds further offshore (Figure 20), rather than feeding or post-feeding aggregations of birds, although these did occur (see *Foraging & feeding* below). Any use of Alpha and Bravo was thus primarily driven by variation in the encounter rate of large transiting flocks on surveys rather than any location specific habitat utilisation.

5.2.15 Plots derived from abundance in flight observed during the breeding season surveys conducted in 2010 and 2011 did not reveal any particular patterns of selection across Alpha or Bravo with a patchy distribution in both years at both sites.

5.2.16 There was however, some evidence of subtle differences in distribution patterns between years. In Alpha during 2010, when population estimates were greater, birds were more concentrated in the southern part of the site, whereas in 2011 the area to the north of this section was seemingly preferred (Figure 21). In Bravo, an area in the south-west supporting higher abundance in 2010 was not used in 2011 when most cells contained a low abundance of flying birds, reflecting the lower numbers of birds generally and the increased proportion recorded on the water (Figure 19 above).

Figure 20. Typical views of Northern Gannets commuting in line formation across Alpha and Bravo.

5.2.17 During the 2017 breeding season, Northern Gannets were most frequently encountered flying in the southwestern part of the study area in the Scalp Bank region (Figure 22a). The distribution of records across the study area was patchy but appears to be become patchier overall in areas further offshore, with occasional groups of records related to larger flocks of birds dotted throughout the study area. The averaged cell KDE surface derived from birds in flight alone (Figure 22b) reveals hotspots of higher abundance estimates which generally reflect occasional records of larger flocks, of up to 84 transiting birds, amongst the smaller groups observed over much of the study area at some stage during the five surveys (Figure 20).

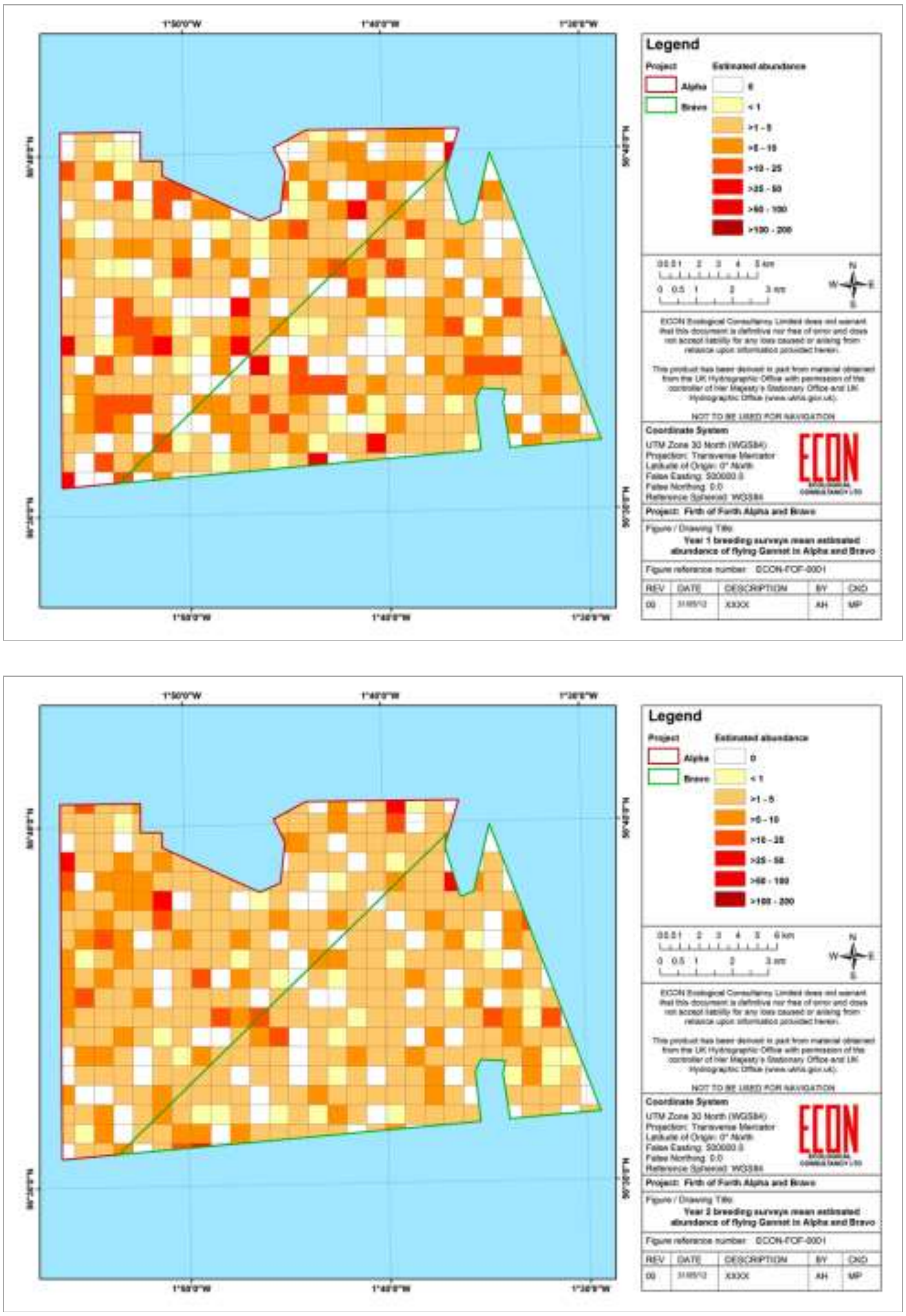


Figure 21. Relative abundance of Gannet expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to September inclusive in 2010 (above) and 2011 (below).

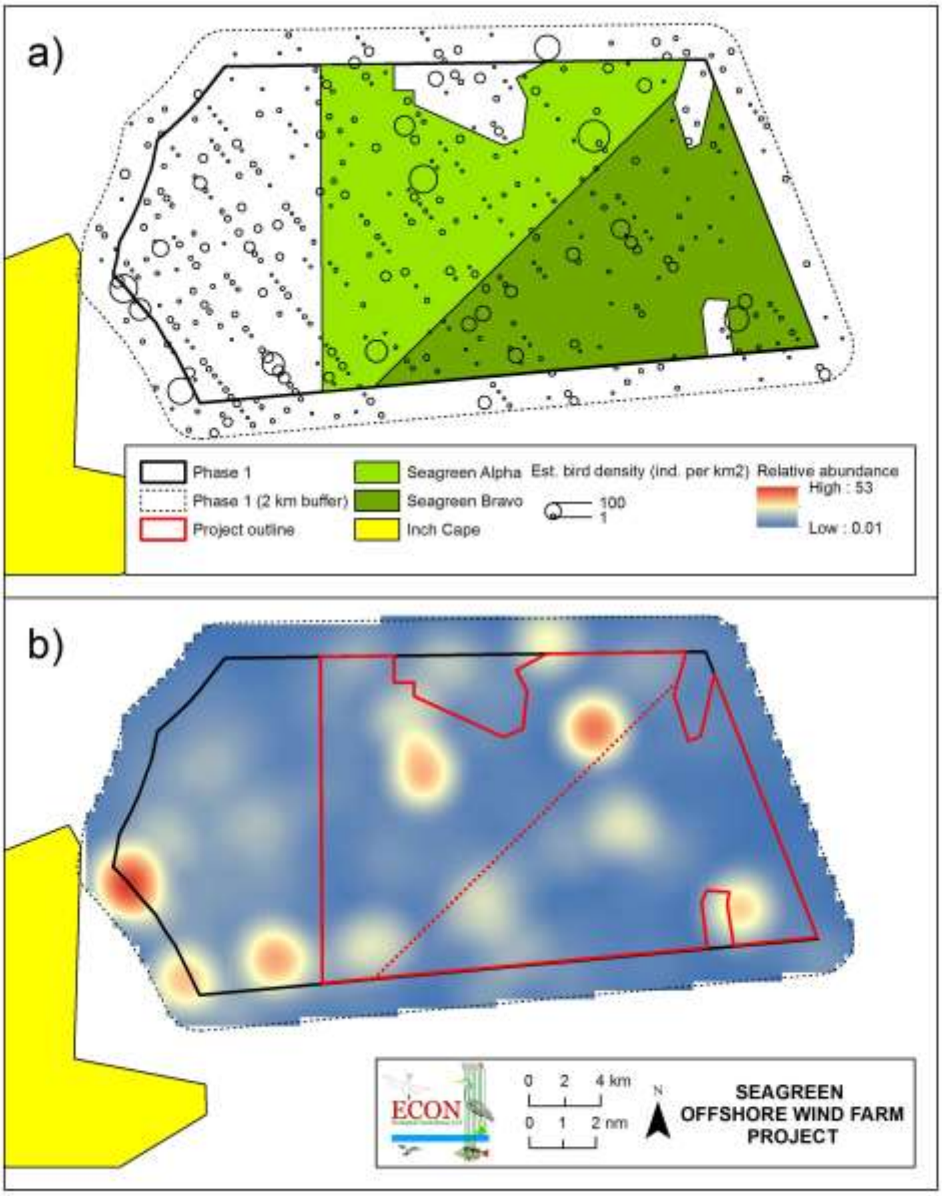


Figure 22. **Density distribution of Northern Gannet in 2017 as shown by: a) mean densities of birds in flight in each survey cell on each of the three survey routes (route two was only surveyed once) and b) the relative abundance surfaces derived using KDE applied to these data.**

5.2.18 Group size in 2017 was directly related with estimated population and density. The lowest mean group size of 1.6 (*n* = 371) was recorded during the first survey, with this rising to 4.9 (*n* = 400) in the second half of May and then to 6.9 (*n* = 663) in June when the peak density and population estimate was observed (Table 17 above). Mean group size then reduced to 2.2 (*n* = 289) and 2.1 (*n* = 213) in July and August respectively as density reduced.

Population structure

5.2.19 In the 2009-2011 surveys, 88.6% of all Northern Gannets were aged in Alpha and Bravo combined. Where a single bird was observed the proportion aged increased to 92.6% but reduced to 88.6% when two birds were observed together and just 25% within flocks of 21 to 30 individuals. In 2017, a lower proportion of birds were aged (65.7%) as a result of the preponderance of birds within larger flocks (Figure 20).

5.2.20 Adults were the dominant age class recorded in all months (Table 18), as to be expected from the fact that most Northern Gannets do not return to colonies until they are ready to commence breeding at 5-6 years of age (Wernham *et al.* 2002).

Table 18. Number and proportion of adult Northern Gannets relative to the total number of birds aged in each month during all boat-based surveys of Alpha and Bravo.

Year	Site	Month											
			Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2009-2011	Alpha	Adults	54	41	296	299	684	452	216	347	226	179	49	12
		%	94.7	100	99.7	100	99.4	92.4	96.0	97.5	93.4	89.1	90.7	85.7
		Total	57	41	297	299	688	489	225	356	242	201	54	14
	Bravo	Adults	72	46	198	248	331	341	266	410	257	262	59	28
		%	94.7	100	100	100	98.8	96.6	97.4	98.6	95.2	98.1	90.8	100
		Total	76	46	198	248	335	353	273	416	270	267	65	28
	Alpha + Bravo	Adults	126	87	494	547	1015	793	482	757	483	441	108	40
		%	94.7	100	99.8	100	99.2	94.2	96.8	98.1	94.3	94.2	90.8	95.2
		Total	133	87	495	547	1023	842	498	772	512	468	119	42
2017	Alpha	Adults					249	201	115	112				
		%					98.8	98.0	92.0	99.1				
		Total					252	205	125	113				
	Bravo	Adults					159	229	71	88				
		%					98.8	97.9	98.6	98.9				
		Total					161	234	72	89				
	Alpha + Bravo	Adults					414	432	192	205				
		%					98.6	98.0	94.6	99.0				
		Total					420	441	203	207				

5.2.21 The proportion of adults encountered in the breeding season was similar in all sites and years. In 2009-2011 in Alpha alone, the proportion aged as adults in the breeding season (April to September) was 96.7% from the aged sample of n = 2,299. A similarly high proportion (97.8%) of Gannets were aged as adults in the sample of n = 1,895 in the breeding season in Bravo (Table 18). In 2017, the proportions of adults were 97.4% (n = 695) in Alpha and 98.4% (n = 556) in Bravo.

5.2.22 The greatest proportions of sub-adult birds were recorded in winter. The increased proportion at this time is likely to be primarily driven by a greater proportional reduction in adult numbers generally. The highest proportion of sub-adult birds in the breeding season was 7.6% in Alpha in June in accordance with the known phenomenon of some non-breeding individuals attending breeding colonies.

Flight behaviour

5.2.23 The dominant flight direction of birds in all areas during the breeding season was southwest, with the proportion of records transiting on that bearing ranging from 40.3% in Bravo during 2009-2011 to 73.5% in Bravo during 2017 (Table 19). This suggests birds are returning to the Bass Rock colony from offshore foraging grounds to the northeast. The possibilities include the Buchan Deep and Halibut Bank areas, where Camphuysen (2011) has previously recorded concentrations of birds. These locations are on the edge of the tidal front area suggested to be core foraging habitat by (Skov *et al*. 2008). In addition, Fladen Grund is also thought to be an important foraging ground (see https://gannetresearch.wordpress.com/), which lies further offshore but on the same trajectory.

5.2.24 Hamer *et al*. (2000, 2007) had previously documented the highly non-random distribution of flights from Bass Rock with a far greater proportion of flights to the northeast and southeast than expected by chance. Whilst the northeast transit was the second most frequently recorded in all areas during the breeding season, this comprised a much smaller proportion of records from 17.3% in Bravo during 2017 to 27% in Alpha in the same year (Table 19). The fact that this accounts for only 40% of the total flights in a southwesterly direction recorded during all breeding season surveys suggests that birds are also likely to access foraging areas using a different outbound route from the Bass Rock colony. One possibility is that they also head east in the direction of Wee Bankie, a known important foraging area (Kober *et al*. 2009) before working their way north, foraging at prey patches *en-route* and returning on a southwest transit that is the dominant flight line in Alpha and Bravo.

5.2.25 Flight height data from 2009-2011 yielded a total of 3,303 records of Northern Gannets in Alpha with 9.4% flights at above 20 m. The equivalent values were 16.3% of n = 2,813 birds in Bravo, considerably higher than that by Cook *et al*. (2011). The disparity may relate to subtle differences in the behaviour of birds within each of the areas, for example, birds gaining height to forage, which appeared to occur at slightly greater frequency in Bravo (see *Foraging & Feeding* below), although densities were generally lower.

Table 19. Number and proportion (%) of flight directions recorded for Northern Gannet during boat-based surveys of Alpha and Bravo. 'None' represents no fixed direction.

Parameters			Compass direction								
			N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**None**
2009-2011 Breeding	Alpha	Count	138	595	78	131	295	1376	112	113	164
		%	4.6	19.8	2.6	4.4	9.8	45.8	3.7	3.8	5.5
	Bravo	Count	135	499	97	124	126	909	95	117	155
		%	6.0	22.1	4.3	5.5	5.6	40.3	4.2	5.2	6.9
	Alpha+ Bravo	Count	273	1094	175	255	421	2285	207	230	319
		%	5.2	20.8	3.3	4.8	8.0	43.4	3.9	4.4	6.1
2009-2011 Non-breeding	Alpha	Count	43	94	26	41	17	48	29	58	37
		%	10.9	23.9	6.6	10.4	4.3	12.2	7.4	14.8	9.4
	Bravo	Count	37	58	46	70	50	67	54	48	67
		%	7.4	11.7	9.3	14.1	10.1	13.5	10.9	9.7	13.5
	Alpha+ Bravo	Count	80	152	72	111	67	115	83	106	104
		%	9.0	17.1	8.1	12.5	7.5	12.9	9.3	11.9	11.7
2017	Alpha 2017	Count	29	230	17	14	28	498	10	16	11
		%	3.4	27.0	2.0	1.6	3.3	58.4	1.2	1.9	1.3
	Bravo 2017	Count	17	148	15	1	5	628	14	19	8
		%	2.0	17.3	1.8	0.1	0.6	73.5	1.6	2.2	0.9
	Alpha+ Bravo 2017	Count	47	390	33	17	33	1132	24	35	20
		%	2.7	22.5	1.9	1.0	1.9	65.4	1.4	2.0	1.2

5.2.26 Observer estimated flight heights in 2017 ranged from >0-1 m to >40-45 m, although the majority of birds were recorded flying close to the sea surface, with 84.8% (*n* = 1881) of birds recorded at <5 m (Figure 23). Only 5.0% of birds were recorded at a height of > 20 m, with this being 2.2% (*n* = 945) in Alpha and 7.3% (*n* = 914) in Bravo. These proportions are lower than had been previously observed in 2009-2011, but show a similar difference between Alpha and Bravo.

5.2.27 As would be expected for an aerial forager, lower flight heights were observed in conjunction with the southwesterly flight direction while transiting back to the colony. From a sample of birds (*n* = 2,578) observed in 2017, 90% of birds flying southwest were at <5 m, compared to 76% of birds (*n* = 854) flying at <5 m on the outbound northeasterly transit, when flying higher may aid the identification and exploitation of any foraging opportunities.

5.2.28 Flight heights were also influenced by wind direction. Of *n* = 111 birds observed flying southwest at a height of >20 m in 2017, 95.5% were utilising a light (Beaufort scale force 1-2) northeasterly tailwind. Increased height offers the prospect of higher wind speed and a greater energetic advantage. In a headwind, flight is more energy efficient close to the water as the wind speed is reduced through friction from the sea surface (see Gibb *et al*. 2017 in relation to Manx Shearwater *Puffinus puffinus*).

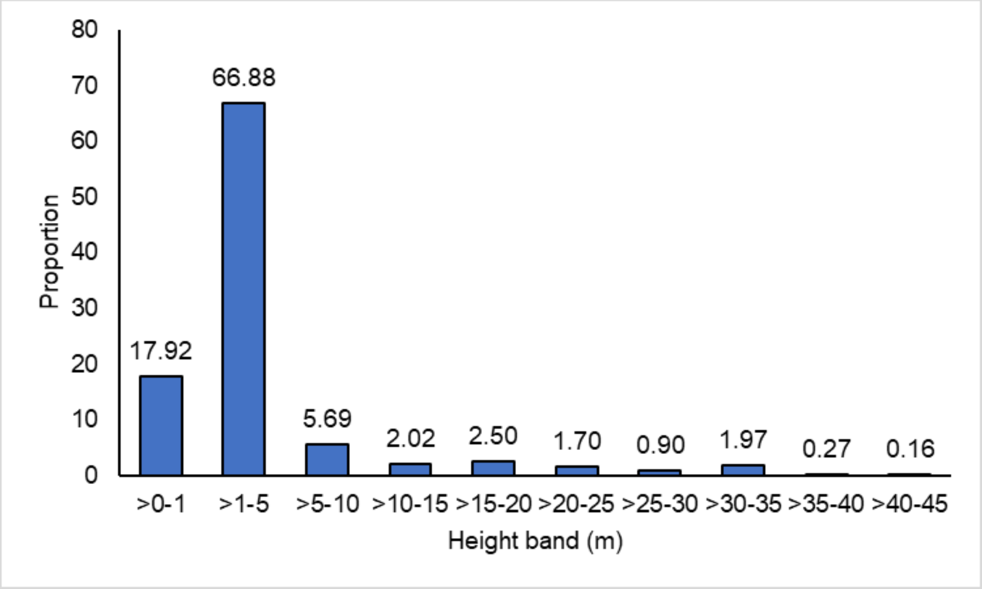


Figure 23. Proportion (%) of flight heights recorded for Northern Gannet (*n* = 1881) during boat-based surveys of Alpha and Bravo combined in 2017.

5.2.29 In 2017, rangefinder records of Northern Gannet (*n* = 350) were gathered in 2017 across Alpha, Bravo and the wider area, recording a maximum corrected flight height of 49.5 m. The most frequently observed height range was >1-5 m (Appendix 1).

5.2.30 Observer accuracy was high, with 68.9% (*n*=386) of observer estimates falling within the same band as recorded by the corrected rangefinder height estimate. A general tendency to slightly underestimate height was apparent and 68% of records not in agreement with the rangefinder were in a lower band (Appendix 1). However, at least a portion of the small number of records showing a deviation of 10-15 m may be due to disparate timing of the point of observation relative to rangefinder acquisition.

Foraging & feeding

5.2.31 Northern Gannet has the ability to adopt a number of strategies to take a wide variety of prey items, but generally feeds on large shoaling fish such as Mackerel *Scomber scombrus*, gadoids and clupeids by plunge diving from heights of 10-40 m (Lloyd *et al.* 1991) and achieving dive beyond the scope of other aerially foraging seabirds. Northern Gannet also readily adapts feeding methods to scoop smaller prey such as sandeels from the surface, perhaps exploiting opportunities created by other species such as diving auks (Camphuysen 2005, Figure 24). Northern Gannets may also associate with dolphins, as these are likely to drive prey to the surface (Camphuysen 2011), as well as scavenge discards from fishing vessels.

5.2.32 Surveys in 2009-2011 found little evidence that Northern Gannet used either Alpha or Bravo as foraging grounds of note, with just 3.9% of birds in Alpha and 3.7% in Bravo engaged in direct feeding activity. The distribution of feeding records was scattered across the sites with isolated individuals and small feeding aggregations (<25 birds) engaged in active feeding during the breeding season (Figure 25).

Figure 24. **Northern Gannets scooping small prey at the surface amongst a multi-species foraging aggregation with Black-legged Kittiwakes with the opportunity created by auks foraging under the surface.**

5.2.33 Similarly, in 2017 there were few records involving just 24 birds engaged in foraging or fishing activity (Figure 25), which were not consistently concentrated in a particular area and did not involve large groups of birds. Largest groups were a flock of five diving amongst Black-legged Kittiwakes, Common Guillemots and Razorbills, four ‘scooping’ fish at the surface in a further multi-species foraging association (MSFA) (Figure 24) and two birds foraging together. Otherwise, most records appear to represent opportunistic foraging by transiting individuals, including two records of single birds actively associating with Harbour Porpoise *Phocoena phocoena*.

5.2.34 Flight records of no fixed direction also typically indicates foraging birds undergoing area-restricted search for prey. Birds were infrequently recorded with no fixed direction, with proportions during breeding season surveys ranging from 0.9% in Bravo during 2017 to 6.9% in Bravo during 2009-2011; also highlighting the potential for inter-annual variation in foraging locations. The highest proportions of no fixed direction flight records were recorded in the winter period although this involves smaller numbers of birds (Table 19). The highest proportion recorded of 13.5% was again in Bravo during 2009-2011 further suggesting that Bravo could hold more opportunities for foraging birds than Alpha.

5.2.35 In addition to flight behaviour, there are other potential indicators of foraging. For example, in July 2017, a relatively large proportion of the estimated population was observed on the water rather than in flight (see Figure 19 above), apparently in post-foraging aggregations. Northern Gannets may gorge at a prey patch to the point of struggling to become airborne again once the event has finished.

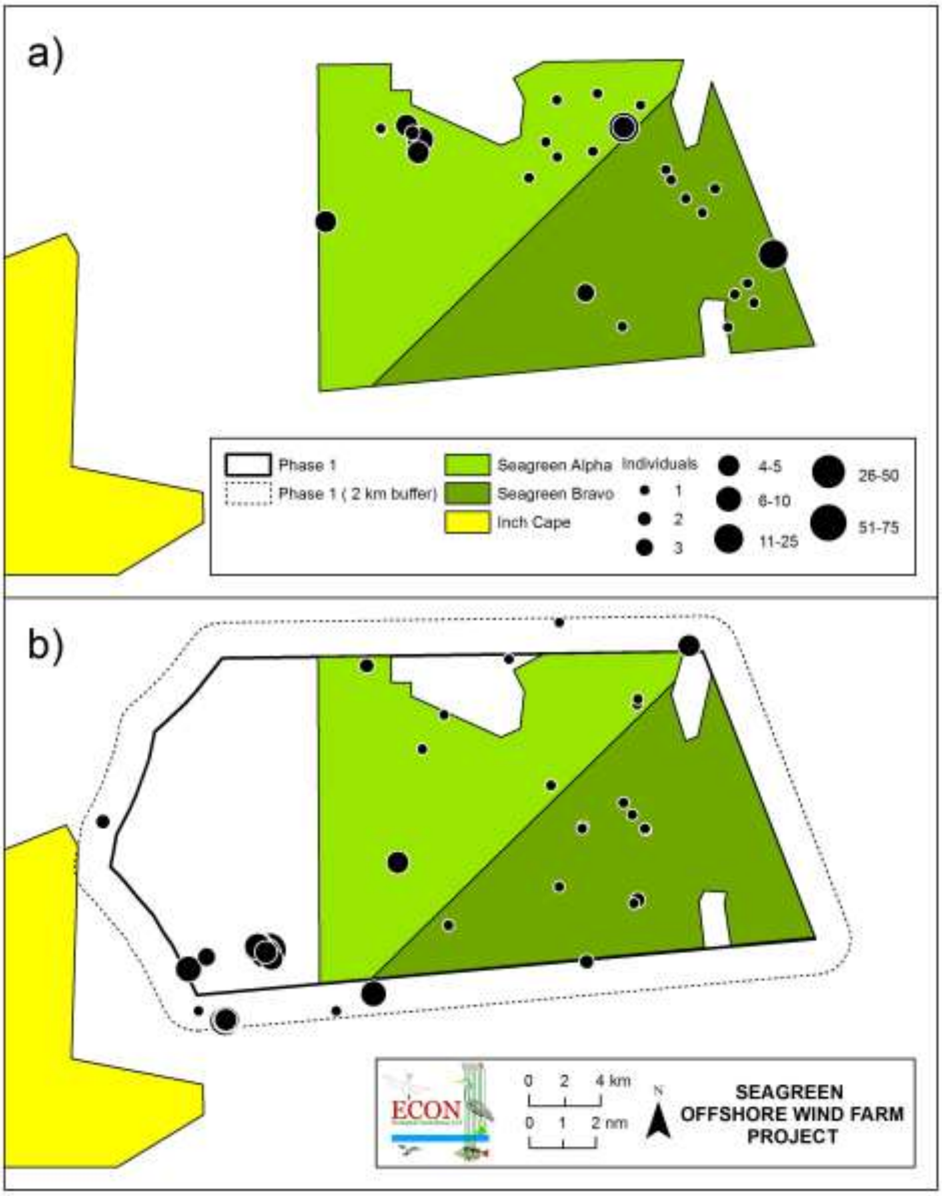


Figure 25. **Distribution and group size of feeding Northern Gannets recorded in the breeding season in: a) 2010 and 2011 for Alpha and Bravo only and b) in Alpha and Bravo and surrounds in 2017.**

5.2.36 In addition, a distinct cluster of foraging records was noted in the southwest near Scalp Bank and outside of Alpha and Bravo (Figure 25); as manifested as one of the less intense hotspots in Figure 22b. However, as records were restricted to one occasion this indicates a temporary availability of prey rather than a consistent aggregation of prey with a particular habitat feature.

5.3 Black-legged Kittiwake

Populations & connectivity

5.3.1 With a global population up to 15,700,000 individuals (Wetlands international 2016), Black-legged Kittiwake is the most numerous gull in the World. Some 1,730,000-2,200,000 pairs breed in Europe (Birdlife International 2015). However, the species is experiencing long-term population decline, although it is not yet classed as Vulnerable by the ICUN. In contrast, severe population decline has been evident in the UK breeding and wintering populations and ranges over the past 25 years, resulting in 'Red' conservation status in the UK (Eaton *et al.* 2015).

5.3.2 Black-legged Kittiwake nests all around the UK coastline, with the largest colonies associated with the sea cliffs around northern and eastern Scotland. The breeding population of the UK was 378,847 pairs in the Seabird 2000 census, having declined by 25% since 1988 (JNCC 2016). Different colonies in the UK and Ireland have declined at different rates, with the more northerly colonies in Scotland suffering the most. For example, from 1999 to 2015 the Fowlsheugh colony declined by almost 50% (JNCC 2016). Changes in the marine environment, specifically prey resources during the breeding season are thought to be responsible (Frederiksen *et al*. 2004).

5.3.3 Within a mean maximum foraging range of 60 km (Thaxter *et al.* 2012) from Alpha and Bravo, Black-legged Kittiwake is designated within two SPAs; Fowlsheugh and the Forth Islands and one separate SSSI; that is, an SSSI not covered by an SPA (Figure 26). Eight further colonies fall within the mean foraging range but are undesignated or notified (Table 20).

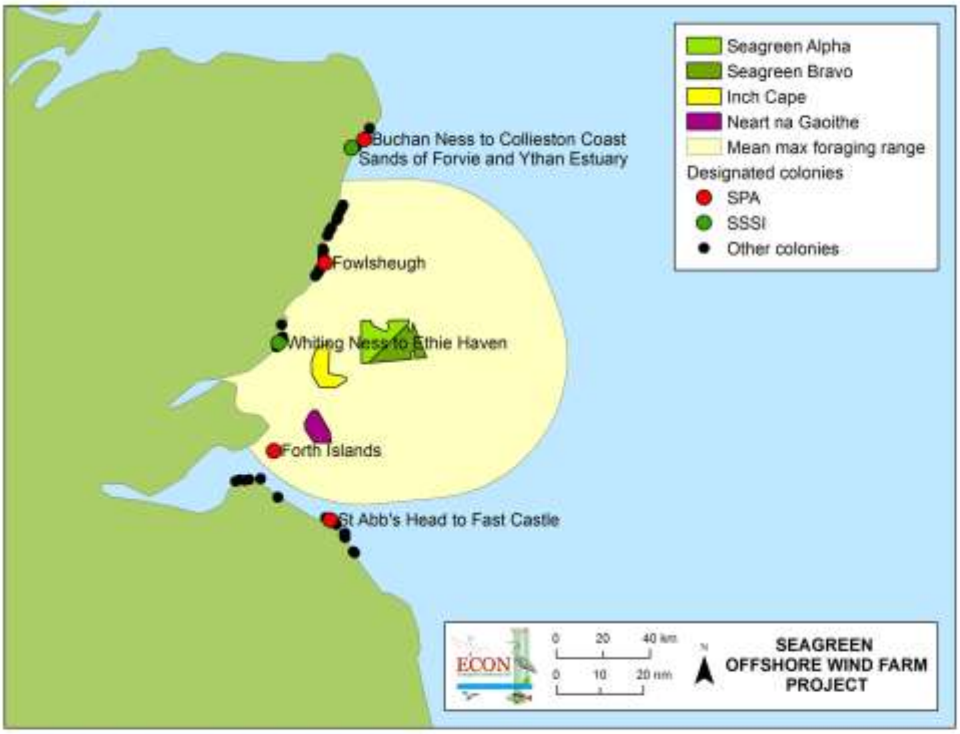


Figure 26. **Distribution of Black-legged Kittiwake breeding colonies within mean maximum foraging range (60.0 km) of Seagreen Alpha and Bravo.**

Table 20. Details of all Black-legged Kittiwake breeding colonies within mean maximum foraging range (60.0 km) from the Alpha and Bravo areas at increasing distance (km), and including SPAs of relevance beyond this distance. Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count in the year specified are shown.

Site and designation	Distance (km)	Natura 2000	Seabird 2000	Latest count	
				Number	Year
Catterline to Inverbervie	27.64		6,136	6,136	1999
Fowlsheugh SPA	30.41	73,300	47,078	19,310	2015
Stonehaven to Wine Cove	33.55		1,612	1,612	1999
Montrose to Lunan Bay	33.95		768	768	2000
Whiting Ness to Ethie Haven SSSI	34.86		5,084	5,084	2000
Newton Hill	38.92		16	16	2002
Newtonhill - Hall Bay	40.75		1,576	1,576	1999
Burn of Daff	41.62		900	900	1999
Findon Ness - Hare Ness	44.97		2,284	2,284	1999
Girdle Ness to Hare Ness	48.82		2,790	2,790	1999
Forth Islands SPA (Isle of May)	52.61	16,800	7,278	8666	2015
St Abb's Head to Fast Castle SPA[1]	67.90	42,340	30,860	5558	2016
Buchan Ness/Collieston Coast SPA[1]	81.85	60,904	28,182	22,964	2017
	Total	193,344	134,564	77,664	

[1] SPA outwith the mean maximum foraging range of Black-legged Kittiwake but included for consideration in HRA.

5.3.4 Notably, the St Abb's Head to Fast Castle and Buchan Ness to Collieston Coast SPAs are located a further 8 km and 22 km outside the 60 km range respectively, although Marine Scotland (2017) state that they are to be considered in the HRA, at least in a cumulative context (Table 19). Tracking suggests that even birds originating from the closer St Abb's Head to Fast Castle SPA are unlikely to reach Alpha and Bravo (Figure 27).

5.3.5 A total of 49,412 Black-legged Kittiwakes are present at colonies within the mean maximum foraging range, with 56.9% of these birds from a SPA. This rises to 77,664, of which 72.7% are within SPAs, if St Abb's Head to Fast Castle and Buchan Ness to Collieston Coast SPAs are considered. However, it should be noted that not all other undesignated Black-legged Kittiwake colonies, within a range consistent with that of the Buchan Ness to Collieston Coast SPA, are currently included within this apportioning.

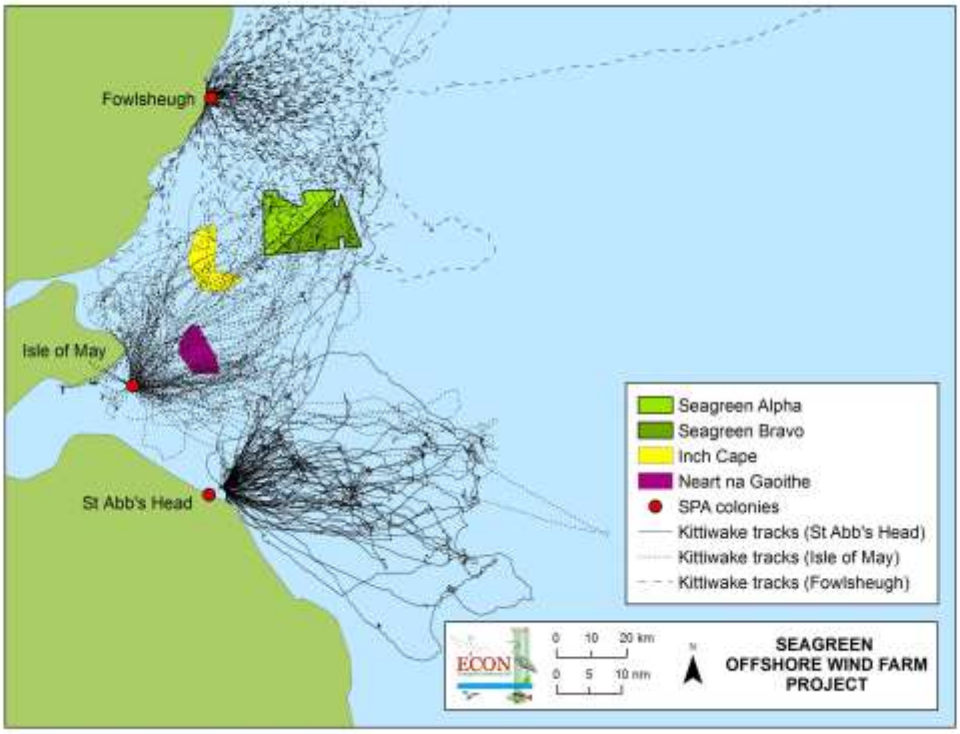


Figure 27. Tracks of breeding Black-legged Kittiwakes fitted with GPS tags from Isle of May (*n* = 36) in 2010 and Fowlsheugh (*n* = 35) and St Abb's Head (*n* = 25) in 2011.

Density & population size

5.3.6 Black-legged Kittiwake was present in all boat-based surveys of Alpha and Bravo throughout 2009-2011 and 2017, although estimated numbers and densities fluctuated between surveys, seasons and years (Figure 28, Table 21). Nevertheless, the basic pattern is of an increase in late winter and early spring, consistent with Black-legged Kittiwakes returning to their nesting colonies as early as January, although March or April is more typical (Cramp *et al.* 1974). Variable numbers of birds then occurred in the different sites in the different years during the breeding season, albeit with clear peaks in different months. Following fledging, especially in August and the dispersal of adults from breeding colonies, the numbers of birds tended to decline, before a secondary peak in late autumn, coincident with the wider passage of birds presumably from a range of colonies.

5.3.7 In the 2010 and 2011 breeding seasons peak population estimates in both Alpha and Bravo tended to be recorded during chick provisioning in June, with peaks of 1,914 individuals in Alpha and 2,813 individuals in Bravo, both in 2011 (Figure 28). In 2017, peak abundance in the breeding season occurred later in July and attained much higher levels than previously recorded with a peak estimate of 13,140 birds in Alpha and 3,656 in Bravo (Figure 28). At this time, Black-legged Kittiwakes were associated with large numbers of auks, apparently attracted by abundant prey resources, which in turn had also attracted numbers of marine mammals, particularly Common Minke Whales *Balaenoptera acutorostrata.*

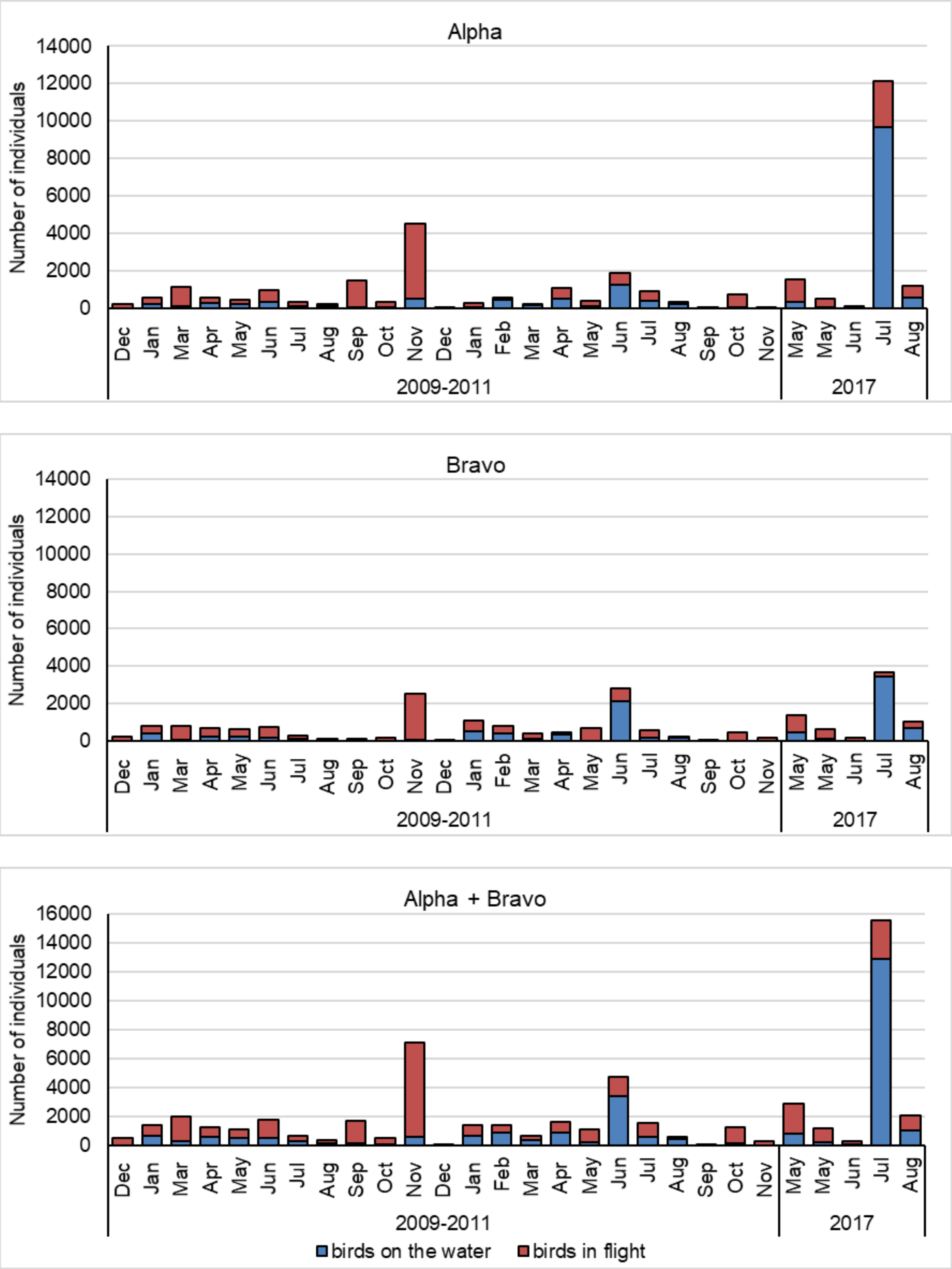


Figure 28. Black-legged Kittiwake population estimates (number of individuals) in Alpha, Bravo and Alpha and Bravo combined by month from boat-based surveys. Estimates are derived from the density of snapshots of birds in flight combined with distance-corrected density of birds on the water from line transect.

Table 21. Monthly mean density (ind. km^{-2}) of Black-legged Kittiwakes in Alpha, Bravo and Alpha and Bravo combined with and without a 2km buffer. The number of surveys completed in each month is also shown. Densities in all cases were derived from a combination of uncorrected line transect data for birds on the water and snapshot data for flying birds.

Project		Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		2	1	2	2	4	3	3	3	2	2	2	2
Alpha	Mean	2.20	2.91	3.61	4.28	3.76	5.09	22.69	3.00	3.83	2.84	11.54	0.62
	SD	1.00	-	3.21	2.02	2.80	4.59	33.66	2.70	5.34	1.48	16.03	0.72
Alpha + 2km	Mean	3.28	4.33	5.38	6.38	4.61	7.63	20.70	6.32	5.70	4.23	17.19	0.92
	SD	1.48	-	4.79	3.02	2.25	6.76	27.48	7.22	7.95	2.21	23.87	1.07
Bravo	Mean	4.84	4.06	3.09	2.92	4.30	6.39	7.76	2.37	0.40	1.59	7.09	0.72
	SD	1.02	-	1.60	0.71	1.87	7.21	9.67	2.70	0.42	1.12	8.63	0.78
Bravo + 2km	Mean	5.45	4.57	3.48	3.29	5.12	7.18	10.37	2.16	0.45	1.79	7.98	0.81
	SD	1.15	-	1.80	0.80	2.98	8.14	13.71	2.16	0.47	1.26	9.71	0.87
Alpha + Bravo	Mean	3.51	3.48	3.35	3.61	3.99	5.73	15.09	2.47	2.13	2.22	9.34	0.67
	SD	0.00	-	2.41	0.67	2.23	5.83	21.42	2.33	2.90	1.31	12.36	0.75
Alpha + Bravo + 2km	Mean	4.85	4.80	4.63	4.98	5.27	7.92	15.26	4.42	2.94	3.07	12.89	0.92
	SD	0.00	-	3.34	0.92	2.97	8.03	19.93	4.95	4.00	1.80	17.07	1.03

5.3.8 Black-legged Kittiwake chicks hatch throughout June and July and take six weeks to fledge. Whilst most dispersal follows fledging in July / August, adult Black-legged Kittiwakes have been known to remain at their nest site after their chicks have fledged, with some staying until November (Cramp *et al.* 1974). The timing of what was an exceptional event in July 2017, coupled with the population structure of the birds recorded (see *Population structure* below) suggests that most if not all the Black-legged Kittiwakes present were adults of local origin provisioning large chicks.

5.3.9 However, the combined total of 16,796 would suggest some 34% of all adults from colonies within foraging range were present (see 5.2.5 above), which seems exceptionally high especially considering that birds may been spread over a wider area than just within Alpha in the vicinity of Scalp and Montrose Banks, compared to the Wee Bankie and Marr Bank complex further south. This raises the possibility of an influx of failed breeders from elsewhere, perhaps more northerly Scottish colonies.

5.3.10 Prior to the events in July 2017, peak population estimates in both Alpha and Bravo had been recorded in November 2011, with 4,511 and 2,554 individuals respectively (Figure 28). At this time, the origin of birds seems likely to be a considerable mixture from colonies around the North Sea, if not further afield.

5.3.11 During the breeding season mean density of Black-legged Kittiwakes generally ranged from 3-5 individuals km^{-2} (Table 21) within both Alpha and Bravo. Whilst there was some increase to 7.76 individuals km^{-2} in Bravo in July 2017, this paled into insignificance relative to the 22.69 individuals km^{-2} recorded in Alpha. This further highlights the concentration of birds in a relatively small area within both Alpha and Alpha and its surrounding 2 km buffers, where a similar density of 20.7 individuals km^{-2} was achieved.

5.3.12 Disregarding the peak density recorded in July within Alpha, breeding season density values within Alpha and Bravo tend to fall below the 12.1 individuals km^{-2} previously noted by Skov *et al*. (1995) for the entire Aberdeen Bank area encompassing the Firth of Forth during April to September covering the main peak of breeding activity.

5.3.13 Outside the breeding season and during the late autumn and winter period, Skov *et al*. (1995) reported densities within a range of 0.5 individuals km^{-2} in the central North Sea up to 10.9 individuals km^{-2} at Fladen Grund. This corresponds to the range of winter densities recorded in Alpha and Bravo with respective peaks of 11.54 individuals km^{-2} and 7.01 individuals km^{-2} in November 2011 (Table 21). It is of note however that a higher density of 17.19 individuals km^{-2} is estimated with the inclusion of a 2 km buffer for Alpha, testament to the importance of Scalp Bank.

Spatial distribution

5.3.14 Distribution maps derived from flying birds in all boat-based surveys during 2009-2011 showed widespread coverage at low abundance (1-5 flying birds km^{-2}), interspersed by patches of high abundance (10-50 flying birds km^{-2}) in the breeding season (Figure 29). There was a hint of greater abundance in the north of the site especially when compared to the winter period, when distribution was particularly patchy (Figure 29).

5.3.15 Patches of higher abundance can be partly linked to the location of foraging birds (see *Foraging & Feeding* below). For example, in the breeding season, most of the larger foraging aggregations lay within Alpha (Figure 29) with some clustering in the northeast and northwest as well as the southwest. The latter area was also distinctly preferred in the winter months (Figure 29) and may represent an extension of what is thought to be good foraging habitat at Scalp Bank.

5.3.16 Inter-annual variation in the spatial distribution of Black-legged Kittiwakes was also apparent. For example, the eastern edge of Bravo was heavily utilised during the breeding season of 2011, suggesting birds were ranging further from breeding colonies compared to 2010 (Figure 30). Daunt *et al*. (2011c) previously showed considerable scope for inter-annual variation in foraging movements of birds fitted with activity loggers from 1999-2002 inclusive. Greatest range to 100-120 km was shown in 2001 compared to a maximum of 60-80 km in 2003 when the majority of trips covered <40 km. Fluctuations in range are invariably linked to inter-annual variation in the abundance and distribution of prey resources.

5.3.17 In 2017, site utilisation tended to decrease with increasing distance offshore, which also corresponds with increasing distance from both colonies at Fowlsheugh and Forth Islands SPAs (Figure 31a). The resultant KDE surface clearly picks up the consistently higher abundance of Black-legged Kittiwakes over Scalp Bank to the west of Alpha (Figure 31). Other, less distinct, patches of higher abundance were also generated probably by intermittent foraging opportunities in individual surveys.

For example, in early May an area in the southwestern corner at the intersection of Alpha and Bravo was heavily used. In contrast, the southeastern corner of Bravo commonly had few records (Figure 31ab).

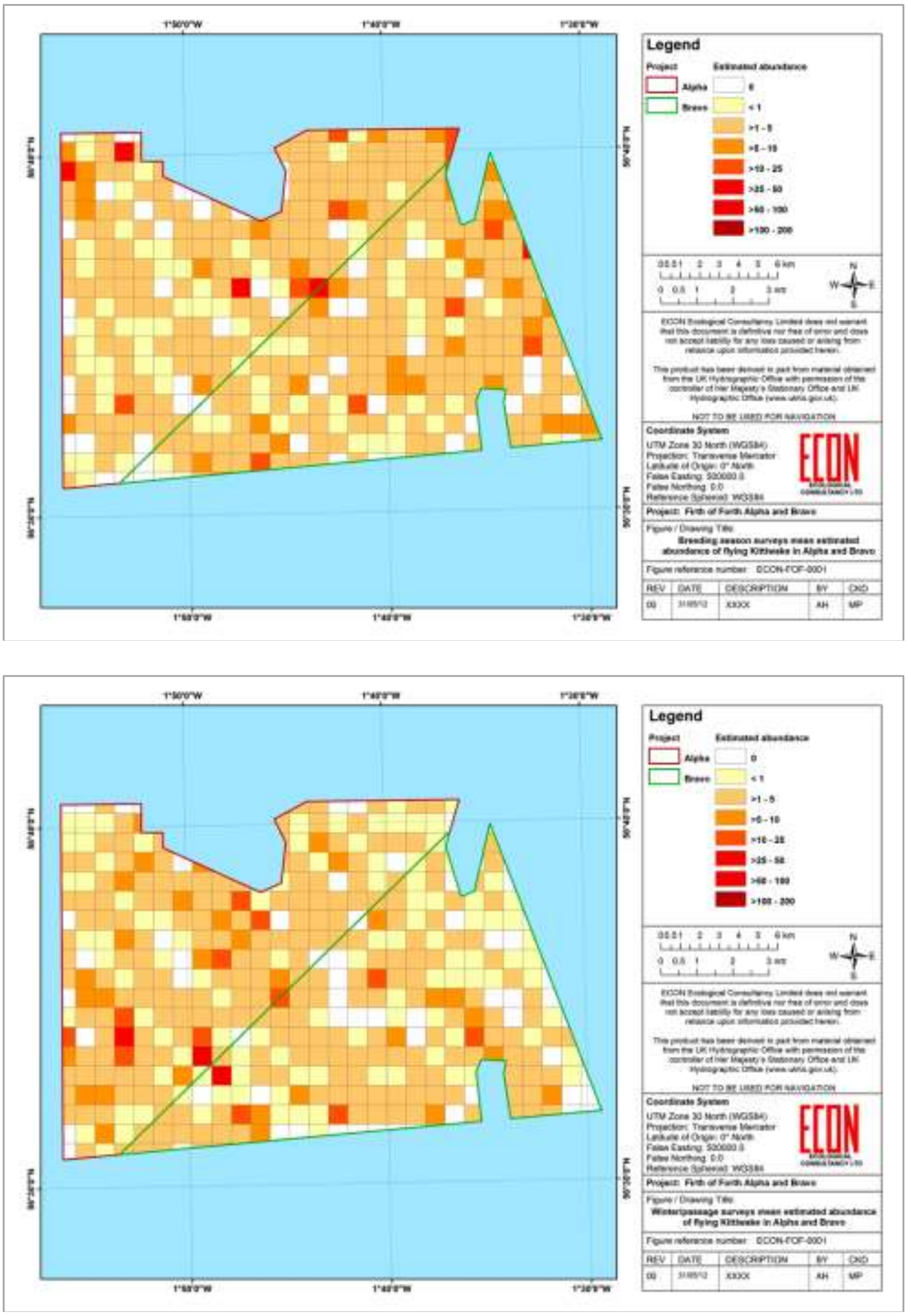


Figure 29. **Relative abundance of Black-legged Kittiwake in 2009-2011 expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August (above) compared to the passage/winter period (below).**

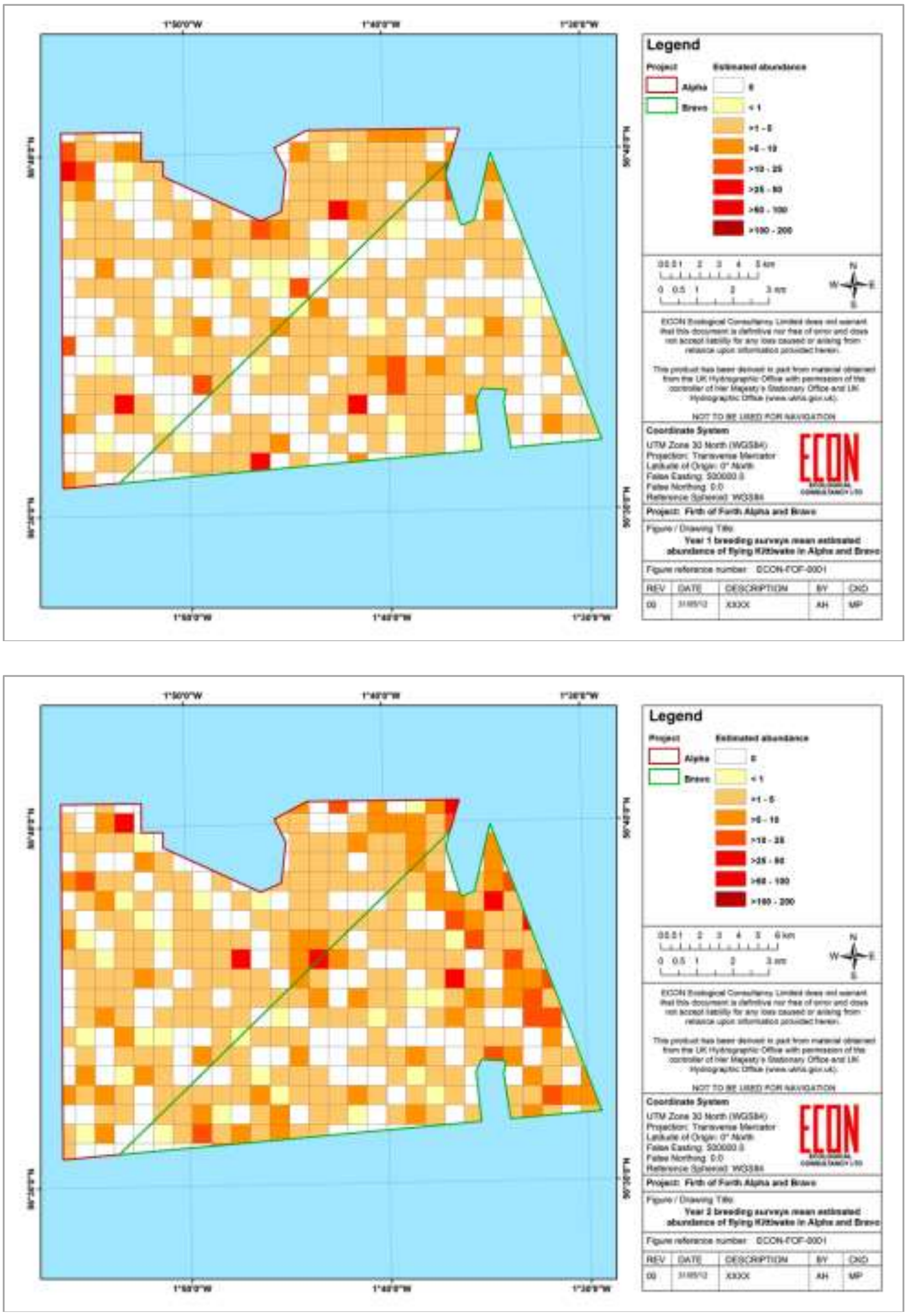


Figure 30. Relative abundance of Black-legged Kittiwake in 2009-2011 expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August in 2010 (above) compared to 2011 (below).

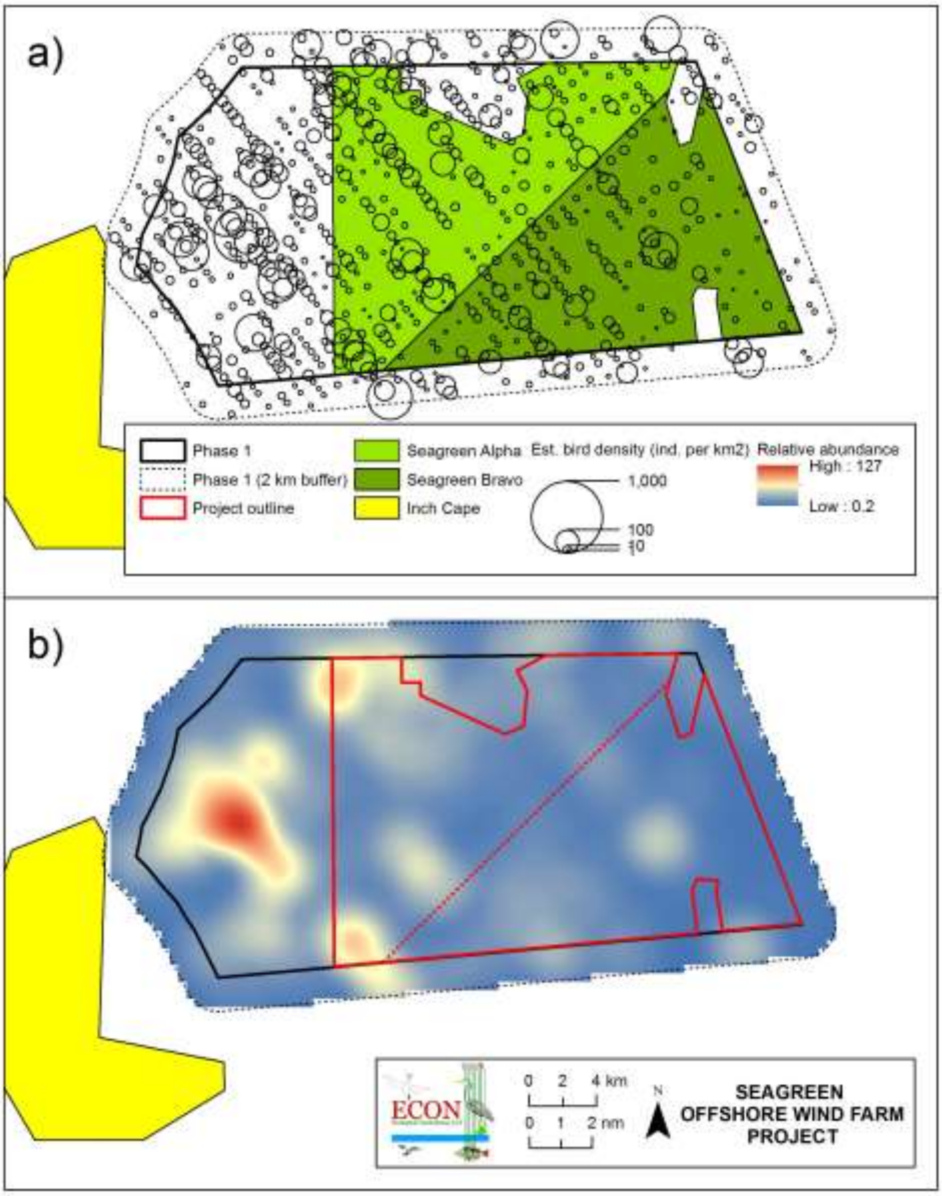


Figure 31. Density distribution of Black-legged Kittiwake in 2017 as shown by: a) mean densities of birds in flight and on the water (corrected values) combined, in each survey cell on each of the three survey routes (route two was only surveyed once), and b) the relative abundance surfaces derived using KDE applied to these data.

Population structure

5.3.18 In total, 78.5% of all Black-legged Kittiwakes in Alpha and Bravo combined were aged during the 2009-2011 surveys, with this reducing to 40.2% in the 2017 breeding season surveys. The reduction was caused by an increase in the numbers of birds within large groups (mean group size of *n* = 21 where >5 birds were present), which reduced the proportion of birds that could be aged. For example, a very high proportion of single birds were aged (91.4%) similar to the 92.6% in 2009-2011, with this declining for two birds recorded together to 85.2% (84% in 2009-2011) and to just 11.0%, with groups of >5 birds (compared to 31.3% in 2009-2011).

5.3.19 In Alpha, the proportion of Kittiwakes aged as adults in the breeding season of April to August was 94.2% (*n* = 1,122) with a similarly high proportion of 95.8% (*n* = 1,118) recorded in Bravo (Table 22). The proportion of adult birds in all areas and in all years was consistently high from April to July before dropping considerably in August, reflecting the fledging and dispersal of juvenile birds (Figure 32).

Table 22. Number and proportion of adult Black-legged Kittiwakes relative to the total number of birds aged in each month during all boat-based surveys of Alpha and Bravo.

Year	Site	Month												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009-2011	Alpha	Adults	127	63	213	299	150	207	332	69	31	122	102	38
		%	72.6	87.5	84.9	97.1	92.0	97.2	99.7	65.7	47.0	78.7	61.1	79.2
		Total	175	72	251	308	163	213	333	105	66	155	167	48
	Bravo	Adults	257	74	200	225	302	290	209	45	26	123	74	44
		%	72.4	74.7	88.9	99.1	96.8	95.1	99.1	71.4	57.8	82.0	68.5	62.9
		Total	355	99	225	227	312	305	211	63	45	150	108	70
	Alpha+ Bravo	Adults	384	137	413	524	452	497	541	114	57	245	176	82
		%	72.5	80.1	86.8	97.9	95.2	95.9	99.4	67.9	51.4	80.3	64.0	69.5
		Total	530	171	476	535	475	518	544	168	111	305	275	118
2017	Alpha	Adults					315	42	223	100				
		%					97.8	95.5	96.5	71.4				
		Total					322	44	231	140				
	Bravo	Adults					310	33	156	91				
		%					97.8	100	97.5	76.5				
		Total					317	33	160	119				
	Alpha+ Bravo	Adults					625	75	379	191				
		%					97.8	97.4	96.9	73.7				
		Total					639	77	391	259				

5.3.20 The proportion of adult birds remained lower over the winter in comparison with the breeding season, reflecting the ease of identifying young birds in this period as well as a likely genuine proportional increase in the local population reduced by the migration of adults to other areas. Most birds from Scottish breeding colonies leave by late August and dispersal into the North Sea and North Atlantic can be rapid (Forrester *et al.* 2007). The wintering range is vast, covering the North Sea, the eastern Atlantic and extending across the North Atlantic to Greenland and eastern Canada, with a southern limit of about 30˚ N (Frederiksen *et al*. 2011). It is therefore highly likely that many birds encountered over winter are not from local colonies and may include juvenile birds from distant breeding areas.

Figure 32. **Black-legged Kittiwake ageing in August showing from left to right an adult, a non-breeding probable second year bird and a first year recently fledged juvenile.**

Flight behaviour

5.3.21 Analysis of flight direction in the breeding season periods at Alpha and Bravo show a southeast to northwest flight axis consistent with birds coming from and going to the large colony at Fowlsheugh (Table 23). A high proportion of flights are also noted to the southwest, with the exception of Bravo in 2009-2011, suggesting birds returning to the Isle of May within the Forth Islands SPA. There was no clear reciprocal northeast flight path, however, suggesting foraging grounds may be accessed using an outbound transit that does not pass through Alpha and Bravo. Alternatively, as Alpha and Bravo are at the upper end of the expected foraging range for birds from the Isle of May, it is possible that the Scalp Bank area is actually the target destination, making it more difficult to detect the inbound flight path.

5.3.22 The highest proportion of birds in both the breeding and non breeding periods in all areas and all years show no flight direction, which is indicative of foraging rather than commuting flight (Table 23). The higher percentage of birds with no fixed flight direction recorded within Alpha during the breeding season would tend to confirm it is of greater relative importance than Bravo for foraging at this time (see *Foraging & feeding* below), although a higher proportion of birds appear to forage in Bravo during the winter.

5.3.23 Flight height data from Alpha derived from boat-based surveys in 2009-2011 found 66% of all birds observed in flight, with 10.7% >20 m. In Bravo, there was a slightly lower proportion of birds in flight (58%), with a greater proportion (15.7%) of these at >20 m, in close agreement with the 16.1% derived by Cook *et al*. (2011) from a range of sites.

Table 23. Number and proportion (%) of flight directions in breeding and non-breeding periods recorded for Black-legged Kittiwake during boat-based surveys of Alpha and Bravo. 'None' represents no fixed direction.

Parameters			Compass direction								
			N	NE	E	SE	S	SW	W	NW	None
2009-2011 Breeding	Alpha	Count	43	49	49	205	98	158	64	145	353
		%	3.7	4.2	4.2	17.6	8.4	13.6	5.5	12.5	30.3
	Bravo	Count	60	97	87	260	95	98	62	147	314
		%	4.9	8.0	7.1	21.3	7.8	8.0	5.1	12.0	25.7
	Alpha+ Bravo	Count	103	146	136	465	193	256	126	292	667
		%	4.3	6.1	5.7	19.5	8.1	10.7	5.3	12.2	28.0
2009-2011 Non-breeding	Alpha	Count	111	298	83	320	85	125	126	492	1069
		%	4.1	11.0	3.1	11.8	3.1	4.6	4.7	18.2	39.5
	Bravo	Count	76	113	111	128	90	151	136	246	415
		%	4.1	11.0	3.1	11.8	3.1	4.6	4.7	18.2	39.5
	Alpha+ Bravo	Count	187	411	194	448	175	276	262	738	1484
		%	4.5	9.8	4.6	10.7	4.2	6.6	6.3	17.7	35.5
2017 Breeding	Alpha	Count	52	45	51	115	69	111	83	157	235
		%	5.7	4.9	5.6	12.5	7.5	12.1	9.0	17.1	25.6
	Bravo	Count	19	36	52	52	31	90	31	68	101
		%	4.0	7.5	10.8	10.8	6.5	18.8	6.5	14.2	21.0
	Alpha+ Bravo	Count	72	82	110	167	101	209	116	229	340
		%	5.0	5.8	7.7	11.7	7.1	14.7	8.1	16.1	23.8

5.3.24 In Alpha and Bravo combined in 2017, Black-legged Kittiwakes were recorded by observers within all 5 m bands up to a maximum of >45-50 m, although only a single bird was assigned to this height band. Birds were most frequently observed flying within the >5-10 m height band, accounting for 36.7% of records (Figure 33). Only 10.5% of records were of birds flying at >20 m, with this proportion falling to 5.2% at >25 m and 2.4% at >30 m, highlighting that the height of turbines is a key consideration in collision risk modelling.

5.3.25 Differences in flight height values may relate to subtle differences in the behaviour of birds within each of the areas. For example, it is likely that foraging and commuting birds are likely to utilise different optimum heights. In 2017, an analysis of a sample of birds with no flight direction (*n* = 1,788) noted 48.9% of birds in the >1-5 m band and 39.7% in the >5-10 m band. This reflects the fact that a majority of birds recorded with no fixed direction were actively foraging low over the sea surface, rather than searching at height (Figure 34).

5.3.26 It is of note that in July 2017, when Black-legged Kittiwake density in Alpha and Bravo was at its highest, the majority of birds were recorded on the water (Figure 28 above) in groups of up to 100 with a mean group size of 15.6 birds. In comparison, over all previous surveys of Alpha and Bravo in 2009-2011 34% and 42% respectively were recorded on the water. The high proportion of birds on the water in July 2017 thus appeared to be exceptional and linked to the presence post-foraging aggregations or the birds waiting for the next foraging opportunity linked to auk activity (see *Foraging & feeding* below).

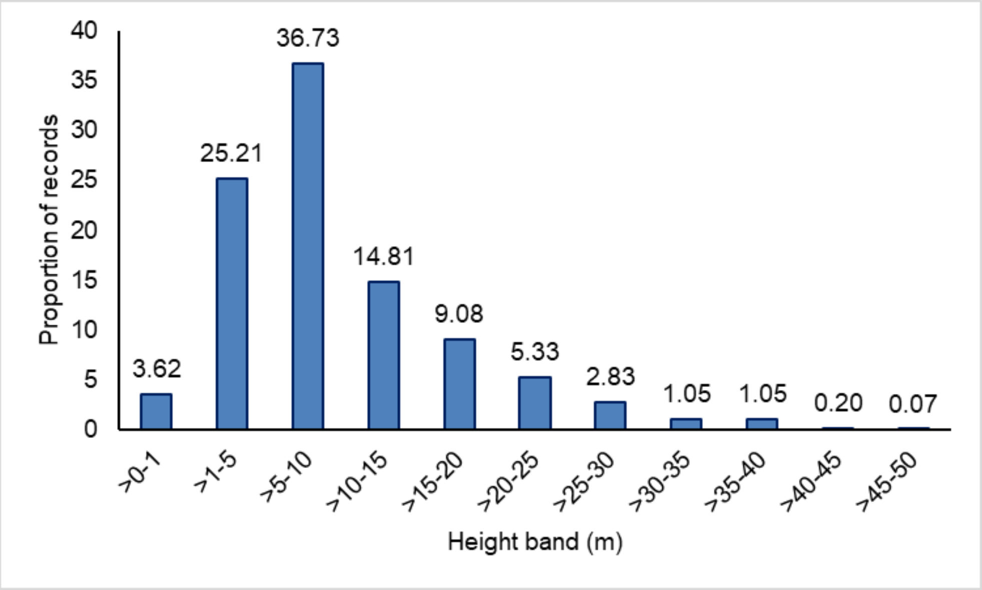


Figure 33. **Proportion (%) of flight heights recorded for Black-legged Kittiwake (*n* = 1,519) during boat-based surveys of Alpha and Bravo combined in 2017.**

Figure 34. **Large numbers of Black-legged Kittiwakes were recorded as foraging with no fixed flight direction at 5-10 m flight height as here within an extensive flock of birds in August 2017.**

5.3.27 During the 2017 surveys, a total of 591 flight heights were estimated by laser rangefinder. The highest corrected flight height acquired by rangefinder was 36.3 m and records were obtained from a maximum horizontal distance of 184.4m. The most frequently reported height band was >10-15 m (Appendix 1).

5.3.28 Observer agreement with the rangefinder found 49.7% (*n*=591) of height estimates were placed within the same 5 m band (Appendix 1). Observers had a tendency to underestimate flight heights of Black-legged Kittiwake, and 63 % of records not in agreement (disregarding band 0-5m) were underestimated, although this was not as noticeable as for Northern Gannet (see 5.2.30 above) and would require relatively little adjustment (Appendix 1).

Foraging & feeding

5.3.29 Black-legged Kittiwake feeds on small pelagic shoaling fish such as sandeels, Sprat *Sprattus sprattus* and small Herring *Clupea harengus* and also scavenge for discards from fishing vessels (Mitchell *et al.* 2004). Black-legged Kittiwakes are a surface-feeding species and are generally thought to be incapable of submerging much more than one body length. Therefore, Black-legged Kittiwakes are dependent on prey reaching the surface which may occur as a result of upwelling water movement associated with frontal systems or particular bathymetric features (Embling *et al*. 2012) or the driving activities of deeper diving species, especially auks (Camphuysen 2005).

5.3.30 There was clear evidence that Black-legged Kittiwake utilised areas within Alpha for foraging during the 2009-2011 survey period, with 2,227 records involving 37% of birds recorded of direct feeding behaviour (Figure 35a). A total of 1,674 birds were recorded within multi-species foraging associations, primarily with auks (Figure 36). Although Bravo is less important for foraging, 26% of all birds recorded were still observed in direct feeding behaviour.

5.3.31 However, it is important to note that the proportion of feeding records was greatly reduced during the breeding season from April and August, to just 7% and 9% of all birds in Alpha and Bravo respectively. This is despite high proportions of birds showing no fixed flight directions, indicative of foraging behaviour (Table 23 above).

5.3.32 Of 3,459 records within Alpha and Bravo during the 2017 breeding season surveys, 185 Black-legged Kittiwakes were recorded as part of an MSFA and a further 93 were engaged in fishing or foraging of some kind. Seven multi-species feeding aggregations involving Black-legged Kittiwakes were observed, with five of these events occurring in July (Figure 35b). These events tended to involve high numbers of birds, with a maximum of 57 noted within a single event (mean 26). Even when not actively engaged in foraging, Black-legged Kittiwakes often attended auks perhaps in anticipation of them foraging or resting with them after feeding.

5.3.33 Black-legged Kittiwakes were usually observed surface picking. However, on one occasion in 2017 a full plunge dive from height with full immersion was observed, more akin to that usually undertaken by Sandwich Tern *Thalasseus sandvicensis* or Northern Gannet. Attempts at kleptoparasatism were also noted on two occasions in 2017, one involving a single bird attempting to steal prey from an Arctic Tern and the other involving two Black-legged Kittiwakes attempting to steal prey from another. In addition to associations with auks, three records of birds associating with Harbour Porpoise were also noted.

5.3.34 It is clear from observations of foraging and fishing birds that the area to the west of Alpha in and Scalp Bank is of greater importance to foraging Black-legged Kittiwakes than the proposed development areas, with a concentration of records in this area and a higher proportion of those records relating to multiple birds (Figure 35b).

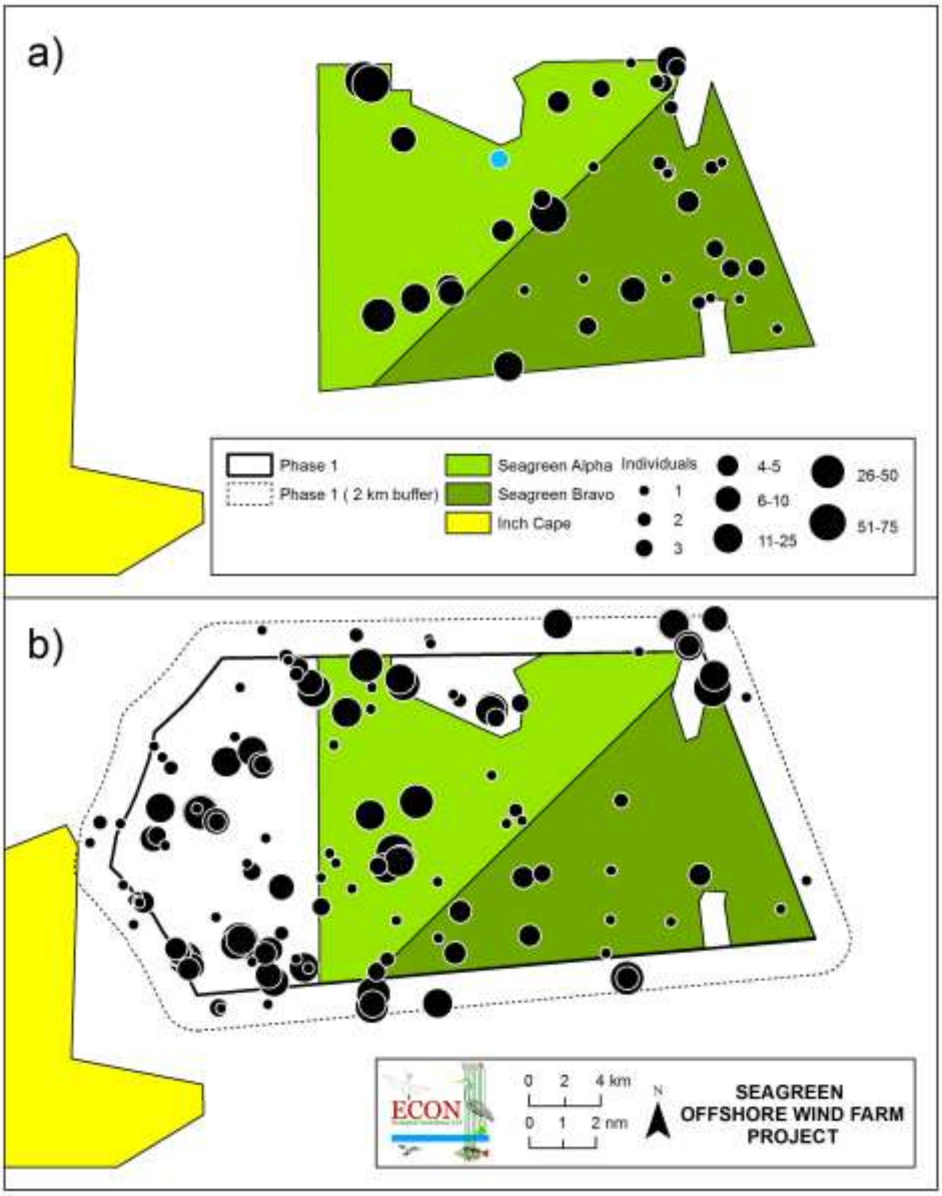


Figure 35. **Distribution and group size of Black-legged Kittiwakes carrying fish (blue) and foraging or feeding (black) recorded in the breeding season in: a) 2010 and 2011 for Alpha and Bravo only and b) in Alpha and Bravo and surrounds in 2017.**

5.3.35 Within Alpha the western area accounts for the majority of foraging recorded, although areas associated with changes in depth in the north and northeastern parts of the site also appear to be utilised for foraging. The small cluster of records in the northeast towards Montrose Bank (Figure 35ab) in the summer is part of the core foraging area for Kittiwakes from both Fowlsheugh and the Isle of May as revealed by tracking (Daunt *et al*. 2011ab).

Figure 36. Black-legged Kittiwakes feeding at the surface as diving auks drive small fish within foraging depth.

5.4 European Herring Gull

Populations & connectivity

5.4.1 The global population of European Herring Gull is currently estimated at 2,060,000-2,430,000 individuals but with a decreasing trend (Birdlife International 2017). In the UK, the breeding population of the race *argenteus*, estimated at 139,200 pairs (12.1% of the world population) declined by more than 50% from 1969 to the Seabird 2000 census (Mitchell *et al*. 2004). Population decline has continued and as a consequence, European Herring Gull is on the 'Red' list of species of conservation concern (Eaton *et al.* 2015) and is a priority UK Biodiversity Action Planning (BAP) species. The reasons for the current declines are not well understood but may be linked to outbreaks of botulism (from refuse) and reductions in food availability from fisheries discards and refuse sites (Furness *et al*. 1992, Madden & Newton 2004).

5.4.2 The species breeds mainly along rocky coasts, although a small proportion nest in other habitats including sand dunes, and inland habitats such as islands in lakes and along rivers. There is an increasing tendency for European Herring Gull to nest on urban rooftops, where birds are often more successful than in natural habitats. Urban nesting can however bring the birds into conflict with humans.

5.4.3 European Herring Gull has a mean maximum foraging range of 61.1 km (Figure 37), which includes the Forth Islands and Fowlsheugh SPAs and nine further non-designated colonies. In combination, these colonies encompass 28,778 breeding individuals within range of Alpha and Bravo (Table 24). This rises to 35,658 individuals if St Abb's Head to Fast Castle and Buchan Ness to Collieston Coast SPAs, which are outside of the mean maximum range, are included according to the specification of Marine Scotland (2017).

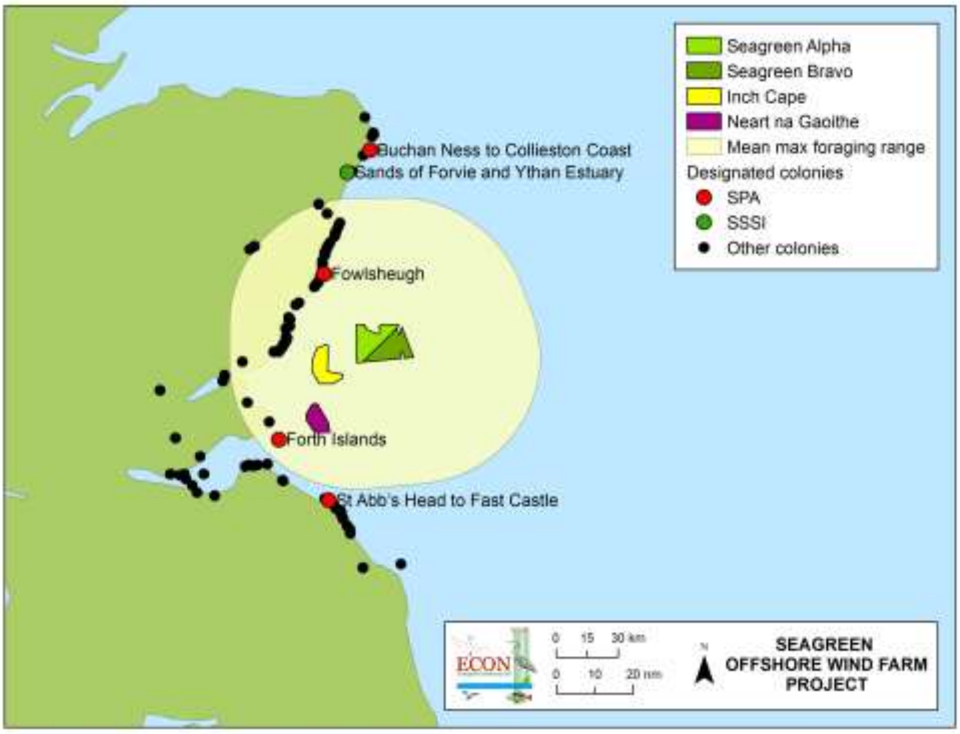


Figure 37. **Distribution of European Herring Gull breeding colonies within mean maximum foraging range (61.1 km) of Alpha and Bravo.**

Table 24. **Details of European Herring Gull breeding colonies within mean maximum foraging range (61.1 km) of Alpha and Bravo in order of increasing distance (km). Sites include all SPAs and SSSIs in range and non-designated master sites with *n*>100 individuals. Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count from the SMP database in the year specified are shown.**

Site and designation	Distance (km)	Natura 2000	Seabird 2000	Latest count	
				Number	Year
Catterline to Inverbervie	27.81		3,402	3,402	1999
Fowlsheugh SPA	30.41	6,380	734	250	2015
Montrose to Lunan Bay	32.71		852	852	2001
Stonehaven to Wine Cove	33.55		1,804	1,804	1999
Lunan Bay to Arbroath	35.46		1,268	1,268	2001
Newton Hill	39.41		510	510	2002
Newtonhill - Hall Bay	40.75		254	254	1999
Burn of Daff	41.62		400	400	1999
Girdle Ness to Hare Ness	48.82		338	338	1999
Forth Islands SPA	52.61	13,200	5,690	13,000	2016
Aberdeen City	55.42		6,700	6,700	2001
St Abb's Head to Fast Castle SPA[1]	67.90	2,320	1,082	650	2016
Buchan Ness to Collieston Coast SPA[1]	81.85	8,584	6,634	6,230	2017
	Total	13,200	29,668	35,658	

[1] *SPA outside of the mean maximum foraging range of European Herring Gull but included for consideration in HRA.*

5.4.4 Within the mean maximum foraging range, 46% of the European Herring Gull population is contained within two SPA's, principally the Forth Islands (45.2%) with a small contribution from Fowlsheugh (0.9%). Fowlsheugh is the closest SPA colony to the proposed development areas, but has seen a severe population decline since its designation.

5.4.5 If St Abb's Head to Fast Castle and Buchan Ness to Collieston Coast are included for consideration in HRA, the proportion of the population within SPAs increases to 78%, with Buchan Ness to Collieston Coast making a considerable contribution (24%). It is also noted that the inclusion of all other non-designated European Herring Gull colonies, within a range consistent with that of the Buchan Ness to Collieston Coast SPA, would influence apportioning.

5.4.6 It is noted that birds from other coastal and especially inland colonies could also conceivably reach Alpha and Bravo. However, this is thought unlikely due to the species foraging ecology in the breeding season (see *Foraging & feeding* below) and as a result these are not included in any considerations of the contribution of different colonies to the birds recorded in the sites.

Density & population size

5.4.7 European Herring Gull was recorded in most surveys of Alpha and Bravo although intermittently absent in all phenological periods (Figure 38). Birds were however generally consistently more numerous in the winter months, following the migration of individuals of the *argentatus* race, especially those breeding in northern Europe, to overwinter in Scottish waters (Forrester *et al*. 2007).

5.4.8 Nevertheless, peak population estimates in Alpha and Bravo during 2009-2011 were observed in the breeding period in June, with 121 birds estimated in Alpha in 2010 and 163 birds estimated in Bravo in 2011 (Figure 38). These peaks accord with the beginning of chick provisioning as chicks hatch from mid-June onwards following eggs laying from mid-April after adults return to colonies in early March (Cramp *et al.* 1974). However, the proportion of adults was relatively low (e.g. 57% in Alpha in 2010) and small numbers of birds were observed relative to the size of local breeding populations, suggesting that few locally breeding adults were actually foraging as far offshore as Alpha and Bravo.

5.4.9 Similarly, low numbers were recorded in the breeding season surveys in 2017, when the timing of peak population estimates also varied between Alpha and Bravo. Within Alpha the peak estimate of 34 was recorded in July, compared to a peak of 44 birds in May. In Alpha and Bravo, the peak population of 41 was recorded in May.

5.4.10 Density was consistently very low in both Alpha and Bravo throughout the year. Mean densities in Alpha ranged from 0.02 individuals km^{-2} in August to 0.32 individuals km^{-2} in June compared to 0 individuals km^{-2} in April, July and August to 0.44 individuals km^{-2} in June in Bravo (Table 25). Densities were not calculated for the project areas with 2km buffers due to the general paucity of records leading to the calculation of potentially spurious correction factors (see 3.2.22 above).

5.4.11 All densities recorded are lower than those reported for the western North Sea in the breeding season in the general literature, with a density of 1.1 individuals km^{-2} (Stone *et al*. 1995) matched by a density of 1.63 individuals km^{-2} for the Firth of Forth to North East Bank in May to June (Skov *et al*. 1995).

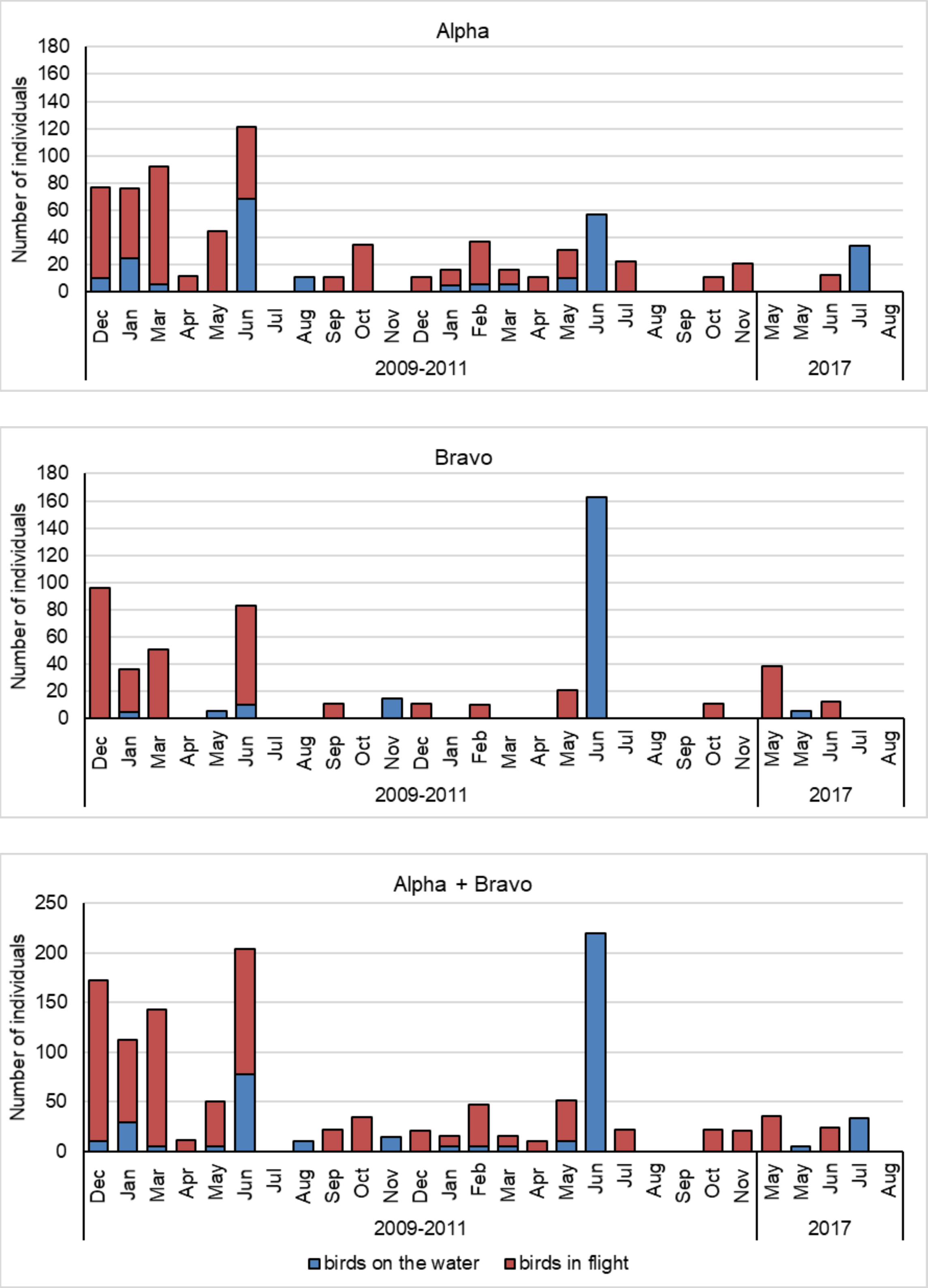


Figure 38. **European Herring Gull population estimates (number of individuals) in Alpha, Bravo and Alpha and Bravo combined by month from boat-based surveys. Estimates are derived from density from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect.**

Table 25. Monthly mean density (ind. km^{-2}) and standard deviation of European Herring Gull in Alpha, Bravo and Alpha and Bravo combined with and without a 2 km buffer. The number of surveys completed in each month is also shown. Densities in all cases were derived from a combination of uncorrected line transect data for birds on the water and snapshot data for flying birds.

Project		Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		2	1	2	2	4	3	3	3	2	2	2	2
Alpha	Mean	0.23	0.19	0.27	0.05	0.10	0.32	0.09	0.02	0.03	0.11	0.05	0.22
	SD	0.22	-	0.27	0.00	0.11	0.28	0.09	0.03	0.04	0.08	0.07	0.24
Bravo	Mean	0.09	0.05	0.13	0.00	0.09	0.44	0.00	0.00	0.03	0.03	0.04	0.28
	SD	0.13	-	0.19	0.00	0.08	0.39	0.00	0.00	0.04	0.04	0.05	0.31
Alpha + Bravo	Mean	0.16	0.12	0.20	0.03	0.09	0.38	0.05	0.01	0.03	0.07	0.05	0.25
	SD	0.18	-	0.23	0.00	0.05	0.28	0.04	0.02	0.04	0.02	0.01	0.27

Spatial distribution

5.4.12 Given the very low numbers of European Herring Gull encountered no firm conclusions could be drawn regarding their distribution. However, in 2009-2011 distribution was very patchy in both the breeding and non-breeding seasons, although birds were more widespread in the latter (Seagreen 2012a). In the 2017 breeding season, although not present on all surveys, European Herring Gull had a limited distribution in May, with this expanding in June and July (Seagreen 2017b).

5.4.13 In general, the higher population and density estimates produced for Alpha (Figure 38 & Table 25 above) tends to suggest that the species declines in abundance with increasing distance from the coast.

Population structure

5.4.14 A high proportion of European Herring Gulls were aged in the two survey periods, with 84.9% of the 185 Herring Gulls during the 2009-2011 surveys being aged, and 73.7% of the 19 recorded in 2017. In 2009-2011, a higher proportion was aged when single birds were encountered (92.1%) compared to groups of 6-10 individuals (25%).

5.4.15 In 2009-2011, the majority of birds encountered during the breeding season between April and August were adults (62%) compared to a greater mixture of ages in the passage/winter period, when 50% were immature birds. The trend of an increased proportion of adults being recorded in July compared to June was reinforced in 2017 (Table 26). The increased proportion of adult birds in July probably represents post-breeding individuals on passage, and as such, their origin cannot readily be determined.

5.4.16 During the breeding season the low proportion of adult birds in the area is to be expected given the foraging ecology of the species (see *Foraging & feeding* below).

Table 26. Number and proportion of adult Herring Gulls relative to the total number of birds aged in each month during boat-based surveys of the Phase 1 Project and study area in 2017 in comparison with the previous surveys of Alpha and Bravo in 2010 and 2011.

Year	Site	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009-2011	Alpha	Adults	22	2	8	1	6	8	2	4	1	1	0	16
		%	66.7	50.0	30.8	25.0	54.5	66.7	100	100	50.0	20.0	0.0	57.1
		Total	33	4	26	4	11	12	2	4	2	5	2	28
	Bravo	Adults	12	1	3	0	3	9	2	0	0	2	1	5
		%	60.0	50.0	33.3	-	60.0	81.8	100	-	-	40.0	50.0	50.0
		Total	20	2	9	0	5	11	2	0	0	5	2	10
	Alpha+ Bravo	Adults	34	3	11	1	9	17	4	4	1	3	1	21
		%	64.2	50.0	31.4	25.0	56.3	73.9	100	100	50.0	30.0	25.0	55.3
		Total	53	6	35	4	16	23	4	4	2	10	4	38
2017	Alpha	Adults					1	2	3	0				
		%					100	33.3	75.0	-				
		Total					1	6	4	0				
	Bravo	Adults					2	0	0	0				
		%					50.0	-	-	-				
		Total					2	0	0	0				
	Alpha+ Bravo	Adults					3	2	3	0				
		%					100	33.3	75.0	-				
		Total					3	6	4	0				

Flight behaviour

5.4.17 During the 2009-2011 surveys, 42% and 62% of European Herring Gulls in Alpha and Bravo respectively, were recorded flying at heights above 20 m. This represents a large proportion of the population present, considering that most birds were recorded in flight (79% and 63% in Alpha and Bravo respectively). The low sample size of observations and the influence of some larger groups encountered on the water surface, could account for the differences between the sites, but there may also be real differences in behaviour patterns of birds between Alpha and Bravo.

5.4.18 In 2017, flight heights across Alpha and Bravo ranged from >5-10 m to >40-45 m although due to the low number of records not all bands were represented. Whilst a true representation of the species flight behaviour could not be gained, 27% of birds were recorded flying above 25 m.

5.4.19 The large size and consistent flight action of European Herring Gull made its acquisition by rangefinder relatively straightforward and 47 records were obtained to a maximum distance of 201.8 m. The maximum corrected height recorded was 52.9 m and 27.7% of records were of birds flying at heights >25 m, with a mean corrected flight height of 20.9 m (Figure 39). The most frequently recorded band was >15-20 m, (27.7% of records).

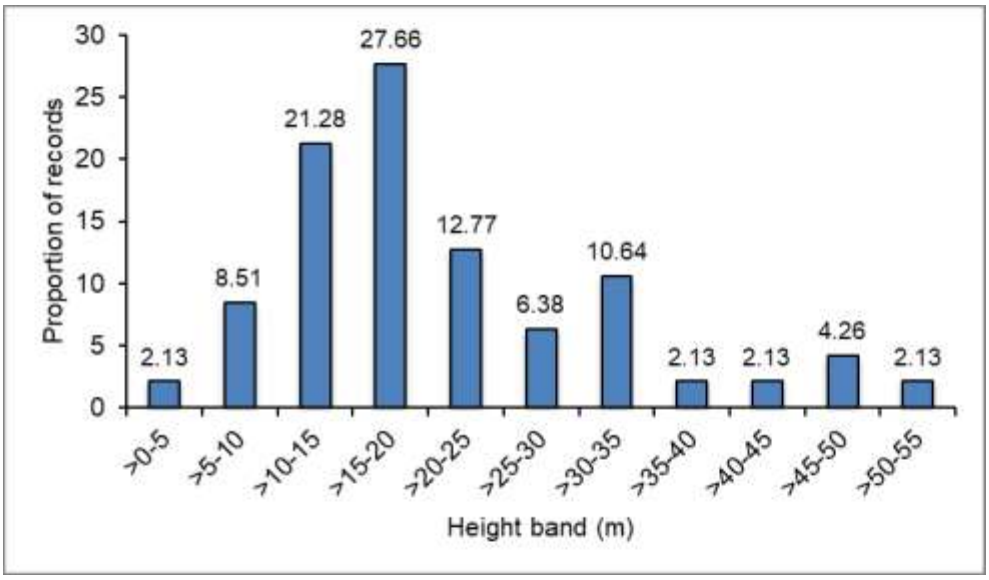


Figure 39. Proportion (%) of flight heights recorded by rangefinder for European Herring Gull (*n* = 47) during boat-based surveys of Alpha, Bravo and surrounds in all 2017 surveys.

5.4.20 As the rangefinder provided a larger dataset of birds from a wider area than just Alpha and Bravo coupled with the fact that the attempt to record heights of all birds encountered was generally successful, the distribution of heights from the rangefinder is thought to be more representative of flight distribution than that derived from the few observations of birds within Alpha and Bravo (Figure 39).

5.4.21 Although sample size was small, flight directions of birds in the 2010 and 2011 breeding seasons within Alpha showed a strong bias to the northeast, thereby indicative of birds from the direction of the largest colony in the Forth Islands SPA (Table 24), rather than the closer colonies at Fowlsheugh SPA and other nearby non-designated colonies. A number of authors (e.g. Lewis *et al*. 2001) have shown that colony size has a direct effect on foraging range of seabirds and it is possible that birds from Forth Islands range further than might be expected.

5.4.22 The paucity of records from Bravo during 2009-2011 and for both Alpha and Bravo in 2007 prevents any inference of colony origin from recorded flight directions. In both cases, the majority of the small numbers of birds were recorded as having no flight direction (Table 27), which is indicative of foraging behaviour although no feeding activity was observed. The tendency for European Herring Gulls to associate with or investigate the survey vessel may the principal reason for the recording of birds with no fixed direction (Table 27).

5.4.23 Overall, it would seem most likely that a mixture of breeding birds from different origins reach Alpha and Bravo, especially considering the patchy occurrence of birds in time and space, but with more than expected from the largest colony complex in Forth Islands SPA. Any operational fishing vessels are also likely to attract birds from a wide area (Camphuysen 1995).

Table 27. **Number and proportion (%) of flight directions recorded for European Herring Gull during boat-based surveys of Alpha and Bravo. No fixed direction is represented by 'None'.**

Parameters			Compass direction								
			N	NE	E	SE	S	SW	W	NW	None
2009-2011 Breeding season	Alpha	Count	5	13	0	4	3	1	2	2	4
		%	14.7	38.2	0.0	11.8	8.8	2.9	5.9	5.9	11.8
	Bravo	Count	1	2	0	0	0	1	0	2	8
		%	7.1	14.3	0.0	0.0	0.0	7.1	0.0	14.3	57.1
	Alpha+Bravo	Count	6	15	0	4	3	2	2	4	12
		%	12.5	31.3	0.0	8.3	6.3	4.2	4.2	8.3	25.0
2009-2011 Non-breeding season	Alpha	Count	7	5	6	23	2	9	11	25	17
		%	6.7	4.8	5.7	21.9	1.9	8.6	10.5	23.8	16.2
	Bravo	Count	17	4	4	9	4	3	2	9	10
		%	27.4	6.5	6.5	14.5	6.5	4.8	3.2	14.5	16.1
	Alpha+Bravo	Count	24	9	10	32	6	12	13	34	27
		%	14.4	5.4	6.0	19.2	3.6	7.2	7.8	20.4	16.2
2017 Breeding season	Alpha	Count	0	0	1	2	0	1	0	3	2
		%	0.0	0.0	11.1	22.2	0.0	11.1	0.0	33.3	22.2
	Bravo	Count	1	0	0	0	0	0	0		1
		%	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
	Alpha+Bravo	Count	1	0	1	2	0	1	0	3	3
		%	9.1	0.0	9.1	18.2	0.0	9.1	0.0	27.3	27.3

Foraging & feeding

5.4.24 Like other large gulls, European Herring Gull has opportunistic feeding habits and exploits a wide food base by scavenging human rubbish and discards from fishing vessels (Lloyd *et al.* 1991), as well as being an active predator of the eggs and chicks of other seabirds, other small birds and rodents (del Hoyo *et al.* 1996).

5.4.25 In the breeding season, European Herring Gull forages over shorter distances (Mitchell *et al.* 2004) and is less marine than Lesser Black-backed Gull (Cramp *et al.* 1974), perhaps even being strictly coastal (Camphuysen 2005). In urban locations up to 85% of food may be obtained from refuse tips, whereas within seabird colonies, the eggs and chicks of other species may be an important food source for incubating and provisioning adults (Mitchell *et al.* 2004).

5.4.26 Very few records of foraging birds were obtained in 2009-2011, with just 2% of all records defined as feeding. No records of foraging or feeding European Herring Gulls were made in 2017. However, unlike 2017, peak populations in Alpha and Bravo in 2009-2011 involved high proportions of birds present on the water (Figure 38), which could indicate recently finished foraging events, which could also explain the high population estimates at these times.

5.4.27 Anecdotal sightings of large gulls associated with distant fishing boats and European Herring Gulls associating with MSFAs observed outside the survey area confirm that the species may forage at sea in the wider area. However, these tended to be immature non-breeding birds rather than breeding birds from nearby colonies.

5.5 Common Guillemot

Populations & connectivity

5.5.1 Common Guillemot is one of the world's more abundant seabirds, breeding on cliffs in large colonies across a large geographic range. The increasing world population has been estimated at over 11 million individuals, with a European population of 2,350,000-3,060,000 mature individuals (JNCC 2016, BirdLife International 2015). Whilst the European North Atlantic colonies support in excess of two million pairs this accounts for < 50% of its global population size and range.

5.5.2 The UK population is estimated at 1.42 million birds, constituting 12.9% and 33.3% of the World and North Atlantic populations respectively (JNCC 2016). As a result of internationally important numbers in ten or fewer colonies, and recent declines in breeding and winter populations and their respective ranges, Common Guillemot is of conservation concern in the UK with 'Amber' status (Eaton *et al.* 2015).

5.5.3 In relation to Alpha and Bravo, there are 14 colonies of Common Guillemots within the mean maximum foraging range of 84.2 km (Table 28, Figure 40). The largest is Fowlsheugh SPA supporting 55,507 individuals (Table 28), which is also the second closest to Alpha at 30 km to the northwest (Figure 40, Table 28). The Forth Islands, St Abb's Head to Fast Castle and Buchan Ness to Collieston Coast SPAs also all contain >30,000 individuals. In combination, the SPAs account for 94% of the breeding population within mean maximum foraging range of Alpha and Bravo. A further ten undesignated colonies support much smaller breeding populations.

Table 28. Details of all Common Guillemot breeding colonies within mean maximum foraging range (84.2 km) of Alpha and Bravo in order of increasing distance. Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count from the SMP database in the year specified are shown.

Site and designation	Distance (km)	Natura 2000	Seabird 2000	Latest count	
				Number	Year
Catterline to Inverbervie	27.64		2,884	2,884	1999
Fowlsheugh SPA	30.41	56,450	62,330	55,507	2015
Stonehaven to Wine Cove	32.77		4,763	4,763	1999
Lunan Bay to Arbroath	34.75		1,002	1,002	2000
Newtonhill - Hall Bay	40.95		61	61	1999
Burn of Daff	41.62		37	37	1999
Findon Ness - Hare Ness	45.45		422	422	1999
Girdle Ness to Hare Ness	47.96		75	75	1999
Forth Islands SPA	65.71	32,000	36,369	30,910	2016
St Abb's Head to Fast Castle SPA	67.90	31,750	43,137	33,627	2016
Eyemouth to Burnmouth	73.35		892	892	2000
Sands Of Forvie	74.05		10	36	2011
Berwick to Scottish Border	80.71		45	45	2000
Buchan Ness to Collieston Coast SPA	81.85	17,280	29,352	33,632	2017
	Total	56,450	181,379	163,898	

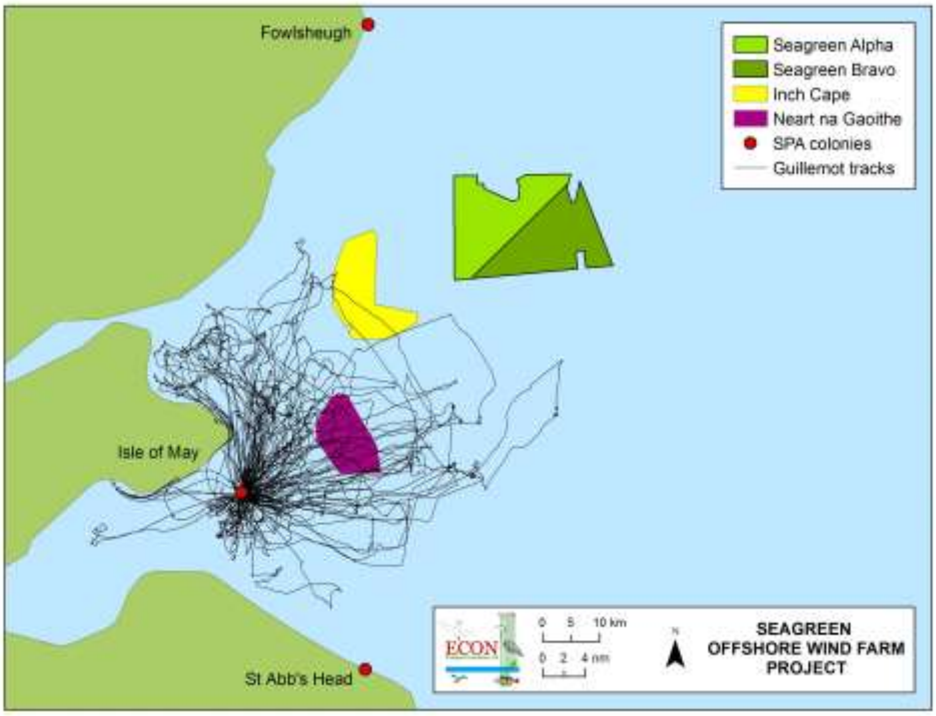


Figure 40. **Tracks of breeding Common Guillemots fitted with GPS tags from the Isle of May (*n* = 33) in 2010.**

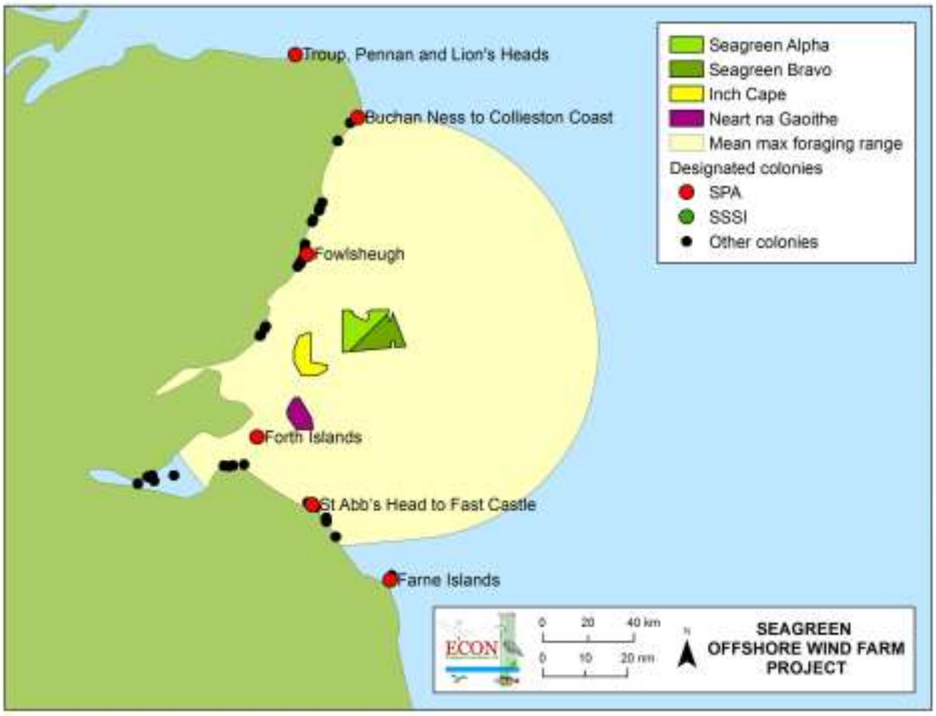


Figure 41. **Distribution of Common Guillemot breeding colonies within mean maximum foraging range (84.2 km) of Alpha and Bravo.**

5.5.4 Previous tracking of Common Guillemots from the Isle of May showed that birds did not reach Alpha and Bravo (Figure 41), at least in the year in question. However, the distance that birds travel will depend on the relative abundance of available resources closer to the colony. Nonetheless, the increasing evidence for the separation of range of seabirds from different colonies even those in close proximity (see Wakefield *et al*. 2013, Soanes *et al*. 2016, Perrow *et al*. 2017), suggests that Common Guillemots from the large, nearby Fowlsheugh colony as well as the smaller colonies in Kincardine and Deeside and Angus will predominate amongst the birds recorded at Alpha and Bravo.

Density & population size

5.5.4.1 Common Guillemot was present on all surveys and tended to be the dominant feature of the ornithological assemblage. The seasonal trends observed at Alpha and Bravo broadly correspond with typical patterns according to Cramp *et al.* (1974). Population estimates were consistently low through the early winter period before rising from January to a peak in March, (Figure 42) corresponding with large numbers amassing in the waters around colonies in March as well as spring passage to other colonies (Cramp *et al.* 1974). However, numbers were then generally lower in April and May, perhaps indicating birds remained closer to colonies as egg laying and incubation commenced, which is shared by both adults (Cramp *et al.* 1974).

5.5.4.2 Chick hatching in June corresponded with a peak in numbers in Alpha and Bravo in 2010 and 2011, although this was later in July in 2017 (Figure 42). Numbers then declined as chicks left the colonies with their male parent and rapidly reduced suggesting complete dispersal from the area, and remained low throughout autumn and winter. Low numbers also suggested little passage through the area from other colonies (Figure 42).

5.5.5 Peak population estimates within Alpha in June showed considerable inter-annual variation with 5,202 to 10,811 individuals in 2010 and 2011 respectively. A similar pattern was noted in Bravo, although the peak population estimate of 6,540 individuals in 2010 was actually observed in March. In 2011, 10,567 individuals were estimated at peak in June (Figure 42).

5.5.6 In the 2017 surveys, peak population estimates were the highest recorded in both Alpha and Bravo at 11,221 and 12,536 birds respectively, and were slightly later than previously recorded, in July, coincident with the beginning of chick fledging and the end of the breeding season (see *Population structure* below). Population estimates preceding the peak were also generally higher and more consistent than recorded in 2010 and 2011, perhaps suggesting more regular use of Alpha and Bravo and the area around Scalp Bank in this year. But as also noted in previous years, dispersal from the colonies and the waters used in the breeding season was rapid and numbers were low in August (Figure 42).

5.5.7 In the 2017 surveys, peak population estimates were the highest recorded in both Alpha and Bravo at 11,221 and 12,536 birds respectively, and were slightly later than previously recorded, in July, coincident with the beginning of chick fledging and the end of the breeding season (see *Population structure* below). Population estimates preceding the peak were also generally higher and more consistent than recorded in 2010 and 2011, perhaps suggesting more regular use of Alpha and Bravo and the area around Scalp Bank in this year. But as also noted in previous years, dispersal

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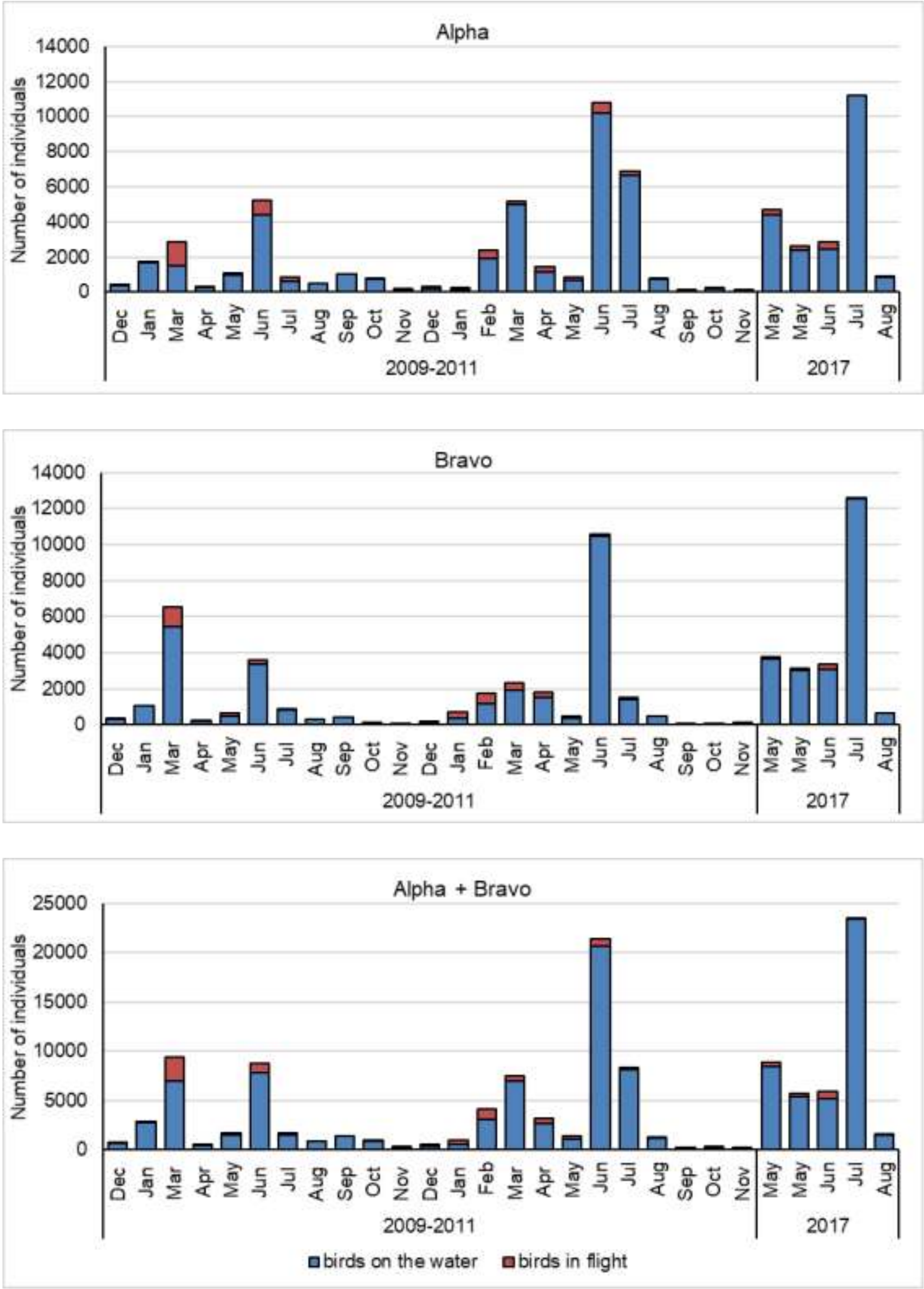

Figure 42. **Common Guillemot population estimates (number of individuals) by month from boat-based surveys of Alpha and Bravo. Estimates are derived from density from snapshots of birds in flight combined with distance corrected density of birds on the water from line transect.**

5.5.8 The high peak population estimates generated, particularly in the 2011 and 2017 breeding seasons were driven by high densities across Alpha and Bravo in June and July with a peak mean density of 32.08 individuals km^{-2} in Alpha in July and 30.19 individuals km^{-2} in Bravo in June (Table 29). For Alpha and Bravo combined, the peak mean density of 30.76 individuals km^{-2} was achieved in June (Table 29).

Table 29. Monthly mean density (ind. km^{-2}) and standard deviation of Common Guillemots in Alpha, Bravo and Alpha and Bravo combined with and without a 2km buffer. The number of surveys completed in each month is also shown. Densities in all cases were derived from a combination of uncorrected line transect data for birds on the water and snapshot data for flying birds.

Project		**Month**											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
		2	**1**	**2**	**2**	**4**	**3**	**3**	**3**	**2**	**2**	**2**	**2**
Alpha	Mean	5.02	12.06	20.42	4.45	11.73	31.91	32.08	3.56	2.95	2.36	0.81	1.77
	SD	5.24	-	8.36	3.95	8.93	20.71	26.37	0.99	3.32	1.98	0.15	0.20
Alpha + 2km	Mean	6.10	14.64	24.80	5.41	12.08	40.15	36.28	4.81	3.58	2.86	0.98	2.15
	SD	6.36	-	10.15	4.79	8.33	23.43	28.37	1.96	4.04	2.40	0.18	0.25
Bravo	Mean	4.58	8.90	22.97	5.21	10.40	30.19	25.68	2.59	1.08	0.52	0.40	1.44
	SD	1.44	-	15.27	5.68	8.68	21.12	33.86	0.92	1.39	0.43	0.03	0.66
Bravo + 2km	Mean	4.40	8.54	22.04	5.00	10.16	27.69	22.89	2.79	1.04	0.50	0.38	1.38
	SD	1.38	-	14.65	5.44	8.68	21.49	29.47	1.38	1.33	0.41	0.03	0.63
Alpha + Bravo	Mean	4.81	10.50	21.69	4.83	11.31	30.76	28.62	3.07	2.03	1.45	0.60	1.61
	SD	3.36	-	3.35	4.80	9.08	21.06	28.40	0.94	2.36	1.21	0.09	0.43
Alpha + Bravo + 2km	Mean	5.28	11.53	23.82	5.30	10.99	34.25	28.26	3.87	2.22	1.59	0.66	1.77
	SD	3.69	-	3.68	5.28	8.25	22.61	26.00	1.81	2.60	1.33	0.10	0.47

5.5.9 The inclusion of a 2 km buffer led to higher densities for Alpha and lower densities for Bravo, although for both sites in combination with each other, the inclusion of the 2 km buffer increased density. The peak density reported within Alpha plus the 2km buffer was 40.15 individuals km^{-2} in June (rather than July as for Alpha alone), compared to 27.69 individuals km^{-2} in Bravo plus the 2km buffer, also in June (Table 29).

5.5.10 Monthly mean densities calculated using DISTANCE for birds on the water were higher than typical values reported for the North Sea. For example, densities of 7.7 and 7.5 individuals km^{-2} for June and July were derived by Stone *et al*. (1995), with Camphuysen (2005) recording densities >10 individuals across the entire area of Firth of Forth extending to Aberdeen and throughout the Moray Firth in the North to the Farnes in the south in June/July.

5.5.11 However, the high peak values presented for Alpha and Bravo are not without precedent as Skov *et al*. (1995) reported a density of 59 individuals km^{-2} for Wee Bankie, to the south of the area during the breeding season. It is likely that inter-annual variation in foraging areas can cause these very high densities to occur across relatively small areas as large groups or rafts of birds develop (Figure 43).

Figure 43. A typical raft of auks on the sea surface in July, comprised mainly of Common Guillemots in various states of plumage, accompanied by a few darker Razorbills.

Spatial distribution

5.5.12 The density distribution maps for birds on the water showed the patchy occurrence of Common Guillemot in the breeding seasons of 2010 and 2011 with many cells recording no birds in bands A & B, and others recording >50 individuals km^{-2} and even >100 individuals km^{-2} (Figure 44). In 2011, considerably more birds were present with more cells containing birds in conjunction with more high density patches especially in the northwest of Alpha. Higher density in the northwest of Alpha in the breeding season becomes more apparent when the two years of data from 2010 and 2011 are combined (Figure 45).

5.5.13 In contrast, there is no clear preference for the northwest of Alpha in the passage and winter period, with a tendency for a few patches of higher density further west in Alpha and very few birds in much of Bravo (Figure 45). The difference in density between breeding season and winter/passage periods is also marked.

5.5.14 During the 2017 breeding season, Common Guillemot was a nearly constant feature across the study area during all surveys (Figure 46a). In each individual survey there were areas where birds appeared to be more concentrated, potentially indicating better foraging locations at those times and leading to a patchy distribution over the site across the survey period.

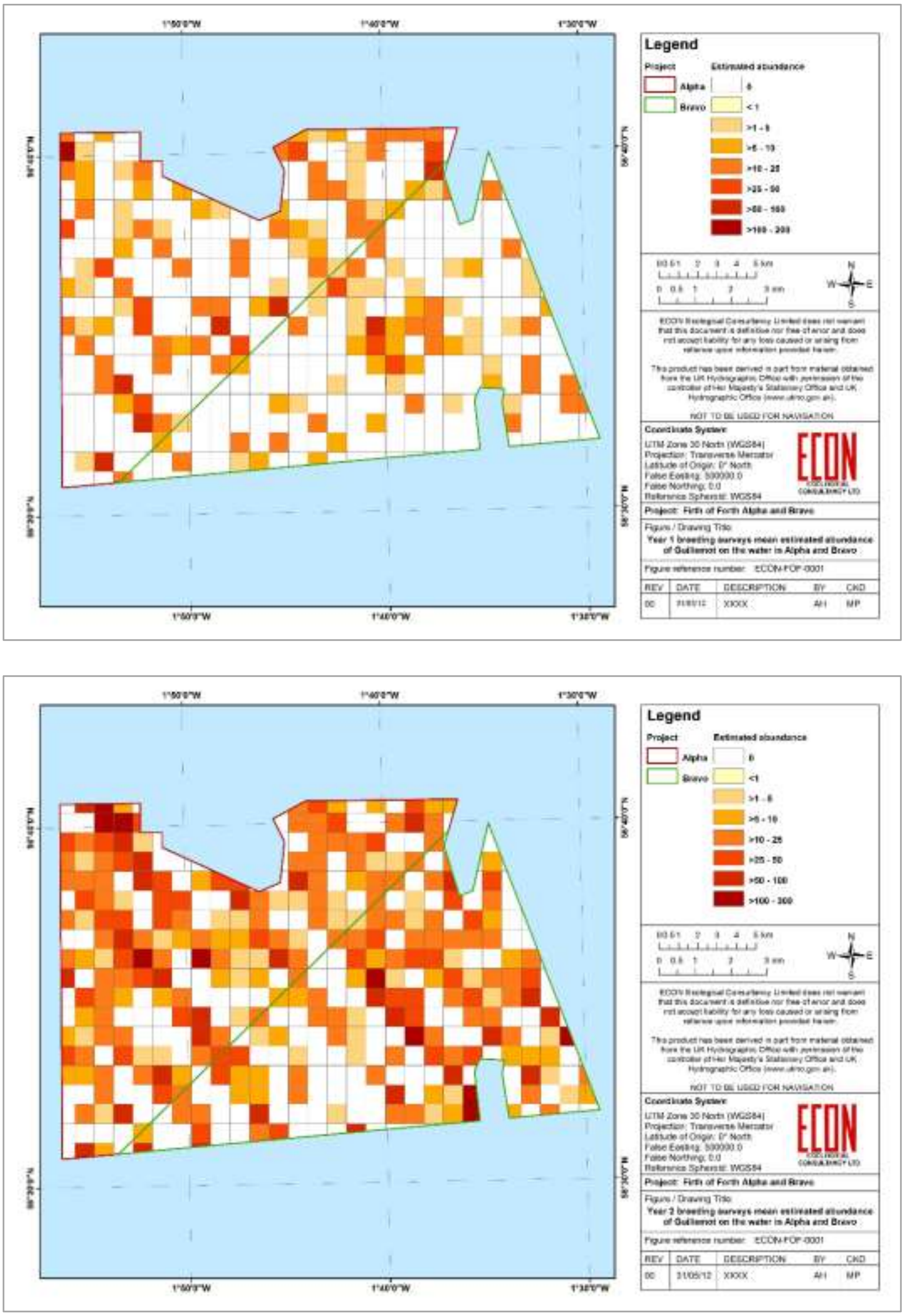

Figure 44. Relative abundance of Guillemot expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^{2} grid cells across Alpha and Bravo in the breeding season of April to July in 2010 (above) compared to 2011 (below).

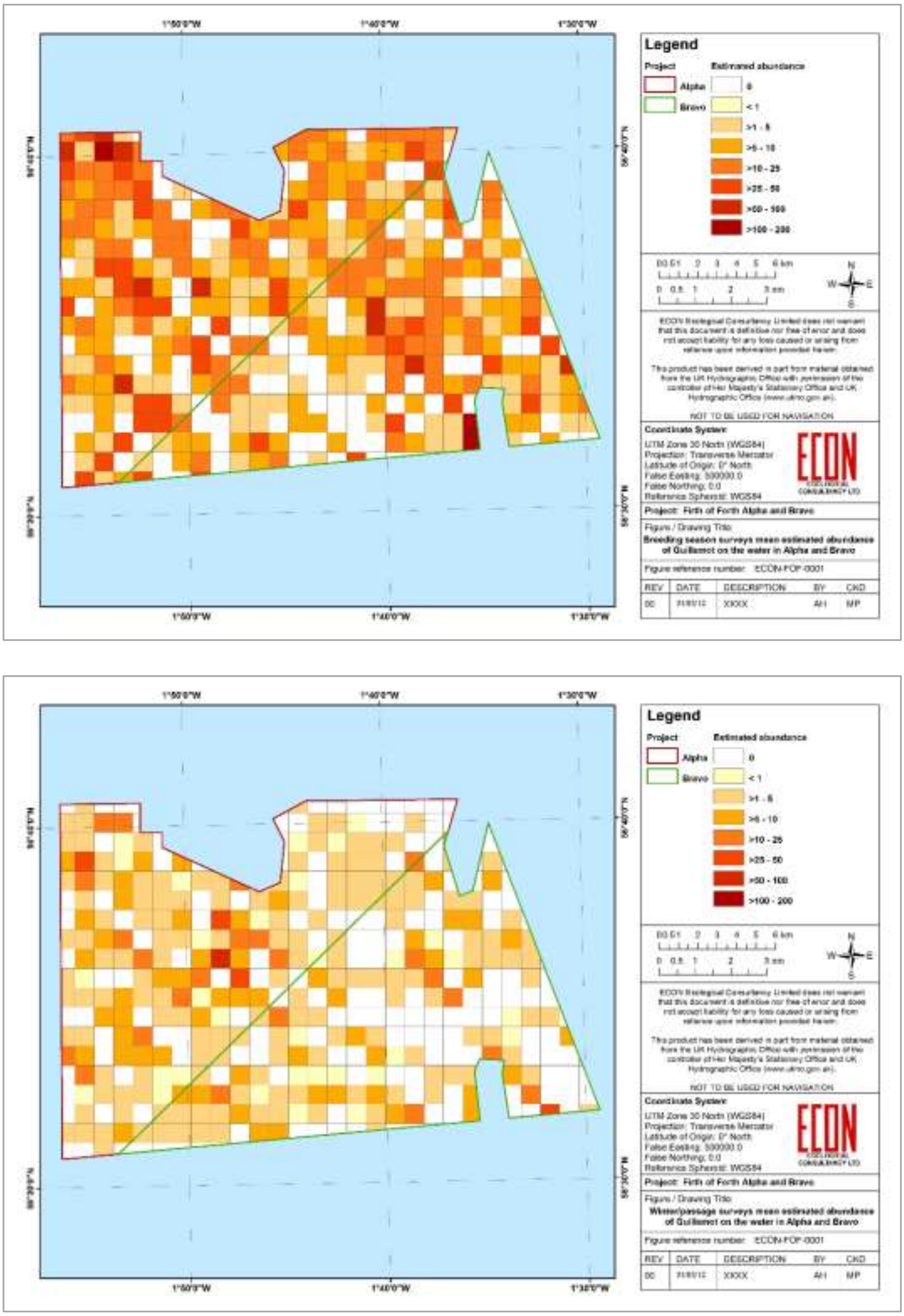

Figure 45. Relative abundance of Guillemot expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^{2} grid cells across Alpha and Bravo in the breeding seasons of April to July 2010-11 (above) compared to the passage/winter period (below).

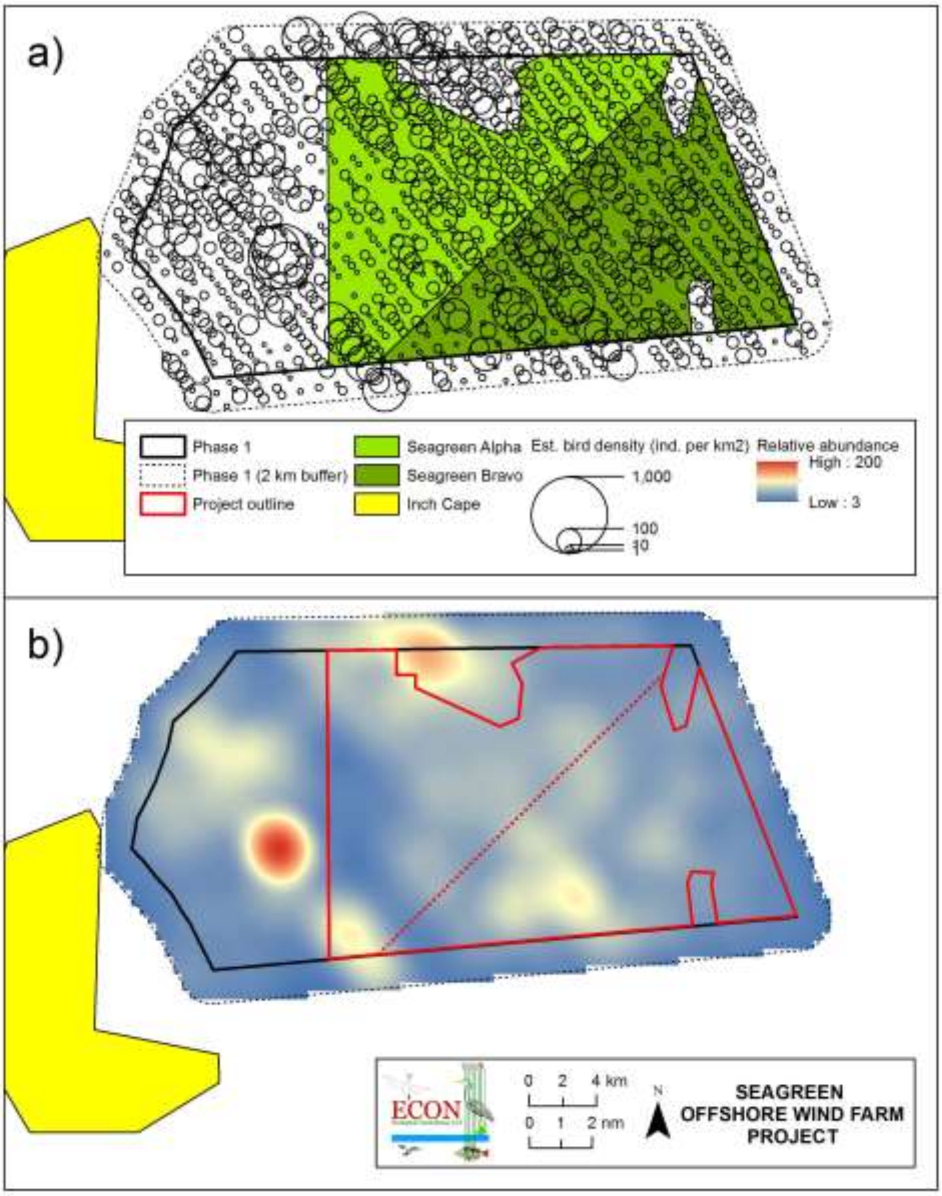

Figure 46. Density distribution of Common Guillemot in 2017 as shown by: a) mean densities of birds on the water (corrected values) in each survey cell on each of the three survey routes (route two was only surveyed once), and b) the relative abundance surfaces derived using KDE applied to these data.

5.5.15 The mean cell densities of Common Guillemot on the water used for the KDE reinforce how numerous and ubiquitous this species was throughout the study area (Figure 46b). The large numbers encountered in July were largely responsible for the extremely high density (the peak is centred around a cell with an estimated density of c. 730 individuals km^{-2}) over parts of Scalp Bank to the west of Alpha and Bravo (Figure 46b). A further clear hotspot lies on the northern edge of Alpha in an area of bathymetric change and deeper water that is excluded from the development area.

Population structure

5.5.16 In general, the proportion of Common Guillemot aged was very low across both survey periods with 6.1% of birds aged overall in 2009-2011 and 3.6% in 2017 (Table 30). Even for single birds in isolation the proportion aged was low at 6.8% in 2009-2011 and 1.2% in 2017. The proportion aged increased slightly to 8.2% for two birds recorded together in 2009-2011, but increased considerably to 17.1% for two birds together in 2017. The reason for this was a result of adult and chick combinations (Figure 47) in the post-breeding period, with the presence of a chick leading to the adult being aged as such.

Figure 47. Adult Common Guillemot, probably a male, with a recently fledged dependent chick.

5.5.17 Otherwise, the reasons for a low proportion of aged birds was the sheer abundance of Common Guillemots, often in large groups, coupled with the difficulty of separating immature and/or non-breeding birds from breeding adults. The latter could however be achieved with confidence on occasion as a result of plumage characteristics.

5.5.18 Chicks fledge from July through to early August, leaping from breeding cliffs into the sea to spend the next six to seven weeks accompanied by their paternal parent (Figure 47). Both birds are flightless at this time as the adult moults and the chick develops its flight feathers. The pair thus disperse further offshore by swimming and using surface currents.

5.5.19 Although the first fledged birds were sometimes noted in June, the majority of young fledged Common Guillemots were encountered in July in all breeding seasons surveyed. For all areas, this is clearly indicated in Table 30 by high proportions of aged birds being juvenile, ranging from 37.8% in Bravo during the 2010 and 2011 breeding seasons to 46.8% in Bravo during 2017. Some juvenile birds persisted into August as they dispersed from colonies into offshore areas but were not recorded at all in September (Table 30).

Table 30. Number and proportion of adult and juvenile (Juv) Common Guillemots relative to the total number of birds aged in each month during boat-based surveys of Alpha and Bravo.

Year	Site	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009-2011	Alpha	Adults	0	0	2	2	72	121	32	22	0	0	0	0
		%	-	-	100	100	96.0	98.4	59.3	61.1	-	-	-	-
		Juveniles	0	0	0	0	0	0	22	14	0	0	0	0
		%	-	-	0.0	0.0	0.0	0.0	40.7	38.9	-	-	-	-
		Total	0	0	2	2	75	123	54	36	0	0	0	0
	Bravo	Adults	2	6	5	7	21	44	45	16	0	1	0	0
		%	100	85.7	100	100	87.5	89.8	60.8	66.7	-	100	-	-
		Juveniles	0	0	0	0	0	2	28	8	0	0	0	0
		%	0.0	0.0	0.0	0.0	0.0	4.1	37.8	33.3	-	0.0	-	-
		Total	2	7	5	7	24	49	74	24	0	1	0	0
	Alpha + Bravo	Adults	2	6	7	9	93	165	77	38	0	1	0	0
		%	100	85.7	100	100	93.9	95.9	60.2	63.3	-	100	-	-
		Juveniles	0	0	0	0	0	2	50	22	0	0	0	0
		%	0.0	0.0	0.0	0.0	0.0	1.2	39.1	36.7	-	0.0	-	-
		Total	2	7	7	9	99	172	128	60	0	1	0	0
2017	Alpha	Adults					12	0	19	26				
		%					60.0	-	54.3	53.1				
		Juveniles					0	0	16	23				
		%					0.0	-	45.7	46.9				
		Total					20	0	35	49				
	Bravo	Adults					17	0	25	14				
		%					60.7	-	53.2	50.0				
		Juveniles					0	0	22	14				
		%					0.0	-	46.8	50.0				
		Total					28	0	47	28				
	Alpha + Bravo	Adults					29	0	44	40				
		%					60.4	-	53.7	51.9				
		Juveniles					0	0	38	37				
		%					0.0	-	46.3	48.1				
		Total					48	0	82	77				

Flight behaviour

5.5.20 The dominant flight direction of Common Guillemots in Alpha and Bravo overall was northwest, followed by southeast (Table 31). This flight axis suggests a dominance of birds commuting to and from the Fowlsheugh colony, although it is of note that proportions of birds on a northwest transit were even higher in Alpha during the non-breeding period. The likelihood is that these birds were still commuting to colonies even outside of the breeding season, as birds may return to breeding sites throughout the year in Scottish colonies (Forrester *et al*. 2007).

Table 31. Number and proportion (%) of flight directions recorded for Common Guillemot during boat-based surveys of Alpha and Bravo. No fixed direction is represented by 'None'.

Parameters			Compass direction								
			N	NE	E	SE	S	SW	W	NW	None
2009-2011 Breeding season	Alpha	Count	57	30	18	97	56	78	50	290	2
		%	8.4	4.4	2.7	14.3	8.3	11.5	7.4	42.8	0.3
	Bravo	Count	42	16	9	26	24	50	22	147	1
		%	12.5	4.7	2.7	7.7	7.1	14.8	6.5	43.6	0.3
	Alpha + Bravo	Count	99	46	27	123	80	128	72	437	3
		%	9.8	4.5	2.7	12.1	7.9	12.6	7.1	43.1	0.3
2009-2011 Non-breeding season	Alpha	Count	91	51	7	45	21	38	102	395	5
		%	12.1	6.8	0.9	6.0	2.8	5.0	13.5	52.3	0.7
	Bravo	Count	166	100	20	73	19	87	122	431	1
		%	16.3	9.8	2.0	7.2	1.9	8.5	12.0	42.3	0.1
	Alpha + Bravo	Count	257	151	27	118	40	125	224	826	6
		%	14.5	8.5	1.5	6.7	2.3	7.0	12.6	46.6	0.3
2017 Breeding season	Alpha	Count	16	5	10	56	15	37	26	111	2
		%	5.8	1.8	3.6	20.1	5.4	13.3	9.4	39.9	0.7
	Bravo	Count	11	11	19	29	14	35	13	52	4
		%	5.9	5.9	10.1	15.4	7.4	18.6	6.9	27.7	2.1
	Alpha + Bravo	Count	29	16	30	85	29	78	42	167	6
		%	6.0	3.3	6.2	17.6	6.0	16.2	8.7	34.6	1.2

5.5.21 The northwest returning flight path was far more frequently recorded than the outbound southeast reciprocal direction, which accounts for less than half those recorded returning to the colony. This suggests birds do not fly direct to Alpha and Bravo, but may attempt to forage in other areas, some of which may even be beyond Alpha and Bravo, which are then crossed by returning birds. Alternatively, it is possible some birds may also reach Alpha or Bravo by swimming to the area from other localities.

5.5.22 A southwesterly flight path was also apparent, which could indicate some transit to the Forth Islands SPA colonies, although the reciprocal outbound northeasterly flight path was not frequently recorded. This could occur if Alpha and Bravo were at the edge of foraging range.

5.5.23 It is of note that for a period of several weeks during the moult period in July and August concomitant with the development of fledged chicks at sea, few Common Guillemots were recorded in flight (see Figure 42 above). When capable of flight, Common Guillemot tends to fly low to the sea surface as reflected in recorded flight heights, with <1% and 1% of birds above 20 m within the Alpha and Bravo boundaries respectively in the 2009-2011 surveys.

5.5.24 In fact, records of birds above 20 m are exceptional and perhaps linked to particular conditions such as strong tailwinds. Indeed, during the 2017 breeding season surveys, no birds were recorded at >10 m from the sea surface (Figure 48) and 98.1% of all records were of birds flying at 5 m or less with the greatest proportion recorded very close to the surface at <1 m (Figure 48).

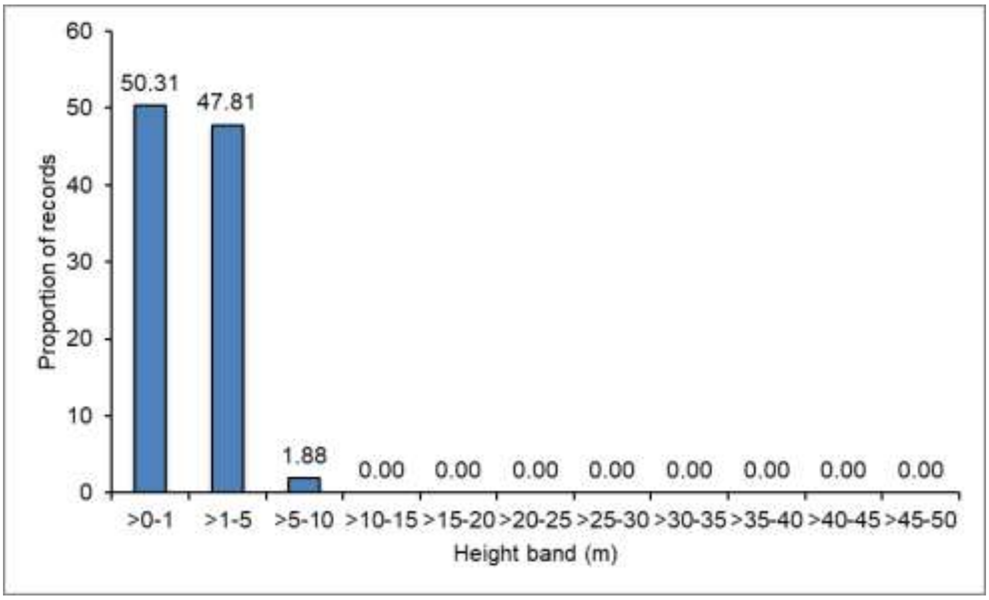

Figure 48. Proportion (%) of flight heights recorded for Common Guillemot (*n*=479) during boat-based surveys of the Alpha and Bravo in all 2017 surveys.

5.5.25 A total of 157 rangefinder records of Common Guillemot collected in 2017 were dominated by birds on the water (79.0%) with the remaining records of birds in flight all falling within the range of 0-10 m. The highest corrected height was 9.9 m with another bird recorded at 9.5 m supporting the observations of the surveyors. Observer agreement with the rangefinder was also very high, as evidenced by the 85% agreement found for pooled ‘auk’ data, the highest of any species (Appendix 1), as would be expected with a limited range of heights all close to the water and often below the survey platform.

Foraging & feeding

5.5.26 Common Guillemot has a broad diet that includes a range of fish species such as sandeels, clupeids (Atlantic Herring and European Sprat), gadoids and a variety of benthic species, linked to the ability to dive to considerable depth (>60 m) (BWPi 2004). This means that Common Guillemot may be buffered against population fluctuation of a particular prey species. Foraging Common Guillemots often form lines at sea, diving in unison presumably working together to corral fish underwater.

5.5.27 Of the birds recorded during the survey programme of 2009-2011, only 5% and 2% of birds exhibited feeding behaviour within Alpha and Bravo respectively (Figure 49a). It is worth noting however that the proportion of auks displaying feeding behaviours is invariably underestimated as this occurs underwater and foraging behaviour of single birds or small groups is also much more difficult to detect than those acting in larger flocks or MSFAs (Figures 24, 35 & 43).

5.5.28 Foraging behaviour was also relatively rarely recorded in the 2017 breeding season surveys, with a total of 122 Common Guillemots observed engaged in foraging or fishing behaviour (Figure 49b), 76.2% of which were involved in MSFAs (Figures 24 & 35). Ten MSFAs containing a minimum of one and a maximum of 20 Common Guillemots were recorded. A further four records of foraging or fishing birds were made, involving 32 birds in single species groups ranging from 2-22 individuals.

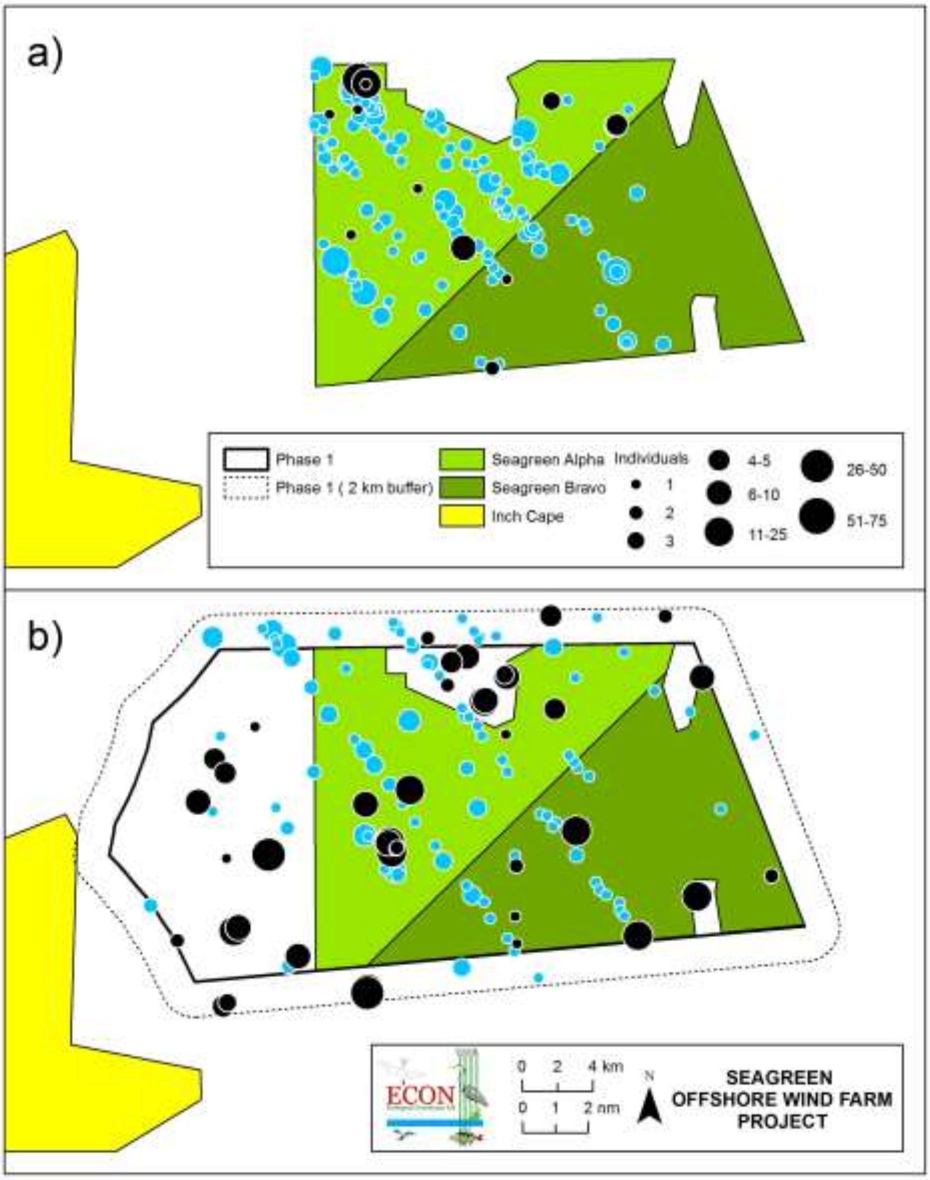

Figure 49. **Distribution and group size of Common Guillemots carrying fish (blue) and foraging or feeding (black) recorded in the breeding season in: a) in 2010 and 2011 for Alpha and Bravo only and b) in Alpha and Bravo and surrounds in 2017.**

5.5.29 The locations of foraging records from both 2010 and 2011 and 2017 breeding season surveys show a patchy distribution, but with more records from Alpha than Bravo (Figure 49). In 2017, foraging appeared to be more evenly distributed over the wider area, but with a clear preference to the area around Scalp Bank, a hint at the importance of bathymetric features to the north and west of Alpha and a large area with no foraging activity within Bravo.

5.5.30 Common Guillemots carrying prey are much more conspicuous due to the relatively large size of items selected for transport back to the colony, and the habit of carrying fish in the bill with the tail protruding (Figure 50). In the 2010 and 2011 surveys, 131 and 56 observations of prey transport were made within Alpha and Bravo respectively. The distribution of these records declined with distance across Alpha and Bravo (Figure 49a), and whilst this does not conclusively demonstrate that foraging occurred within the area it does seem likely to broadly represent the location of feeding activity. In 2017, 70 Common Guillemots were observed carrying fish across Alpha and Bravo combined and were typically recorded in small groups closely aligned with each other (Figure 50).

Figure 50. Closely associated Common Guillemots carrying prey in the direction of the Fowlsheugh colony in June 2017.

5.5.31 The majority of chick provisioning takes place in June and analysis of prey carrying adults in 2017 found that of the 67 noted as carrying fish, 82.1% were flying northwest, 4.5% southwest and 1.5% north. The remaining records (11.9%) are birds on the water carrying prey. This again suggests linkage with the Fowlsheugh colony (see 5.5.19 above). No Common Guillemots carrying fish were noted in July or August in 2017, presumably as breeding was complete and any dependent chicks are closely associated with their accompanying parent at sea (Figure 47).

5.5.32 The location of many prey transport records along specific transect lines in Figure 49b for 2017, is caused by intense foraging activity and many records being made over relatively short time periods in the June survey. The 2009-2011 surveys of Alpha and Bravo provide a greater spread of records, perhaps indicating more dispersed and less intensive foraging activity (Figure 49a).

5.6 Razorbill

Populations & connectivity

5.6.1 Razorbill is a far less numerous seabird than Common Guillemot, with a World population estimated at 610,000 - 630,000 pairs (Mitchell *et al.* 2004). The European population, thought to represent 95% of the global population, is currently estimated at 979,000–1,020,000 mature individuals (BirdLife International 2015). A number of European populations are increasing, although the severe population decline Iceland, affecting 60% of the European population, is of global significance (Birdlife 2017).

5.6.2 The UK supports 187,100 breeding individuals of the race *islandica*, which forms 20.2% of the world population of all Razorbills (JNCC 2016). The majority of colonies are located in Scotland and along the west coasts of Wales, England and Ireland. Razorbill is of 'Amber' conservation status in the UK as a result of at least 50% of the breeding population being found at ten or fewer sites and declines in breeding and wintering populations and ranges (Eaton *et al.* 2015).

5.6.3 Razorbill has a mean maximum foraging range of 48.5 km, which in relation to Alpha and Bravo encompasses 11,125 breeding individuals within ten colonies (Figure 51, Table 32). Fowlsheugh SPA supports the bulk of the breeding population within this range (67%), with the rest supplied by nine small non-designated colonies. Fowlsheugh is also the second closest colony to the Alpha and Bravo area and thus seems likely to supply most of the Razorbills recorded within the sites and surrounds.

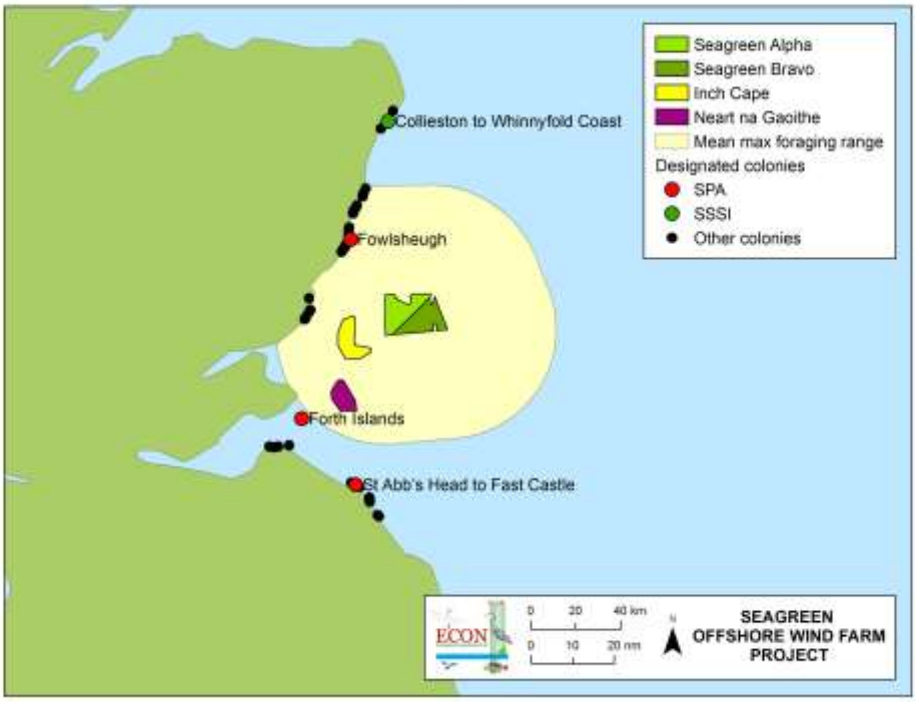

Figure 51. Distribution of Razorbill breeding colonies within mean maximum foraging range (48.5 km) of Alpha and Bravo.

5.6.4 With the inclusion of the Forth Islands and St Abb's Head to Fast Castle SPAs for consideration in HRA, the breeding population increases to 30,604 individuals. Under this scenario the SPA populations account for 88% of the breeding birds that could be encountered at Alpha and Bravo. However, it should be noted that not all other non-designated Razorbill colonies within a similar range to the Buchan Ness to Collieston Coast SPA, have been included within this apportioning calculation.

Table 32. **Details of Razorbill breeding colonies at increasing distance from Alpha and Bravo and within mean maximum foraging range (48.5 km). Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count from the SMP database in the year specified are shown.**

Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
				Number	Year
Catterline to Inverbervie	27.64		1,962	1,962	1999
Fowlsheugh SPA	30.41	5,800	6,362	7,426	2015
Stonehaven to Wine Cove	33.16		578	558	1999
Montrose to Lunan Bay	33.95		4	4	2000
Lunan Bay to Arbroath	34.86		558	558	2000
Newton Hill	39.41		58	58	2002
Newtonhill - Hall Bay	40.75		112	112	1999
Burn of Daff	41.62		54	54	1999
Findon Ness - Hare Ness	45.45		337	337	1999
Girdle Ness to Hare Ness	47.96		56	56	1999
Forth Islands SPA	52.61	2,800	4830	4,993[2]	2015
St Abb's Head to Fast Castle SPA[1]	67.90	2,180	2,875	14,486	2016
	Total	10,780	17,786	30,604	

[1]SPA outside of the mean maximum foraging range of Razorbill, but included for consideration in HRA.[2](5,038 from JNCC website)

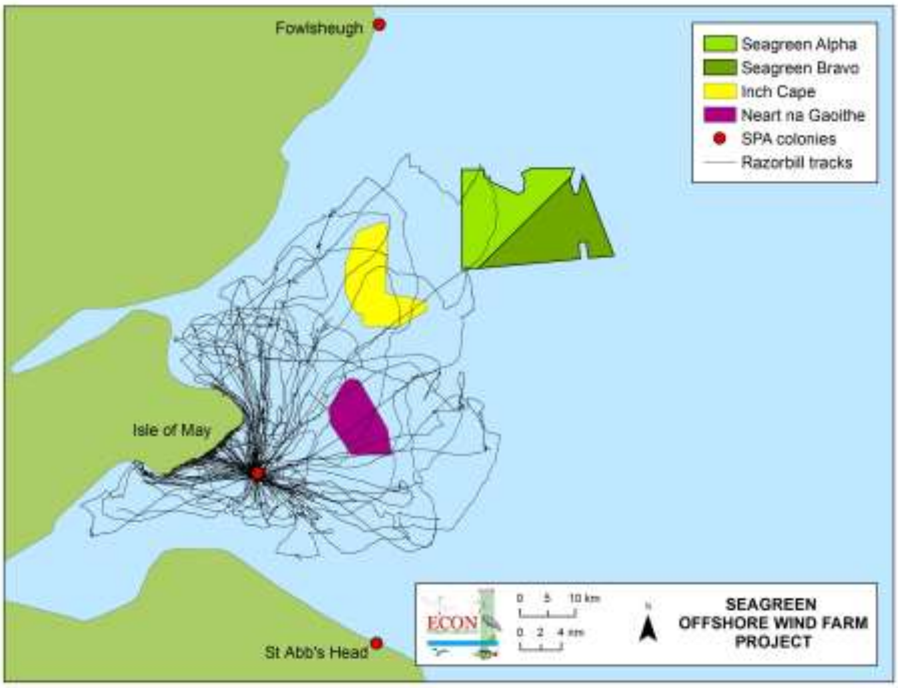

Figure 52. **Tracks of breeding Razorbills fitted with GPS tags from Isle of May (*n* = 18) in 2010 as redrawn following Daunt *et al*. (2011a).**

5.6.5 Previous tracking studies from the Isle of May colony (Forth Islands SPA) in 2010 confirmed the potential for birds to reach Alpha (Figure 52), although only a low proportion (two trips representing 1.8%) reached the site (Daunt *et al*. 2011a). Most of the apparent foraging effort suggested by the tracking was concentrated to the north and west of the Isle of May in more inshore areas with few tracks intersecting Inch Cape (4.6%) or Neart Na Gaoithe (6.4%) (Daunt *et al*. 2011a). As with Common Guillemot, the potential for inter-annual variability in foraging behaviour has not been fully addressed (see Daunt *et al*. 2011c). Nevertheless, it seems likely that birds from Fowlsheugh, which is considerably closer to Alpha and Bravo than the Forth Islands, are likely to account for most Razorbills observed in Alpha and Bravo during the breeding season.

Density & population size

5.6.1 Razorbill was observed within the Alpha and Bravo in all surveys undertaken from 2009-2011 and 2017, with some differences between sites and according to within site seasonal and inter-annual patterns. In general, after low populations over winter, numbers increased immediately prior to the start of the breeding season in February and March. Populations then tended to decline over egg laying in April and into the incubation (shared by both parents) and early chick provisioning periods (Figure 53). Peak populations were then recorded at the end of the breeding season reflecting fledging and dispersal offshore. Following the autumn passage period numbers declined again, though some fluctuation was noted (Figure 53).

5.6.2 Populations tended to be higher in Alpha, with a peak of 2,102 individuals in July 2011 within the 2009-2011 survey period. The equivalent peak in Bravo was 1279 in September 2010 over the same survey period. In 2017, exceptional peak populations of 6,142 and 6,065 individuals in Alpha and Bravo respectively were noted in July 2017, representing a 24-fold increase from June populations.

5.6.3 The resultant peak population estimate for Alpha and Bravo in-combination of 11,933 is very close to the combined total population of breeding individuals present at Fowlsheugh and Forth Islands SPAs (12,419 individuals – Table 32) and was an integral part of a large-scale foraging event also involving large numbers of Common Guillemots (see 5.5.6 above) and Black-legged Kittiwakes (see 5.37 above). Numbers across the combined Alpha and Bravo area then decreased dramatically in August to similar levels previously observed in 2010 and 2011 although with a higher proportion (69.5%) recorded within Alpha compared to Bravo (Figure 53).

5.6.4 The low population estimates during the breeding season suggest Alpha and Bravo are not important for foraging during the incubation and chick provisioning phases, which is consistent with the results of Daunt *et al.* (2011a) showing the tendency of Razorbills to forage in inshore waters in relatively close proximity to the colony (Forth Islands SPA), albeit with particular offshore areas of importance (Figure 52).

5.6.5 Monthly mean peak densities were achieved in July in all areas, with a peak of 14.39 individuals km^{-2} in Alpha compared to 12.33 individuals km^{-2} within Bravo (Table 33). The inclusion of a 2 km buffer increased density in Alpha to 17.30 individuals km^{-2} and decreased density in Bravo to 12.33 individuals km^{-2} in the same month. Densities were relatively consistent across the spring and autumn passage periods in Alpha and Bravo, although Bravo showed a high density of birds into September of 5.84 individuals km^{-2} compared to 2.96 individuals km^{-2} in Alpha suggesting dispersal from colonies was still apparent in more offshore areas (Figure 53).

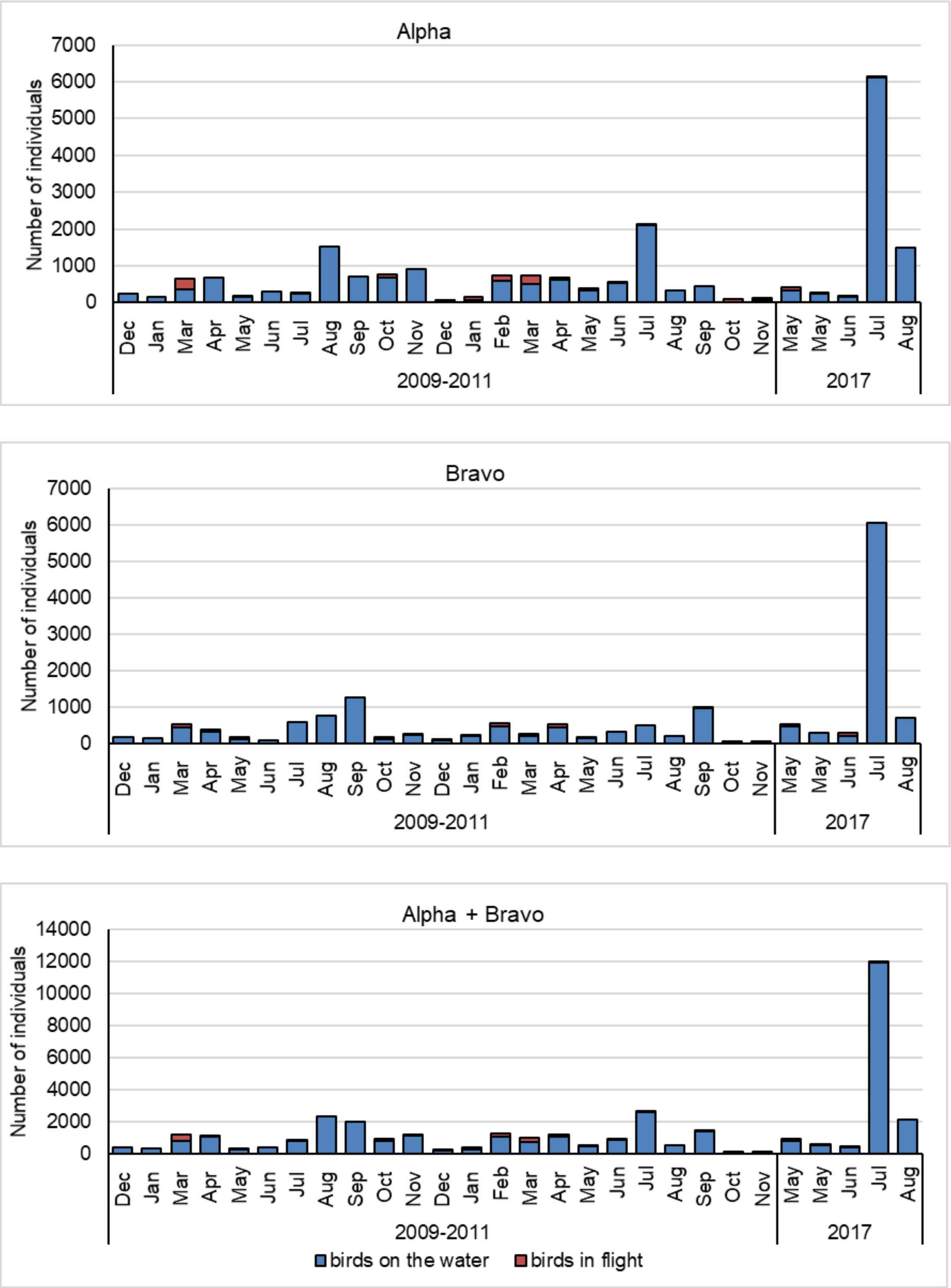

Figure 53. **Razorbill population estimates (number of individuals) by month from boat-based surveys of Alpha and Bravo. Estimates are derived from density from snapshots of birds in flight combined with distance corrected density of birds on the water from line transect.**

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5.6.6 The mean densities by month (Table 33) exceed those derived by Stone *et al*. (1995) for the western North Sea in March, July and August of 0.2, 1.0 and 2.1 individuals km^{-2} respectively. Mean monthly densities are broadly similar to those presented by Skov *et al*. (1995) for the key areas of Moray Firth (6.1 ind. km^{-2}) and Scalp Bank (7.1 ind. km^{-2}) which is immediately adjacent to Project Alpha, in August. The peak of up to 14.39 individuals km^{-2} in July within Alpha exceeds the range of 2-10+ individuals km^{-2} previously recorded in parts of the Firth of Forth in June/July by Camphuysen (2005), but this is thought to relate to an exceptional event (see 5.6.3 above).

Table 33. Monthly mean density (ind. km^{-2}) and standard deviation of Razorbills in in Alpha, Bravo and Alpha and Bravo combined with and without a 2 km buffer. The number of surveys completed in each month is also shown. Densities in all cases were derived from a combination of DISTANCE corrected line transect data for birds on the water and snapshot data for flying birds.

Project		**Month**											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
		2	**1**	**2**	**2**	**4**	**3**	**3**	**3**	**2**	**2**	**2**	**2**
Alpha	Mean	0.84	3.75	3.58	3.52	1.61	1.75	14.39	5.69	2.96	2.21	2.57	0.83
	SD	0.04	-	0.30	0.00	0.63	0.94	15.25	3.42	0.88	2.48	2.81	0.64
Alpha + 2km	Mean	1.13	5.02	4.79	4.71	1.81	2.50	17.30	8.74	3.97	2.96	3.45	1.11
	SD	0.05	-	0.40	0.00	0.71	1.09	17.21	5.76	1.18	3.32	3.77	0.86
Bravo	Mean	0.99	2.90	2.04	2.31	1.51	1.29	12.33	2.90	5.84	0.61	0.75	0.78
	SD	0.28	-	1.00	0.54	0.91	0.68	16.45	1.62	1.08	0.47	0.80	0.21
Bravo + 2km	Mean	1.11	3.26	2.30	2.60	1.33	1.32	11.33	4.65	6.57	0.69	0.84	0.88
	SD	0.32	-	1.12	0.61	0.57	0.72	14.11	3.52	1.21	0.53	0.90	0.23
Alpha + Bravo	Mean	0.91	3.33	2.82	2.92	1.55	1.52	13.13	4.27	4.39	1.42	1.67	0.80
	SD	0.12	-	0.34	0.27	0.66	0.68	15.24	2.50	0.98	1.48	1.82	0.43
Alpha + Bravo + 2km	Mean	1.12	4.09	3.46	3.58	1.54	1.89	14.22	6.80	5.39	1.74	2.05	0.99
	SD	0.15	-	0.42	0.33	0.44	0.82	15.46	4.87	1.20	1.82	2.23	0.52

Spatial distribution

5.6.7 In 2009-2011, the distribution of Razorbill across Alpha and Bravo was patchy in both the breeding and non-breeding seasons (Figure 54). Birds were more widespread over the winter period when the area held a relatively stable population. During the breeding season there was a suggestion that the western part of Alpha and the eastern part of Bravo were preferred, with few records in the centre of the combined area (Figure 54).

5.6.8 There was a clear difference in the distribution of Razorbill between the breeding seasons of 2010 and 2011 (Figure 55). In the former, the majority of records were made in the northeast corner of the site, whereas in the latter, the majority of the birds were observed along the western edge of Alpha close to Scalp Bank (Figure

55). The latter period incorporates the high estimated population of birds in July of that year (Figure 53 above).

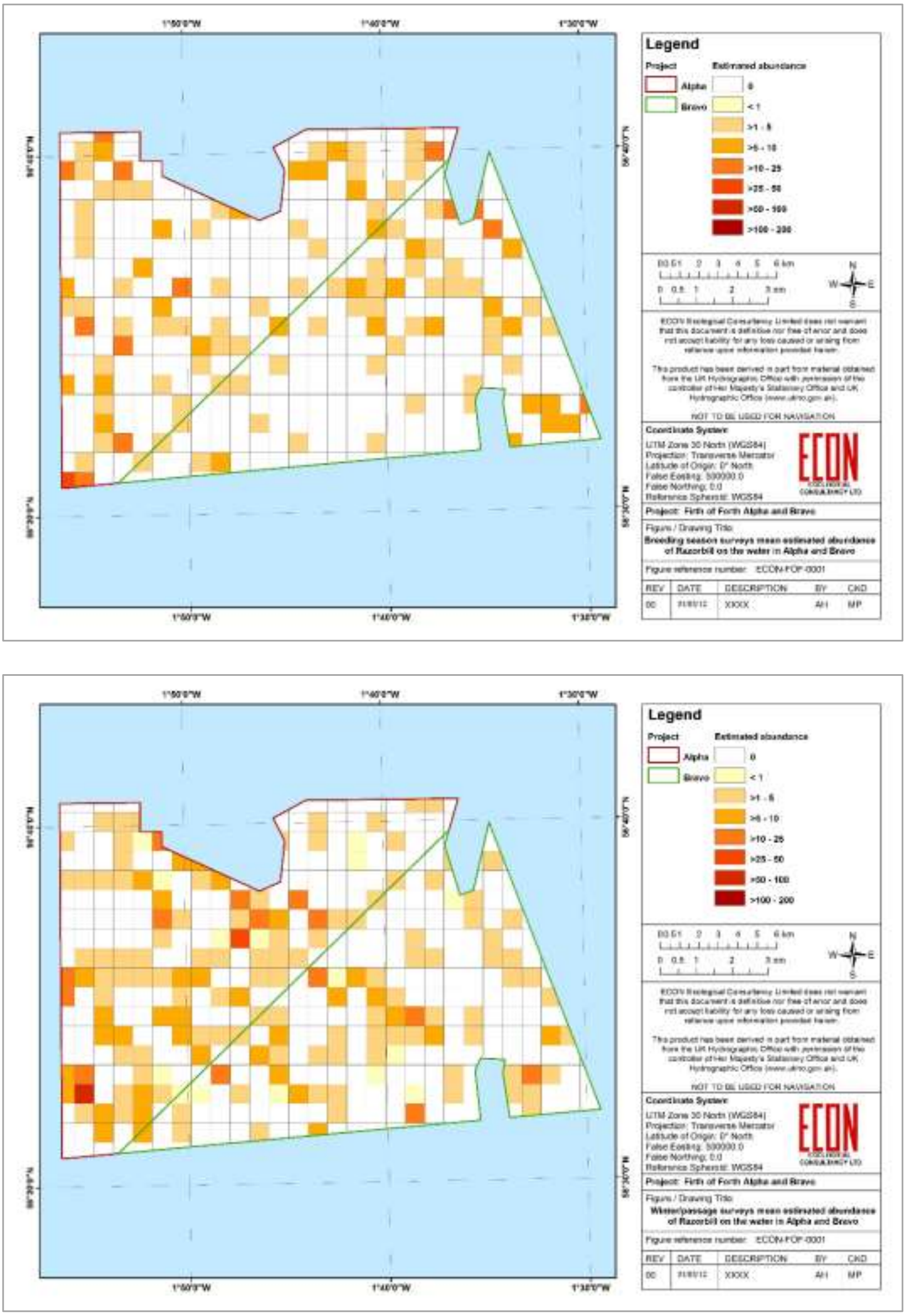
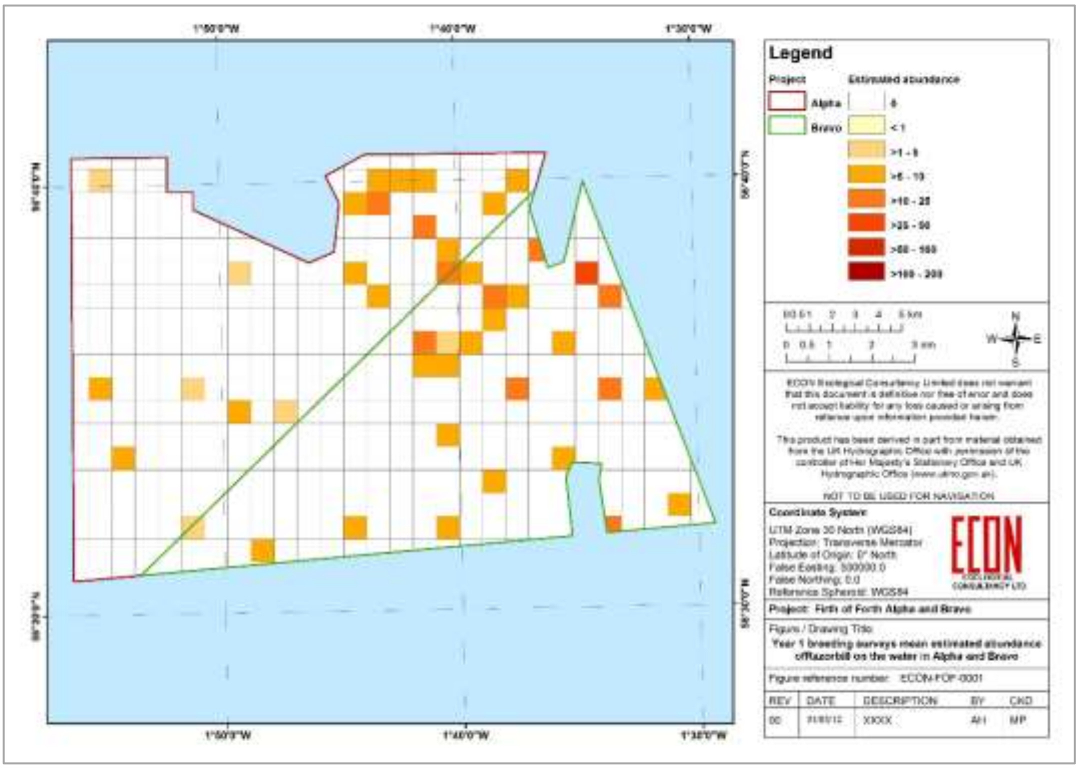


Figure 54. Relative abundance of Razorbill expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^{2} grid cells across Alpha and Bravo in the breeding seasons of April to August (above) compared to the passage/winter periods in 2009-2011 (below).



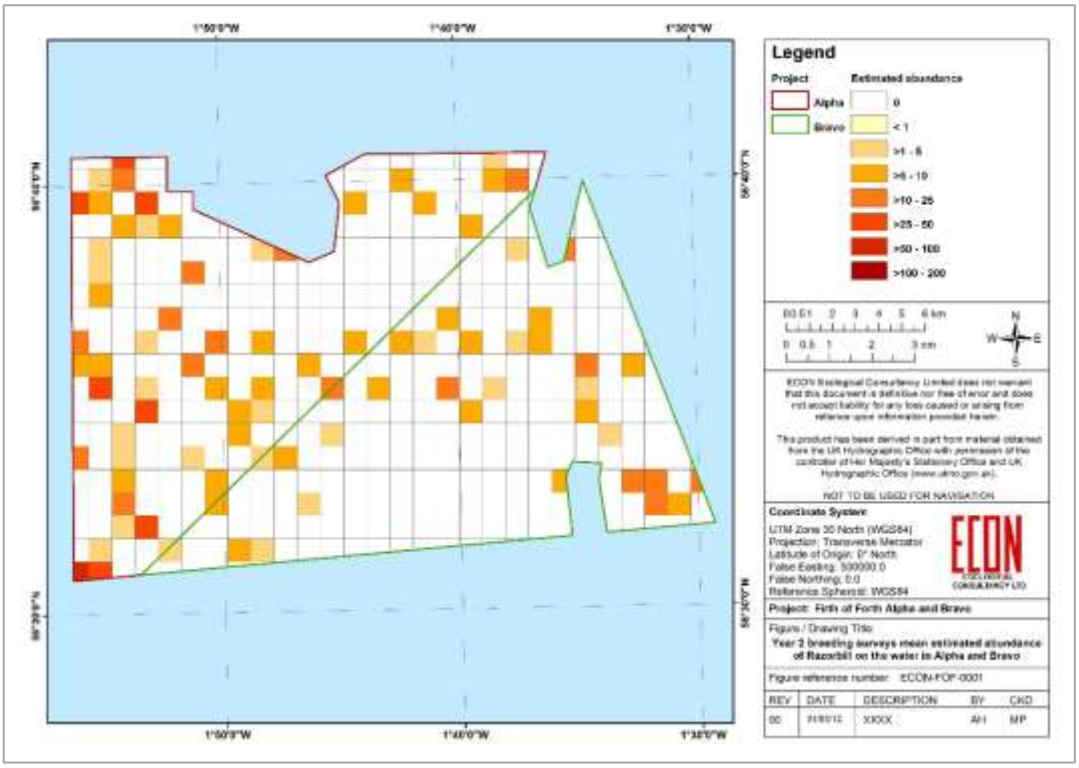


Figure 55. **Relative abundance of Razorbill expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^{2} grid cells across Alpha and Bravo in the breeding season of April to July in 2010 (above) compared to 2011 (below).**

5.6.9 During the 2017 breeding season, Razorbills utilised much of Alpha and Bravo, although densities were higher outside of the proposed development zones (Figure 56a). Within Alpha, an area to the west held few birds while in Bravo the southeast corner was similarly unpopulated. Interestingly, these areas supported relatively high densities of birds in the breeding season of 2011 (Figure 55).

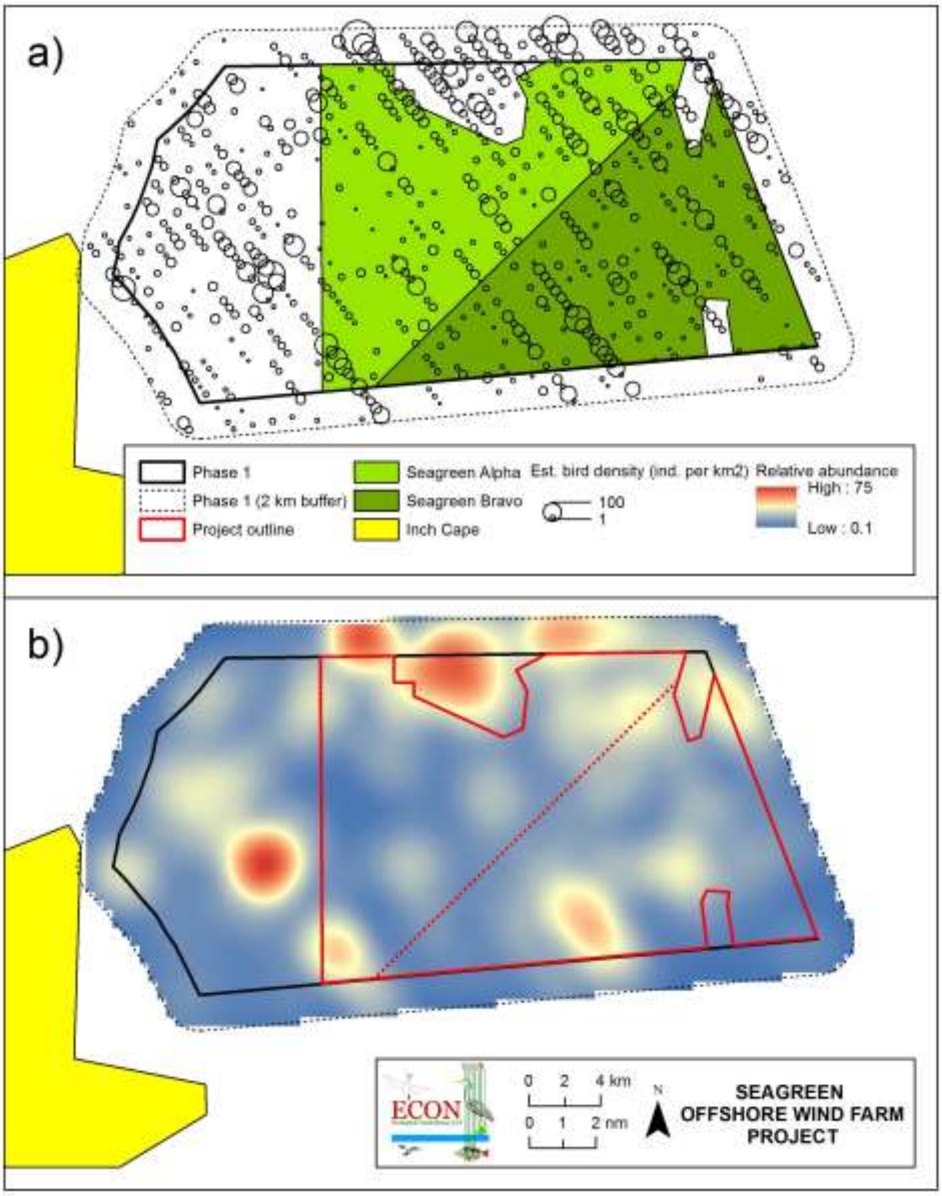


Figure 56. **Density distribution of Razorbill in 2017 as shown by: a) mean densities of birds on the water (corrected values) from birds in each survey cell on each of the three survey routes (route two was only surveyed once), and b) the relative abundance surfaces derived using KDE applied to these data.**

5.6.10 The KDE surface (Figure 56b), derived from birds on the water in 2017 generally mirrors the distribution of Razorbill in July and August, the two months when Razorbill was most abundant (Figure 53 above). The key hotspots to the west (Scalp Bank) and north (the area of deep water and bathymetric change) of Alpha were prominent, with some other patches of lower density in Alpha and especially in Bravo, reflecting aggregations most likely associated with foraging opportunities.

Population structure

5.6.11 A greater proportion (11.7%) of Razorbills were aged in 2009-2011 compared to Common Guillemots in the surveys of Alpha and Bravo combined. The contrast between the proportions of birds aged when the observation was of a single bird (3%) compared to two together (26.4%) was also more apparent. This again highlights the increase confidence of ageing an adult bird when with a fledged chick. In 2017, the same trend was noted with 6.0% of Razorbills aged and again a marked contrast between the proportion of birds aged with a single bird present (9.7%) compared to two together (28.49%).

5.6.12 The first fledged chicks were usually noted in June (Figure 57), although the majority fledge in July (Table 34). The aged proportion of birds noted as juvenile ranged from 34.6% in 2017 within Bravo to 46.2% within Alpha in the same year. Proportions of birds aged as juvenile fell within this range in 2009-2011 and showed less variation between Alpha and Bravo.

Figure 57. Two Razorbills, each with a dependent chick in July 2017.

5.6.13 The peak occurrence of juvenile birds in July with these persisting into August (none were recorded in September) coupled with an increase in estimated populations at least in some years suggests increased site utilisation during the fledging and dispersal period when chicks are still accompanied and provisioned by the paternal parent. The fact that birds are parents and chicks are flightless in this period as they undergo moult and develop flight feathers respectively, reinforces the view that most birds are of local origin at this time.

Table 34. **Number and proportion of adult and juvenile (Juv) Razorbills relative to the total number of birds aged in each month during boat-based surveys of the Phase 1 Project and study area in 2017 and Alpha in 2010 and 2011.**

Year	**Site**	**Month**											
			Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2009-2011	Alpha	Adults	0	0	0	0	6	1	18	50	0	0	0	0
		%	-	-	-	-	100	50.0	56.3	53.2	-	-	-	-
		Juv	0	0	0	0	0	1	14	43	0	0	0	0
		%	-	-	-	-	0.0	50.0	43.8	45.7	-	-	-	-
		Total	0	0	0	0	6	2	32	94	0	0	0	0
	Bravo	Adults	0	0	0	0	9	2	31	25	0	1	0	0
		%	-	-	-	-	90.0	66.7	58.5	53.2	-	50.0	-	-
		Juv	0	0	0	0	0	1	22	22	0	1	0	0
		%	-	-	-	-	0.0	33.3	41.5	46.8	-	50.0	-	-
		Total	0	0	0	0	10	3	53	47	0	2	0	0
	Alpha + Bravo	Adults	0	0	0	0	15	3	49	75	0	1	0	0
		%	-	-	-	-	100	60.0	57.6	53.6	-	50.0	-	-
		Juv	0	0	0	0	0	2	36	65	0	1	0	0
		%	-	-	-	-	0.0	40.0	42.4	46.4	-	50.0	-	-
		Total	0	0	0	0	15	5	85	140	0	2	0	0
2017	Alpha	Adults					1	0	7	26				
		%					33.3	-	53.8	55.3				
		Juv					0	0	6	21				
		%					0.0	-	46.2	44.7				
		Total					3	0	13	47				
	Bravo	Adults					1	0	17	20				
		%					14.3	-	65.4	62.5				
		Juv					0	0	9	12				
		%					0.0	-	34.6	37.5				
		Total					7	0	26	32				
	Alpha + Bravo	Adults					2	0	24	46				
		%					20.0	-	61.5	58.2				
		Juv					0	0	15	33				
		%					0.0	-	38.5	41.8				
		Total					10	0	39	79				

5.6.14 Moreover, in the 2009-2011 surveys of Alpha and Bravo, higher proportions of juvenile birds were noted in August than in July, which could suggest later fledging or simply reduced site utilisation by dispersing paternal Razorbills and their attendant chicks. In 2,017 the proportion of juveniles dropped in Alpha from July to August with a corresponding increase noted in Bravo seemingly reflecting the ongoing offshore movement of these birds.

Flight behaviour

5.6.15 Flight directions of Razorbills throughout the year across Alpha and Bravo clearly show birds in transit to Fowlsheugh on a northwesterly flight path, with a range from 51.3% in Alpha in the non-breeding period in 2009-2011 to 19.2% in Bravo during the 2017 breeding season surveys Table 35). The predominance of the northwesterly flight path in the non-breeding season may be linked to the attendance of colonies by the end of March (Forrester *et al.* 2007). In Alpha, northerly flights were equally prominent during the breeding seasons in 2009-2011, which were thought to be a subtle variation in direction caused by the more coastal location of Alpha, not necessitating an obvious westerly component to the flight path.

Table 35. Number and proportion (%) of flight directions recorded for Razorbill during boat-based surveys of Alpha and Bravo. No fixed direction is represented by 'None'.

Parameters			**Compass direction**								
			N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**None**
2009-2011 Breeding season	Alpha	Count	13	3	5	2	2	4	9	13	1
		%	25.0	5.8	9.6	3.8	3.8	7.7	17.3	25.0	1.9
	Bravo	Count	26	4	0	0	5	5	6	32	1
		%	32.9	5.1	0.0	0.0	6.3	6.3	7.6	40.5	1.3
	Alpha + Bravo	Count	39	7	5	2	7	9	15	45	2
		%	29.8	5.3	3.8	1.5	5.3	6.9	11.5	34.4	1.5
2009-2011 Non-breeding season	Alpha	Count	40	21	15	0	24	29	23	160	0
		%	12.8	6.7	4.8	0.0	7.7	9.3	7.4	51.3	0.0
	Bravo	Count	28	10	5	9	14	24	15	77	0
		%	15.4	5.5	2.7	4.9	7.7	13.2	8.2	42.3	0.0
	Alpha + Bravo	Count	68	31	20	9	38	53	38	237	0
		%	13.8	6.3	4.0	1.8	7.7	10.7	7.7	48.0	0.0
2017 Breeding season	Alpha	Count	1	1	6	3	2	13	3	17	2
		%	2.1	2.1	12.5	6.3	4.2	27.1	6.3	35.4	4.2
	Bravo	Count	4	4	0	5	2	6	0	5	0
		%	15.4	15.4	0.0	19.2	7.7	23.1	0.0	19.2	0.0
	Alpha + Bravo	Count	5	5	7	8	4	22	3	22	2
		%	6.4	6.4	9.0	10.3	5.1	28.2	3.8	28.2	2.6

5.6.16 A southwesterly flight path was also prominent in 2017, suggestive of birds commuting to the Forth Islands SPA (Table 35). In Bravo, the proportion of birds recorded on a southwesterly transit (28.2%) was greater than the proportion on a northwesterly transit (19.2%), which is consistent with the greater proximity of Bravo to the Forth Islands. In 2009-2011 a westerly flight path was also apparent across Alpha, which may suggest some birds commuting to the smaller non-designated colonies along the coast to the south of Fowlsheugh.

5.6.17 A southeasterly flight direction was not frequently observed, except within the limited data gathered in Bravo in 2017 (Table 35). Thus, there appears to be a net sink (loss) of birds returning to the colony rather than coming from it. A similar pattern was noted for Common Guillemot and the same possibilities of birds not flying directly to Alpha and Bravo or swimming into the sites from surrounding nearby areas may apply (see 5.5.20 above).

5.6.18 Apart from when flightless during moult, Razorbill tends to fly low to the sea surface, as reflected in recorded flight heights. During the 2009-2011 surveys, 22% of birds were recorded in flight, with just 1.2% flying above 20 m within Alpha compared to no birds at this height in Bravo. In 2017, no birds were recorded at >10 m and 94.9% of records represented birds flying at heights of 5 m or less (Figure 58).

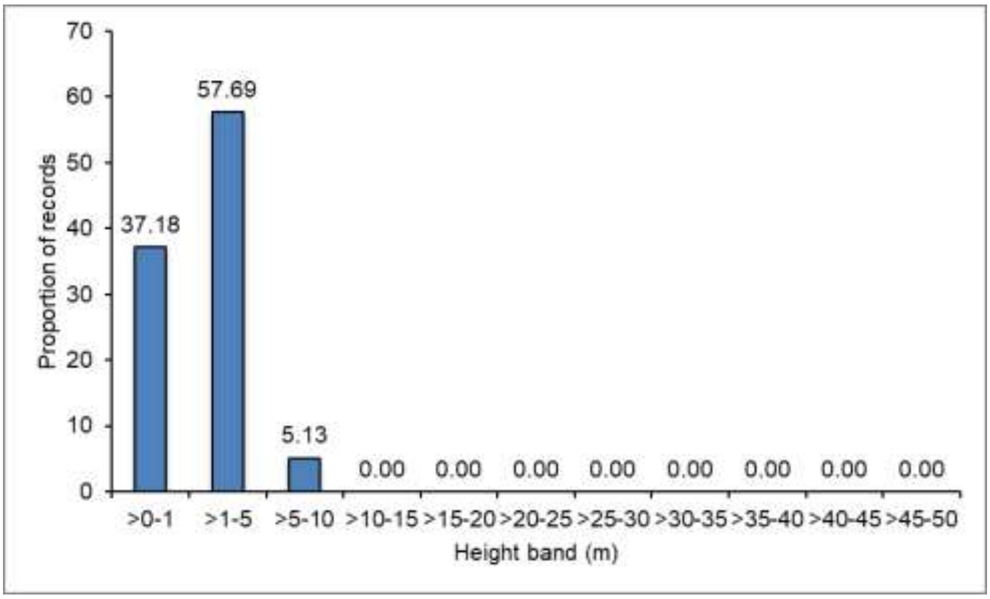


Figure 58. Proportion (%) of flight heights recorded for Razorbill (*n* = 78) during boat-based surveys of Alpha and Bravo in 2017.

5.6.19 A total of 26 rangefinder records collected in 2017 yielded a maximum corrected height of 12.5 m, with birds most frequently recorded in the >0–5 m (42.3% of records) and >5–10 m (30.8% of records) bands. Observer agreement was very high, as represented by 86% agreement with the rangefinder shown for pooled 'auk' data (Appendix 1), as would be expected with a limited range of heights close to the sea surface and often below the survey platform.

Foraging & feeding

5.6.20 Mixed feeding groups of Razorbills and Common Guillemots are frequently encountered with both presumably targeting prey such as sandeels and clupeids. There are however clear differences in their feeding ecology (Ouwehand *et al.* 2004), with Razorbills being more specific in their prey choice, favouring smaller shoaling species and rarely diving deeper than 35 metres and often with reduced frequency (Benvenuti *et al.* 2001). Common Guillemots on the other hand take a wider variety of species and dive to greater depths. Differences in feeding ecology may lead to differences in distribution, reproductive and fledging success and post fledging mortality between the two species at any one colony.

5.6.21 During the 2009-2011 surveys, >75% of birds recorded in both Alpha and Bravo were on the water surface and 9% of these birds were recorded as being engaged in foraging activity within Alpha, compared to 18% within Bravo, including 200 Razorbills noted in a single MSFA. The bulk of these records were outside of the breeding season and there were very few foraging records from within Alpha or

Bravo in the 2010 and 2011 breeding seasons (Figure 59a). However, given the peaks in density immediately before and at the end of the breeding season, birds from local colonies seem likely to be involved.

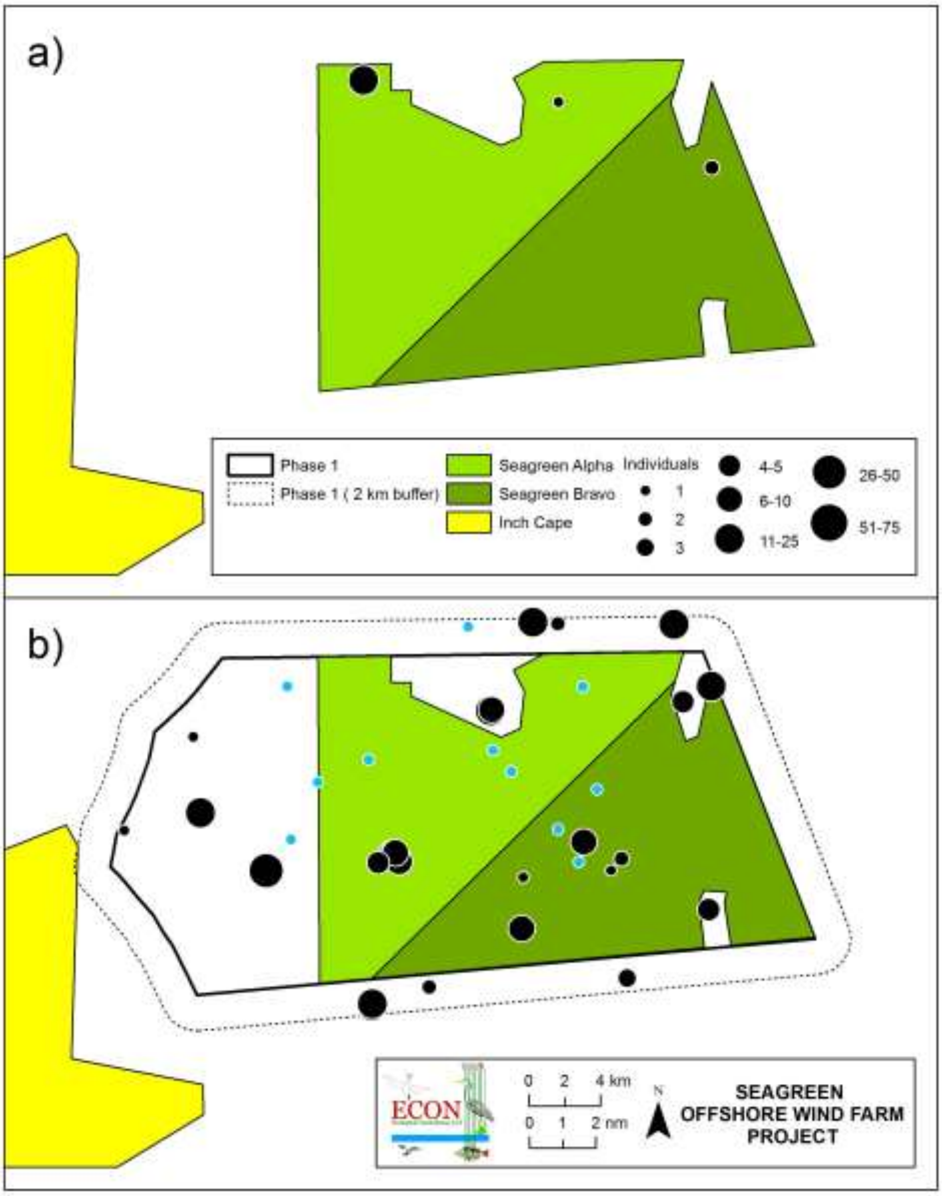


Figure 59. Distribution and group size of Razorbills carrying fish (blue) and foraging or feeding (black) recorded in the breeding season in: a) 2010 and 2011 for Alpha and Bravo only and b) in Alpha and Bravo and surrounds in 2017.

5.6.22 A total of 17 Razorbills were observed engaged in fishing behaviour within Alpha and Bravo in 2017 and of these, 52.9% (a single group of 9 birds) were involved in a MSFA. In general however, foraging records were patchily distributed (Figure 59b), with Scalp Bank to the west of Alpha and a number of areas with deeper water and bathymetric change seemingly offering foraging opportunities for Razorbill.

5.6.23 No Razorbills were seen carrying prey back to colonies in the 2009-2011 surveys (Figure 59a). In contrast, in June 2017, seven Razorbills were observed carrying fish in Alpha and Bravo, with a further four records within the wider survey area (Figure 59b). Of all eleven birds observed, 45.5% were flying northwest in the direction of Fowlsheugh. The destination of birds flying in the other flight directions recorded, with 18.2% to the southwest and 27.2% north or northeast, could not be determined. The remaining 9.1% of birds carrying prey were doing so whilst swimming on the sea surface.

5.6.24 Foraging behaviour was rarely recorded, although as previously described for Common Guillemot (see 5.5.26 above), foraging is generally difficult to observe. Foraging behaviour of single birds or small groups is also much more difficult to detect than those in acting in larger flocks or MSFAs. As for Common Guillemot, it seems highly likely that a large proportion of Razorbills recorded within Alpha and Bravo would have foraged within the area at some point.

5.7 Atlantic Puffin

Populations & connectivity

5.7.1 The global population of Atlantic Puffin is estimated at 5.5–6.6 million breeding pairs (Mitchell *et al.* 2004) within its breeding range of the North Atlantic and adjacent Arctic Ocean. In northwest Europe, comprising 75% of its global breeding range Atlantic Puffin is widespread but patchily distributed, with notable concentrations in Iceland and Norway. The European population is estimated at 4.8–5.8 million pairs, equating to 9.6–11.6 million mature individuals (BirdLife International 2015). Rapid declines in both its global and European range has resulted in a classification of 'Vulnerable' under the population size criterion (BirdLife International 2017).

5.7.2 In the UK, Atlantic Puffin is the second most abundant seabird, with an estimated 580,700 breeding pairs, 85% of which are in Scotland. The UK population represents ~10% of the World population (JNCC 2016). Atlantic Puffin is of 'Red' conservation status in the UK due to it being globally threatened and as a result of recent declines in both breeding and winter populations and ranges in the UK (Eaton *et al.* 2015).

5.7.3 The mean maximum foraging range for Atlantic Puffin has been estimated at 105 km (Thaxter *et al*. 2012). This range from Alpha and Bravo areas encompasses two SPAs comprising The Forth Islands SPA and the Farne Islands SPAs, four further SSSI sites and 11 other non-designated colonies (Table 36, Figure 60). The combined breeding population of these sites is 186,569 individuals (Table 36), with the combination of the Forth Islands and Farne Islands SPAs accounting for 99% of the breeding birds within mean maximum foraging range of Alpha and Bravo.

5.7.4 The Farne Islands SPA, containing 79,924 individuals, is approximately 100 km from the Alpha and Bravo area (Table 36). However, although within theoretical foraging range the Farne Islands SPA is not to be considered for HRA (Marine Scotland 2017) presumably on account of the low potential of birds from the Farne Islands overlapping the range of birds from the Forth Islands. The exclusion of the Farne Islands makes little difference to the SPA: non-SPA colony ratio however, as this still contributes 97% of the combined breeding population of 106,645 individuals.

Table 36. **Details of all Atlantic Puffin breeding colonies at increasing distance from Alpha and Bravo within mean maximum foraging range (105.4 km). Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count from the SMP database in the year specified are shown.**

Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
				Number	Year
Catterline to Inverbervie	27.64		344	344	1999
Fowlsheugh (SSSI)	31.09		50	30	2006
Stonehaven to Wine Cove	33.55		213	213	1999
Whiting Ness to Ethie Haven (SSSI)	34.79		189	189	2001
Lunan Bay to Arbroath	34.93		1	1	2001
Newton Hill	38.92		17	17	2002
Newtonhill - Hall Bay	40.95		3	3	1999
Burn of Daff	41.62		20	20	1999
Findon Ness - Hare Ness	45.45		103	103	1999
Girdle Ness to Hare Ness	47.96		3	3	1999
Forth Islands SPA	52.61	28,000	140,849	103,912	2013
St Abb's Head to Fast Castle (SSSI)	68.48		52	7	2011
Eyemouth to Burnmouth	73.31		21	21	2000
Collieston to Whinnyfold Coast (SSSI)	81.85		623	623	2001
Inchkeith	91.25		1,641	1,157	2009
Farne Islands SPA[1]	98.98	69,420	111,348	79,924	2013
Inchcolm	100.04		40	2	2010
	Total	97,420	255,517	186,569	

[1]*SPA inside the mean maximum foraging range of Atlantic Puffin, but not included for consideration in HRA.*

5.7.5 All Puffin colonies within 70 km of Alpha and Bravo are relatively small, although according to Seabird 2000, the largest and closest colony at around 27 km at its closest point lies along the coastline between Catterline and Inverbervie. Recent surveys in the 2017 breeding season found just 20 individuals present in this area. By comparison, in the latest survey, the Forth Islands SPA, particularly the Isle of May, supported 103,912 individuals comprising 56% of the breeding population within range. The centre of the Forth Islands SPA is just over 50 km away from the closest points of Alpha and Bravo.

5.7.6 Tracking of a limited number of individuals from the Isle of May in 2010 (Figure 61) suggested only 1% of the trips made by birds reached Alpha, with none reaching Bravo, relative to the 5% reaching both Inch Cape and Neart Na Gaoithe. Harris *et al*. (2012) show the kernel density contours for this data, with Alpha barely clipping the 90% contour. The area around Scalp Bank falls within the 50% contour representing a key foraging location in conjunction with the area around Wee Bankie directly to the east of the colony on the Isle of May. Neart Na Gaoithe lies on the direct flight path from isle of May to the Wee Bankie.

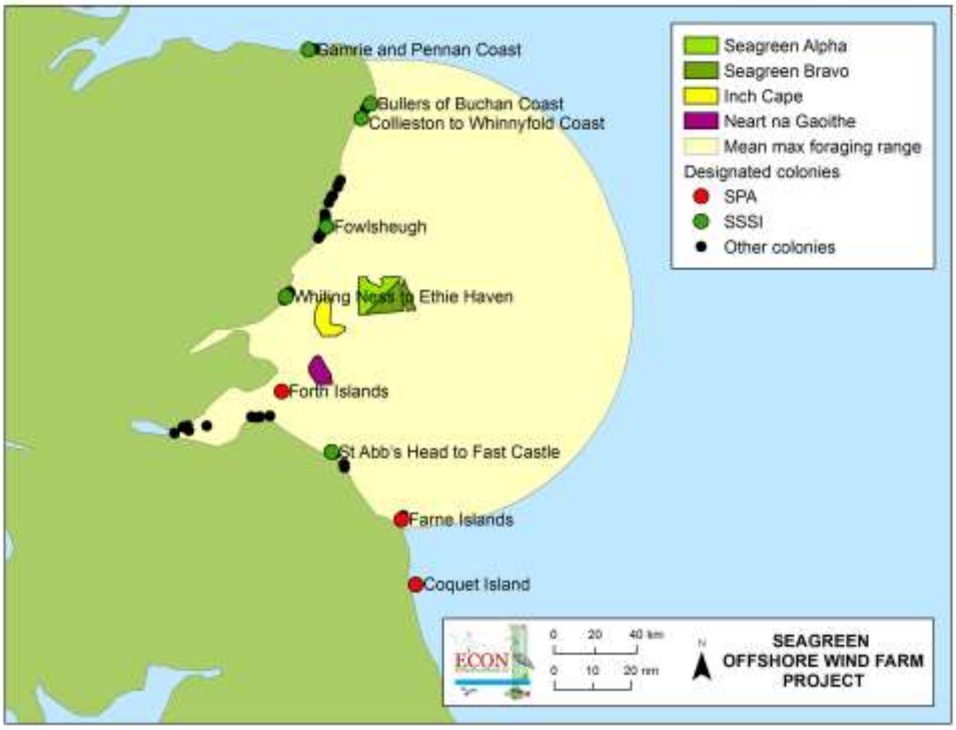


Figure 60. **Distribution of Atlantic Puffin breeding colonies within mean maximum foraging range (105.4 km) of Alpha and Bravo.**

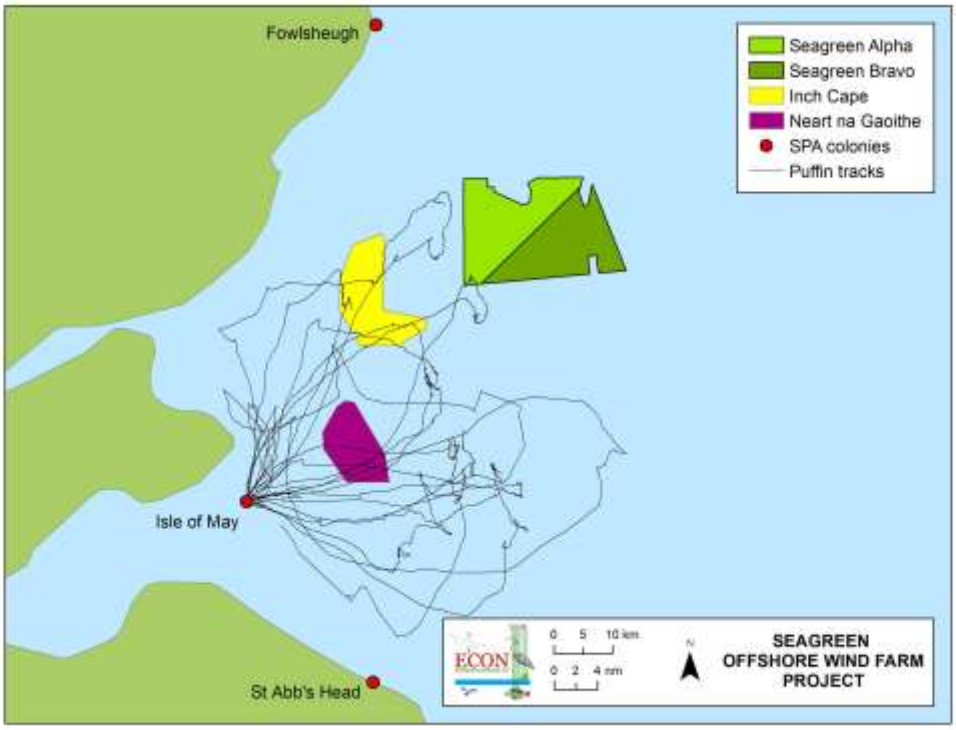


Figure 61. **Tracks of breeding Atlantic Puffins fitted with GPS tags from Isle of May (*n* = 7) in 2010 (see Harris *et al*. 2012).**

Density & population size

5.7.7 Atlantic Puffin was recorded on all surveys and displayed a different pattern of abundance to the other auks. As an extremely pelagic seabird, Atlantic Puffin only returns to land to breed, occupying colonies from March to August. Accordingly, population estimates were low over winter and although spring passage in March (2010) and April (2011) was apparent, the resultant increase in numbers was still low relative to the local breeding population, with an estimated maximum of 693 individuals in Bravo in 2011 (Figure 62). A typical decline in populations in May (Figure 62) coincides with shared incubation (by both parents) of the single egg laid in late April (Cramp *et al.* 1974).

5.7.8 Substantial increases in population sizes in June across Alpha and Bravo in 2010 and 2011 coincided with the expected chick hatching period, with overall peak populations of 2,787 and 5,438 individuals in Alpha and Bravo respectively, in 2011. It is of note that a June peak was not observed in 2017, with a steady rise in the numbers of birds present from June to August (Figure 62), broadly coincident with the six-week provisioning period of chicks within the nest burrow by their parents.

5.7.9 Atlantic Puffin numbers increased by 5-fold in July 2017 from June values in line with a similar four-fold increase in numbers of Common Guillemot (see 5.5.6 above) and the much higher increase (24-fold) in Razorbill populations at the same time (see 5.6.2 above), all in response to a large-scale feeding event (see 5.3.7 & 5.6.3 above).

5.7.10 Following this event, Atlantic Puffin numbers continued to rise leading to breeding season peaks of 1,491 and 1,552 birds in Alpha and Bravo respectively, although these were much lower than recorded in previous surveys (see 5.7.8 above). Nonetheless, as numbers of Common Guillemot and Razorbill both declined (see Figures 42 & 53 respectively), Atlantic Puffin had the highest estimated population of any auk species within Alpha and Bravo combined, reflecting the later or at least more protracted breeding season of Atlantic Puffin.

5.7.11 Numbers of Atlantic Puffins remained fairly high and stable in the August–November period in 2010, but quickly declined from a September peak that was particularly pronounced in Bravo in 2011. The pattern observed is mirrored by that of breeding birds from the Isle of May tagged in 2007 that remained in an area offshore of Fraserburgh to the Farnes incorporating the outer Forth during the August to December period (Harris *et al.* 2010). After this point, these birds moved out of the area, with some reaching the east Atlantic. Conversely, after being abandoned by their parents in July or August and left to fledge independently, 'pufflings' are thought to quickly move offshore after leaving their colonies (Forrester *et al.* 2007).

5.7.12 At the peak of the breeding season, Skov *et al*. (1995) recorded a density for the area immediately around the Isle of May of 16.3 individuals km^{-2}, whereas Camphuysen (2005) notes a density of >10 individuals km^{-2} in several parts of the Firth of Forth in June and July. Peak densities in Alpha and Bravo reach these values at peak in June. After the breeding season in August and September, Skov *et al*. (1995) recorded 7.5 individuals km^{-2} in the wider Forth area including around the Isle of May, which are either similar to those recorded in Alpha and or exceeded by those in Bravo (Table 37). Moreover, the densities in the early winter in both Bravo and Alpha exceed any density value presented by Skov *et al*. (1995) although data appear to be rather scant.

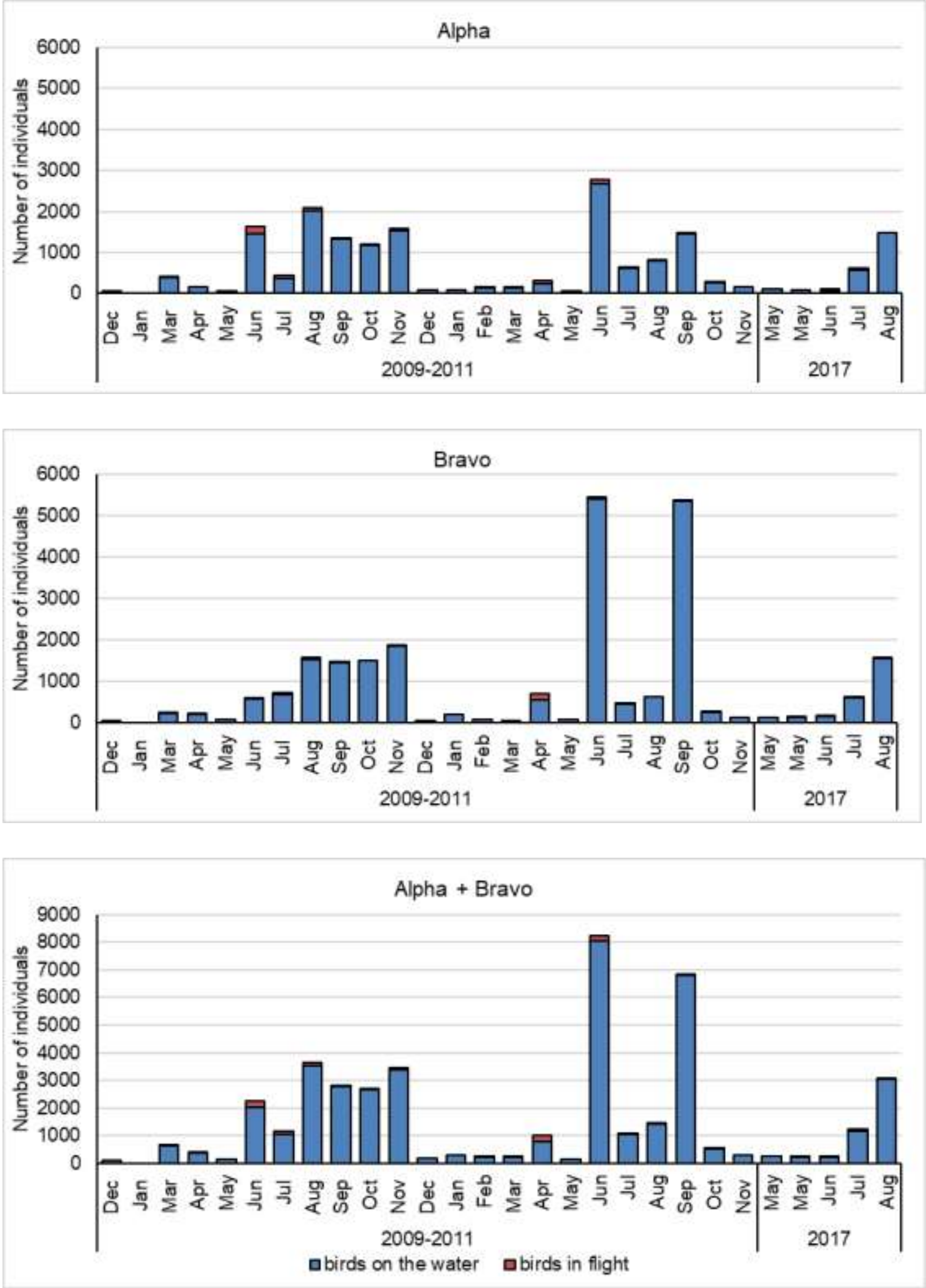


Figure 62. **Atlantic Puffin population estimates (number of individuals) in Alpha, Bravo and Alpha and Bravo combined by month from boat based surveys. Estimates are derived from the density from snapshots of birds in flight combined with distance corrected density of birds on the water from line transect.**

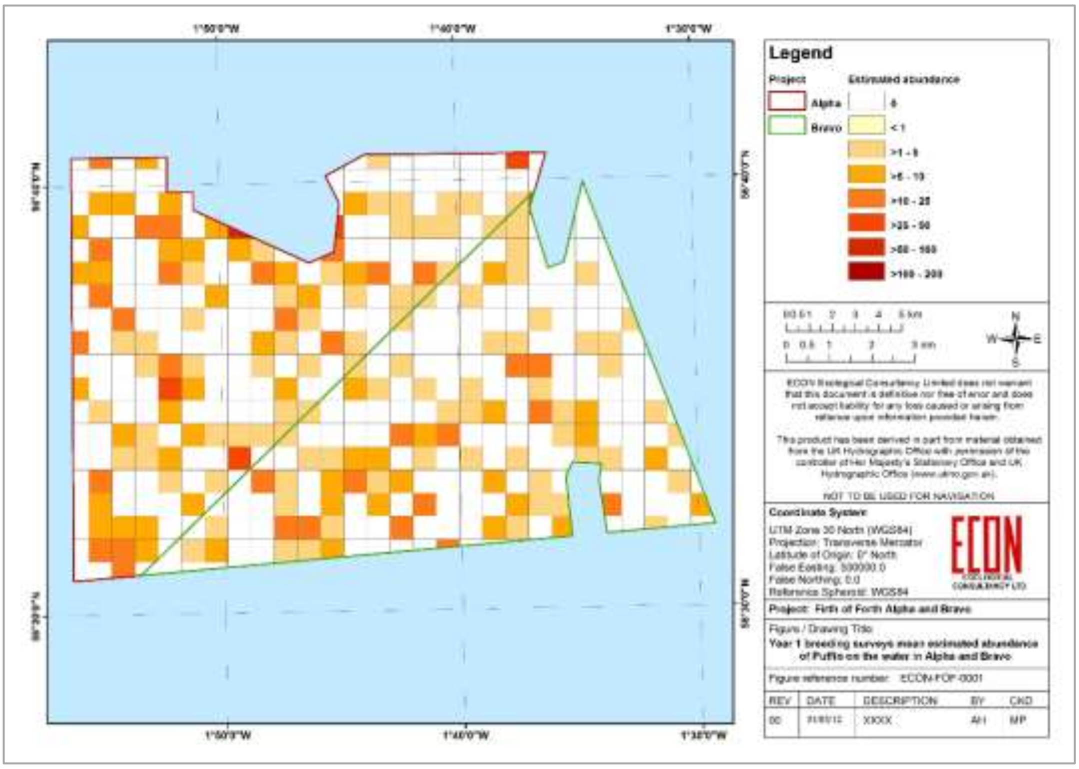
Table 37. **Monthly mean density (ind. km^{-2}) of Atlantic Puffins in Alpha, Bravo and Alpha and Bravo combined, with and without a 2km buffer. The number of surveys completed in each month is also shown. Densities in all cases were derived from a combination of distance corrected line transect data for birds on the water and snapshot data for flying birds.**

Project		**Month**											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
		2	**1**	**2**	**2**	**4**	**3**	**3**	**3**	**2**	**2**	**2**	**2**
Alpha	Mean	0.21	0.75	1.40	1.21	0.44	7.64	2.86	7.42	7.10	3.80	4.42	0.37
	SD	0.29	-	0.93	0.60	0.14	6.84	0.54	3.21	0.52	3.29	5.07	0.16
Alpha + 2km	Mean	0.21	0.75	1.41	1.22	0.43	7.67	2.87	7.60	7.13	3.82	4.43	0.37
	SD	0.29	-	0.94	0.60	0.11	6.88	0.55	3.24	0.52	3.30	5.09	0.16
Bravo	Mean	0.52	0.42	0.81	2.34	0.57	10.70	3.07	6.46	17.67	4.55	5.15	0.27
	SD	0.73	-	0.69	1.76	0.19	15.10	0.68	2.77	14.27	4.51	6.36	0.07
Bravo + 2km	Mean	0.55	0.44	0.87	2.49	0.66	11.30	3.17	7.20	18.87	4.86	5.49	0.29
	SD	0.78	-	0.74	1.88	0.25	16.24	0.72	3.24	15.23	4.81	6.79	0.08
Alpha + Bravo	Mean	0.36	0.59	1.11	1.77	0.51	9.15	2.95	6.94	12.34	4.17	4.78	0.32
	SD	0.51	-	0.81	1.18	0.15	10.61	0.21	2.91	7.33	3.89	5.71	0.12
Alpha + Bravo + 2km	Mean	0.37	0.60	1.14	1.81	0.55	9.32	3.00	7.15	12.63	4.27	4.89	0.33
	SD	0.52	-	0.83	1.20	0.19	10.91	0.19	3.00	7.50	3.98	5.85	0.12

Spatial distribution

5.7.13 Atlantic Puffin was similarly distributed within Project Alpha during the 2010 and 2011 breeding seasons at low density (1-5 individuals km^{-2}) with occasional patches of higher density (>10 individuals km^{-2}) especially in the western part of the site in closer proximity to Scalp Bank (Figure 63). In contrast, in Bravo, there was a considerable difference in the pattern between breeding seasons, driven by the abundance of birds in June 2011 when some patches of very high density (>100 individuals km^{-2}) were recorded in the central part of the site to the mid-point on the southern boundary (Figure 63). Conversely, in 2010, birds were at very low density or even absent from many grid cells in Bravo.

5.7.14 Outside the breeding season, there appeared to be lower density at the northwest corner of Alpha with the highest patches of density corresponding to feeding groups of 25-50 birds in the southwest corner parallel to the boundary with Project Bravo (Figure 64). In Bravo, density distribution was broadly similar between the breeding season and the passage/winter period with patches of > 25 individuals km^{-2} interspersed by lower values, with no clear preference for specific areas (Figure 64).



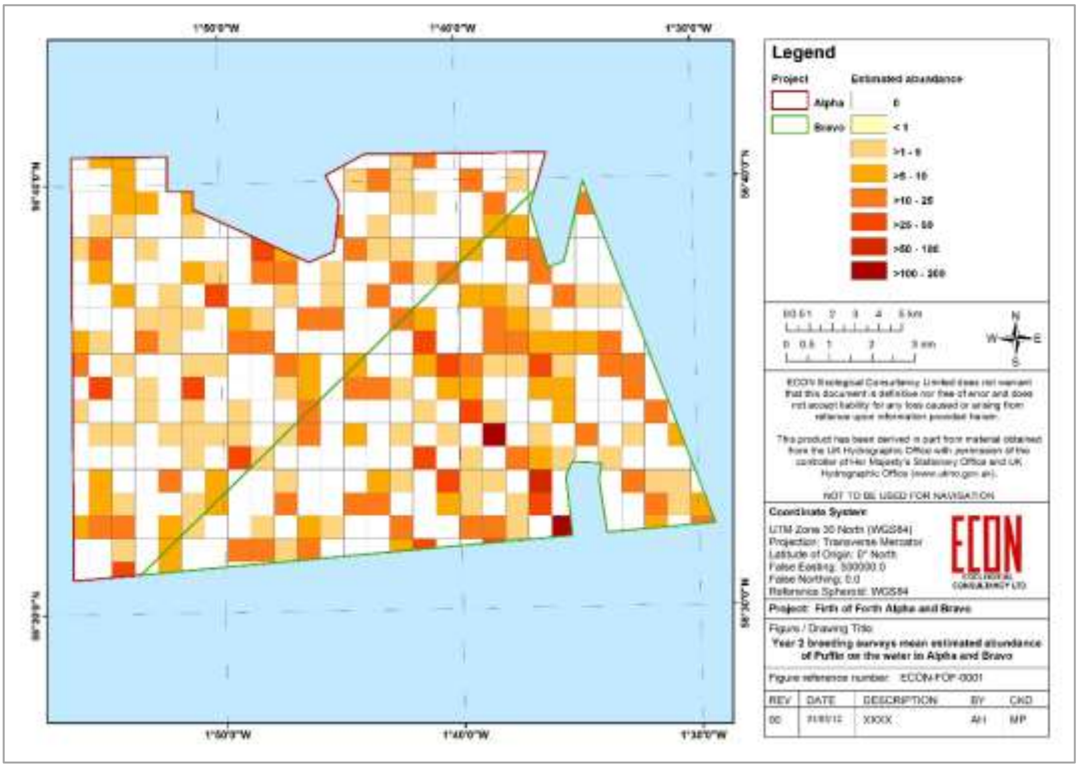
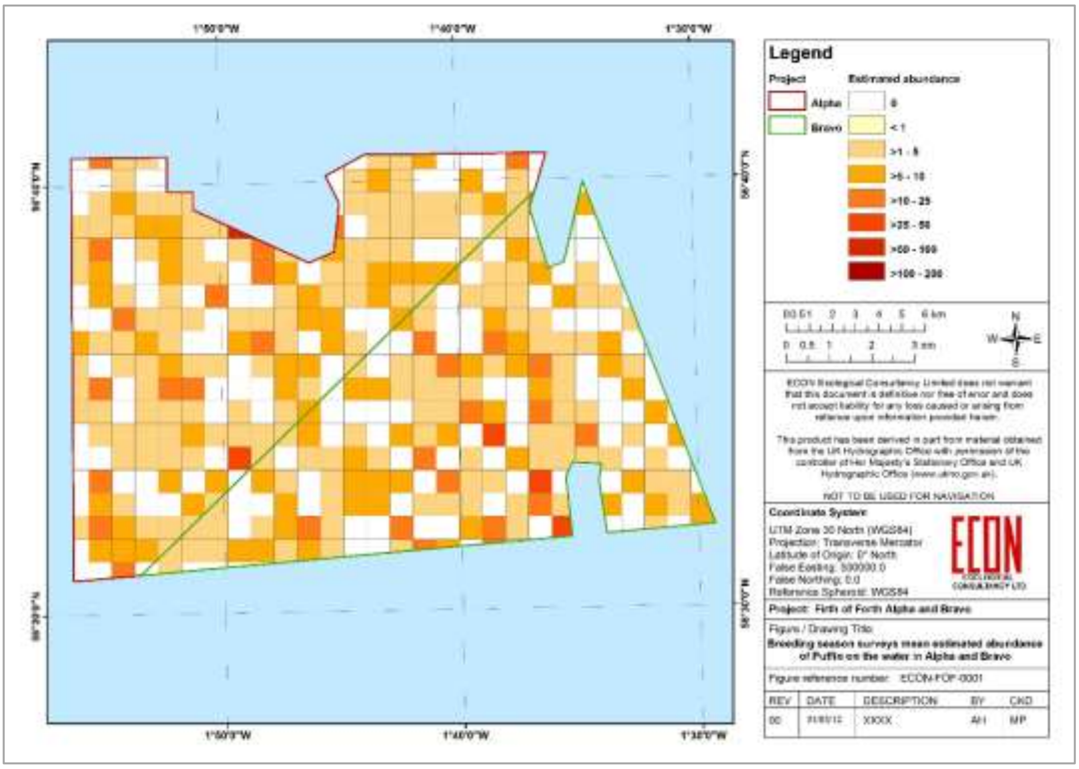


Figure 63. **Relative abundance of Atlantic Puffin expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August in 2010 (above) compared to 2011 (below).**



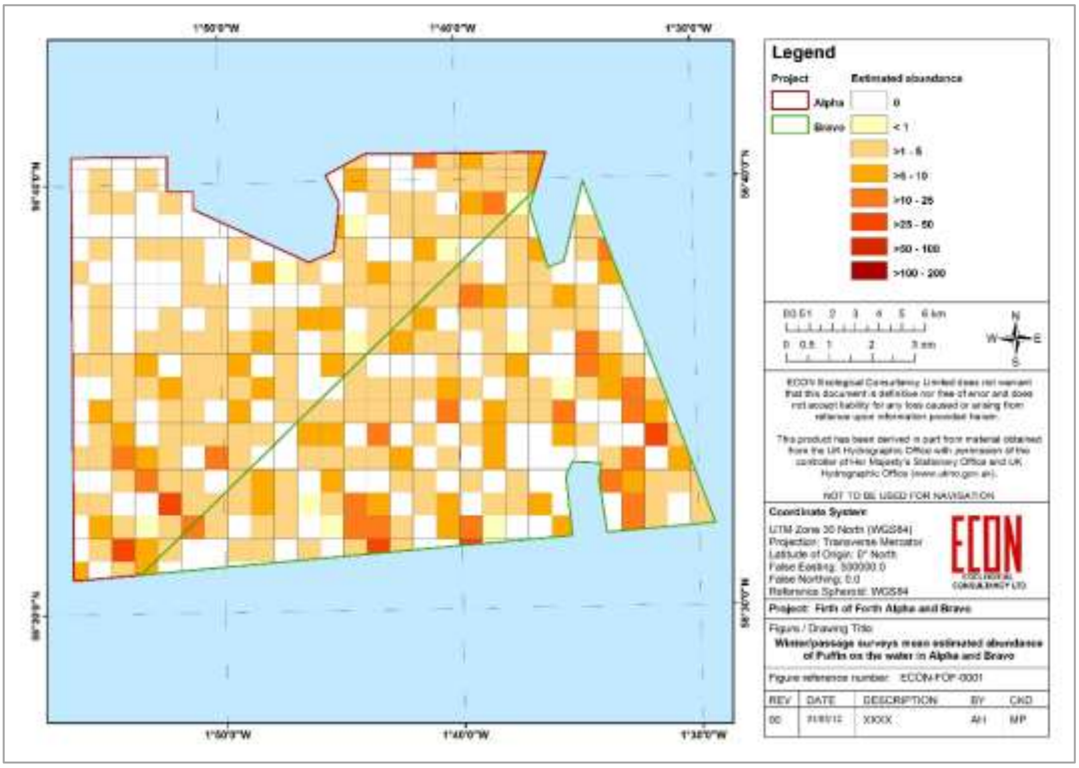


Figure 64. **Relative abundance of Atlantic Puffin expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^{2} grid cells across Alpha and Bravo in the breeding season of April to August (above) compared to the passage/winter period (below) in 2009-2011.**

5.7.15 Throughout the breeding season in 2017 the distribution of Atlantic Puffin observations changed considerably over the course of the surveys leading to almost full site coverage (Figure 65a). In May, observations were largely limited to the most inshore parts of the study area to the west over Scalp Bank. However, as numbers increased through July and August the distribution shifted further offshore. By August, the areas most populated by Atlantic Puffin were toward the very eastern edge of Bravo and possibly associated with the edge of Montrose Bank, in the 2 km buffer (see Seagreen 2017b). This general offshore movement likely reflects the dispersal of fledged juveniles and post-breeding adults.

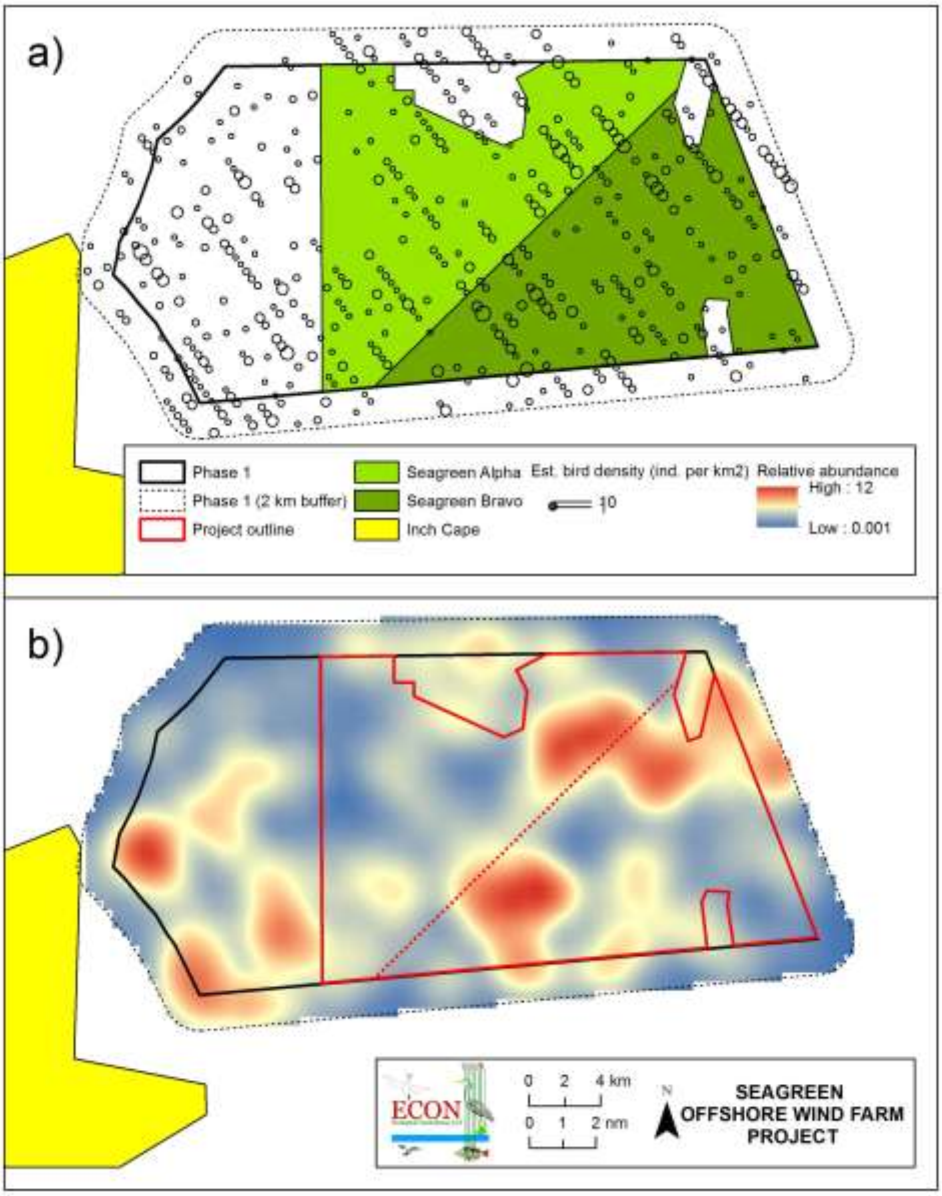


Figure 65. **Density distribution of Atlantic Puffin in 2017 as shown by: a) mean densities of birds on the water in 2017 (corrected values) in each survey cell on each of the three survey routes (route two was only surveyed once), and b) the relative abundance surfaces derived using KDE applied to these data.**

5.7.16 The KDE surface resulting from the cell-averaged densities of birds on the water (Figure 65b) shows a number of hotspots across the whole study area. This is thought to reflect the changing distribution of birds as they move offshore, rather than any one particular area that consistently harboured greater numbers of birds. The overall spatial distribution pattern from all years impression points to the general importance of the Scalp Bank area outwith the area of development, as well as the seemingly greater importance of Bravo relative to Alpha in the breeding season of 2017 at least. This could simply reflect the greater proximity of Bravo compared to Alpha for the numerically dominant Isle of May colony (see 5.7.5 above, Table 36).

Population structure

5.7.17 The proportion of Atlantic Puffins aged in 2009-2011 was low at 8.8% for Alpha and Bravo combined. In 2017, the proportion of Puffins aged was substantially higher at 36.1%; much higher than for the other auk species although this is to be expected as only breeding season data is considered. Part of the reason for this is that sub-adult and adult Atlantic Puffins were more confidently differentiated than Razorbill and Common Guillemot throughout the breeding season, due to more obvious differences in bill colour and size. Unlike the other auk species (see 5.5.15 for Common Guillemot and 5.6.11 for Razorbill), the proportion of single birds aged was higher (11.4% in 2009-2011) than when two birds were observed together (6.6% in 2009-2011), which fits with the fact that Atlantic Puffins do not associate with their fledged young.

5.7.18 The aged proportions of Atlantic Puffin in surveys of Alpha and Bravo show an inherent bias toward ageing of juvenile birds, with this being especially apparent in the early winter, when in some instances only juvenile birds were aged (Table 38). This is partly because sub-adult and breeding Atlantic Puffins can be difficult to separate in the field, particularly under at-sea survey conditions.

5.7.19 The timing and abundance of juvenile Atlantic Puffins does follow distinct trends however. For example, whereas juveniles begin to be reported in July, they are a much more prominent feature of the population in August. Higher proportions of juveniles were also noted in Bravo than Alpha throughout the surveys (Table 38), consistent with the offshore movement of juveniles (see 5.7.16 above).

Flight behaviour

5.7.20 In general, there is a paucity of records relating to flying Atlantic Puffins, especially in 2017 (see Figure 62 above). Nevertheless, at least during the 2010 and 2011 breeding seasons, the flight directions of any flying birds in Alpha and Bravo appears to confirm a link with the Isle of May in the Forth Islands SPA, with a distinct southwest flight path accounting for 30.0% of flights in Alpha and 40.6% in Bravo of birds potentially returning to the colony. A less well-represented reciprocal northeast flight path from the colony is also apparent (Table 39). The disparity between the two directions, especially in Bravo (41% compared to 15% for southwest and northeast respectively) suggests Bravo lie towards the outer limit of the range of birds from the colony, or as suggested for the other auks (see 5.5.20 above for Common Guillemot and 5.6.17 above for Razorbill), Atlantic Puffins may swim into the site from other areas nearby.

Table 38. **Number and proportion of adult Atlantic Puffins relative to the total number of birds aged in each month during boat-based surveys of Alpha and Bravo.**

Year	Site	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009-2011	Alpha	Adults	0	0	1	2	5	18	12	44	0	3	0	1
		%	-	-	100	100	55.6	72.0	92.3	69.8	0.0	50.0	0.0	100
		Juv	0	0	0	0	0	0	1	19	2	3	1	0
		%	-	-	0.0	0.0	0.0	0.0	7.7	30.2	100	50.0	100	0.0
		Total	0	0	1	2	9	25	13	63	2	6	1	1
	Bravo	Adults	0	0	0	0	3	10	13	46	1	11	0	1
		%	-	-	-	-	100	71.4	86.7	57.5	16.7	78.6	-	50.0
		Juv	0	0	0	0	0	0	2	34	3	3	0	1
		%	-	-	-	-	0.0	0.0	13.3	42.5	50.0	21.4	-	50.0
		Total	0	0	0	0	3	14	15	80	6	14	0	2
	Alpha + Bravo	Adults	0	0	1	2	8	28	25	90	1	14	0	2
		%	-	-	100	100	66.7	71.8	89.3	62.9	12.5	70.0	0.0	66.7
		Juv	0	0	0	0	0	0	3	53	5	6	1	1
		%	-	-	0.0	0.0	0.0	0.0	10.7	37.1	62.5	30.0	100	33.3
		Total	0	0	1	2	12	39	28	143	8	20	1	3
2017	Alpha	Adults					0	0	4	60				
		%					0.0	0.0	25.0	68.2				
		Juv					0	0	9	27				
		%					0.0	0.0	56.3	30.7				
		Total					2	1	16	88				
	Bravo	Adults					0	2	3	72				
		%					0.0	66.7	60.0	78.3				
		Juv					0	0	0	17				
		%					0.0	0.0	0.0	18.5				
		Total					1	3	5	92				
	Alpha + Bravo	Adults					0	2	7	132				
		%					0.0	50.0	33.3	73.3				
		Juv					0	0	9	44				
		%					0.0	0.0	42.9	24.4				
		Total					3	4	21	180				

5.7.21 In 2017, the southwesterly flightpath was also represented in Bravo, though it was not observed in Alpha. The overall dominant northerly flight direction of Atlantic Puffins (Table 39) does not equate to the location of any breeding colonies (see Figure 61 above) and may relate to adult birds dispersing from the area having abandoned their young at the end of the breeding season.

Table 39. **Number and proportion (%) of flight directions recorded for Atlantic Puffin during boat-based surveys of Alpha and Bravo. No fixed direction is represented by 'None'.**

Parameters			**Compass direction**								
			N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**None**
2009-2011 Breeding	Alpha	Count	9	33	5	17	16	45	9	12	4
		%	6.0	22.0	3.3	11.3	10.7	30.0	6.0	8.0	2.7
	Bravo	Count	10	21	5	13	4	56	18	8	3
		%	7.2	15.2	3.6	9.4	2.9	40.6	13.0	5.8	2.2
	Alpha + Bravo	Count	19	54	10	30	20	101	27	20	7
		%	6.6	18.8	3.5	10.4	6.9	35.1	9.4	6.9	2.4
2009-2011 Non-breeding	Alpha	Count	4	1	0	1	4	6	3	7	0
		%	15.4	3.8	0.0	3.8	15.4	23.1	11.5	26.9	0.0
	Bravo	Count	0	2	1	0	2	4	1	8	0
		%	0.0	11.1	5.6	0.0	11.1	22.2	5.6	44.4	0.0
	Alpha + Bravo	Count	4	3	1	1	6	10	4	15	0
		%	9.1	6.8	2.3	2.3	13.6	22.7	9.1	34.1	0.0
2017 Breeding	Alpha	Count	13	5	2	1	3	3	0	0	0
		%	48.1	18.5	7.4	3.7	11.1	11.1	0.0	0.0	0.0
	Bravo	Count	3	3	3	1	1	6	0	0	3
		%	15.0	15.0	15.0	5.0	5.0	30.0	0.0	0.0	15.0
	Alpha + Bravo	Count	16	9	5	2	4	9	1	0	3
		%	32.7	18.4	10.2	4.1	8.2	18.4	2.0	0.0	6.1

5.7.22 Atlantic Puffins tend to fly very close to the sea surface, even compared to the other auks. In 2009-2011, 0.5% and 0% of flights were at >20 m in Alpha and Bravo respectively. In 2017 no birds were recorded at flight heights of >10 m with 98% of records placing Atlantic Puffins at heights of >0-5 m (Figure 66).

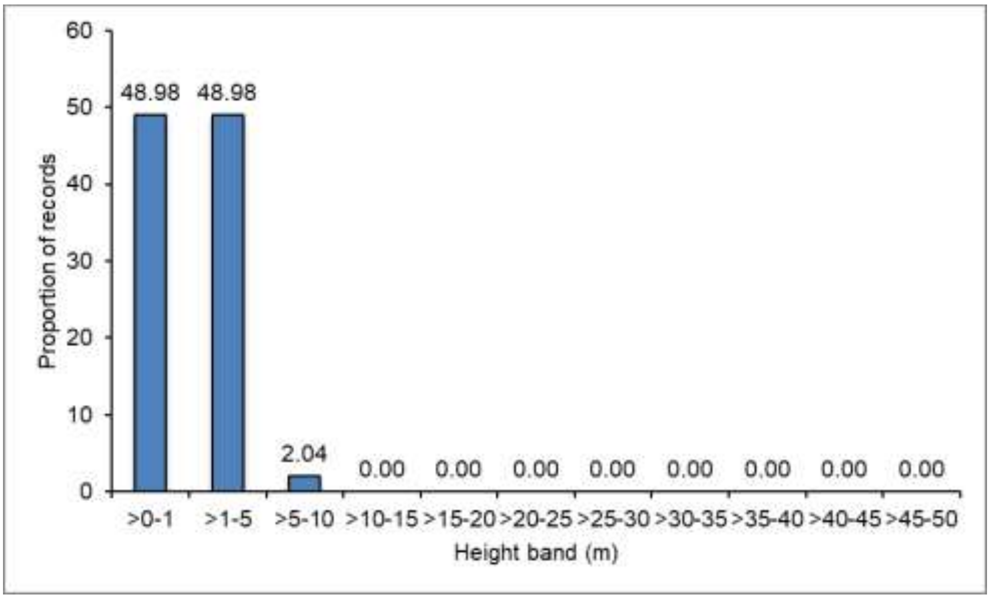


Figure 66. **Proportion (%) of flight heights recorded for Puffin (*n*= 49) during boat-based surveys of Alpha and Bravo in all 2017 surveys.**

5.7.23 Very few rangefinder records were obtained for Atlantic Puffin in 2017, as a result of their diminutive size, rapid flight action and the scarcity of birds in flight. Five records were obtained with a maximum corrected flight height of 3.3 m. Observer accuracy was considered to be excellent as also noted for the other auks (see 5.5.24 for Common Guillemot and 5.6.19 for Razorbill above).

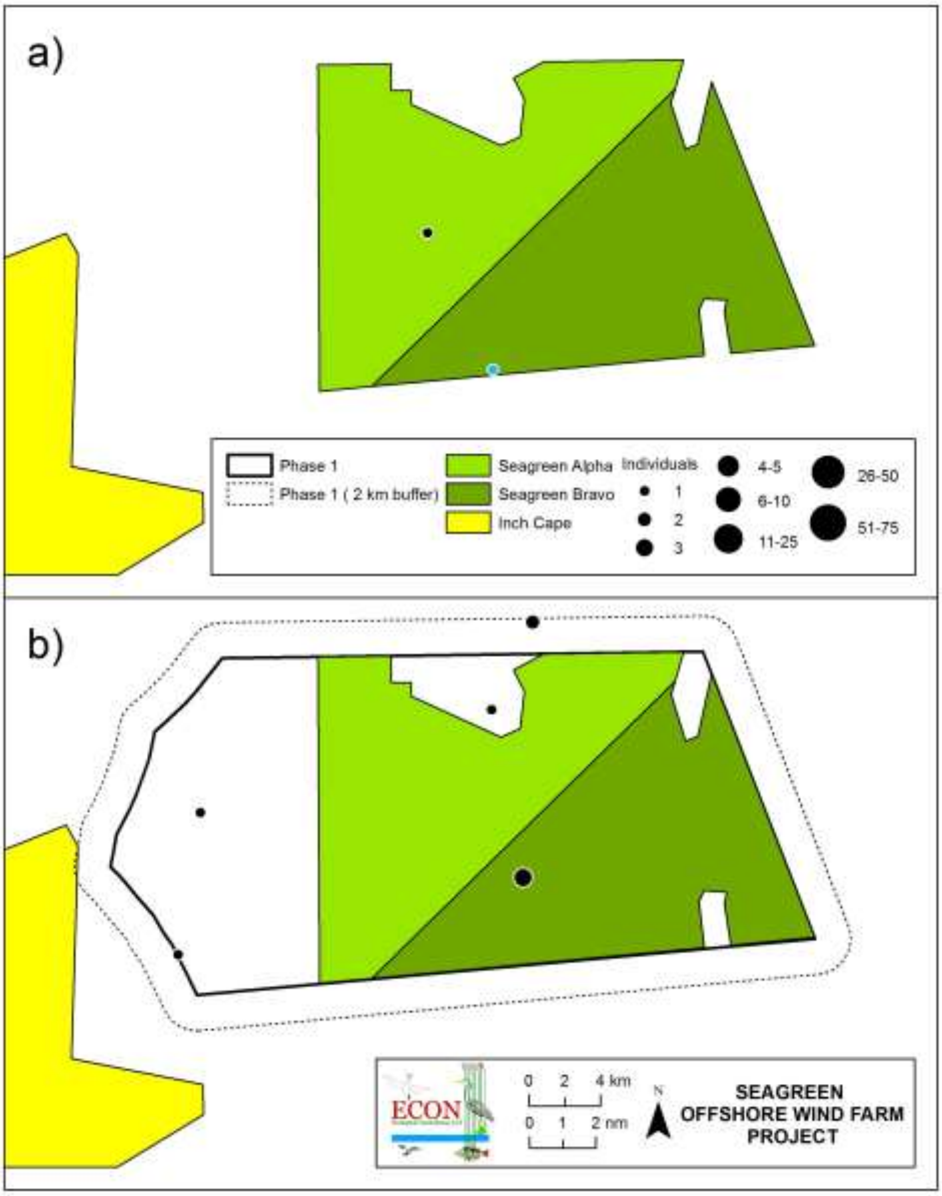


Figure 67. **Distribution and group size of foraging and feeding Atlantic Puffins recorded in the breeding season in: a) 2010 and 2011 for Alpha and Bravo only and b) in Alpha and Bravo and surrounds in 2017.**

Foraging & feeding

5.7.24 The main prey species of Atlantic Puffin in the UK is thought to be the Lesser Sandeel *Ammodytes marinus*, although small clupeids are also consumed. Birds dive from the surface and pursue prey underwater and may make multiple captures normally at depths of <15 metres (Lloyd *et al.* 1991). In the past 20 years the temperature of the North Sea has increased by 2°C, to the detriment of cold-water plankton, the key prey of sandeels, and encouraged warm-water fish such as Snake Pipefish *Entelurus aequoreus*, which are of poor nutritional value and difficult for chicks to swallow (Grémillet & Boulinier 2009). Shortage of preferred prey is thought to be a key factor in the decline in Atlantic Puffin populations.

5.7.25 Very little feeding or foraging behaviour was observed within Alpha or Bravo in any year, with a single bird noted as foraging in Alpha during 2009-2011 with a further bird observed carrying prey (Figure 68a). In 2017, a total of eight birds were recorded within five MSFAs, with three of these birds and one of the MSFAs observed within Bravo (Figure 68b). Of the rest, all fell to the north or west of Alpha, with no records within Alpha itself. Moreover, all but one of these records pertains to the August survey, with the only exception being a single bird in a MSFA in July. No birds were recorded carrying prey in 2017 (Figure 68b).

6. CONCLUDING SUMMARY

6.1.1 In total, 59,342 birds were observed in 28 boat-based surveys of Alpha and Bravo, 23 of which were undertaken between December 2009 and November 2011 inclusive with a further 5 carried out in May to August inclusive in 2017.

6.1.2 The ornithological assemblage comprised fifty-three species and twelve unidentified taxa and was dominated by the focal breeding seabird species. Common Guillemot (32%), Black-legged Kittiwake (23%), Northern Gannet (16%), Razorbill (9%) and Atlantic Puffin (3%) comprised 87% of all birds recorded. Unidentified auks (5%), Northern Fulmar (3%) and Arctic Tern (2%) were the next most numerous taxa meaning 97% of the ornithological assemblage was accounted for by seven species and one unidentified taxon (auks). European Herring Gull was poorly represented, accounting for <1% of all birds recorded.

6.1.3 The additional breeding surveys in 2017 surveyed a wider area including 2 km buffer areas around the entirety of Phase 1, that including a large area to the west of Alpha encapsulating Scalp Bank that was excluded from development in the 2014 consented proposals. These surveys clearly showed the importance of the Scalp Bank area for foraging birds of a number of species. Other ‘hotspots’ included an area to the north of Alpha in an area of deeper water and an area to the northeast of Alpha, on the edge of Montrose Bank. It is of note that all of these areas fall outwith the proposed Alpha and Bravo developments and neither Alpha nor Bravo appear to contain particularly important foraging grounds for any of the six key sensitive receptors.

6.1.4 Northern Gannet was present on all surveys, with a peak density of 10.11 individuals km^{-2} in June coinciding with the late incubation, hatching and early chick provisioning stage of the breeding cycle. Densities were in line with those previously recorded in Alpha and Bravo and studies of the wider area.

6.1.5 The majority of Northern Gannets encountered were adult birds in flight, and a general lack of foraging behaviour indicates that most birds were transiting through the sites. The majority of transiting birds recorded during the breeding season were on a southwesterly flight path strongly indicative of birds commuting to the Bass Rock colony some 65 km away. The reciprocal northeasterly flight path was less frequently observed suggesting a less direct route is taken to important foraging areas in the northeast, notably Fladen Grund.

6.1.6 Northern Gannet is considered to be vulnerable to collision as a result of the proportion of flights at risk height, relatively low flight manoeuvrability and the amount of time spent in flight. Flight heights were generally low however with the majority of birds flying close to the sea surface. Flight heights were higher in Bravo with 16% at >20 m in 2009-2011 (c.f. 9% in Alpha) and 7% in 2017 (c.f. 2% in Alpha). Distribution across Alpha and Bravo was patchy although on balance birds were more frequently encountered in the western part of the study area.

6.1.7 Black-legged Kittiwake was recorded on all surveys, but density was highly variable, ranging from 0.6 ind km^{-2} in Bravo during December to a peak of 22.7 individuals km^{-2} in July within Alpha. The peak density was greatly influenced by an exceptionally large gathering of birds and marine mammals across the area in 2017. Black-legged Kittiwake displayed a preference for the area to the west of Alpha and this was clearly driven by foraging opportunities in the vicinity of Scalp Bank. Distribution within Alpha and Bravo varied probably in response to prey resources.

6.1.8 The northwest-southeast flight path was the most important, accounting for 30% of records in both survey periods, indicating birds commuting to the Fowlsheugh colony. A southwesterly flight path that was more prominent in Alpha also suggested birds from the Forth Islands were utilising the area. The highest proportion of flying birds at all times across Alpha and Bravo were assigned with no fixed direction which is indicative of foraging behaviour.

6.1.9 Black-legged Kittiwake is considered to be potentially vulnerable to collision. Flight heights up to 50 m were recorded, although most birds were recorded flying at heights of <25 m and thus potentially under the rotor swept area of the current generation of large turbines. In Alpha, 11% of birds were noted at heights >20 m in 2009-2011 while in Bravo the proportion was higher at 16%. Similar proportions were noted in 2017 across Alpha and Bravo when 11% of flying birds were at >20m and the >5-10 m height band was the most frequently utilised (37% of records).

6.1.10 European Herring Gull was only recorded in small numbers and was completely absent in some months. Densities were consistently low with a peak density of only 0.44 individuals km^{-2} in June. The scarcity of records meant a reliable scaling factor could not be calculated for the 2 km buffer area. As so few adult birds were noted in the breeding seasons it is suggested that birds from nearby breeding colonies, particularly Fowlsheugh, are unlikely to routinely utilise Alpha or Bravo. This is consistent with inshore foraging behaviour especially in the breeding season.

6.1.11 Common Guillemot was present throughout the survey period, often as the most numerous seabird. The peak density of 32.1 individuals km^{-2} in Alpha was recorded in July, while the peak in Bravo of 30.2 individuals km^{-2} occurred in June. The timing of peak densities coincides with the later period of chick provisioning and initial fledging and dispersal. The inclusion of a 2 km buffer around Alpha increased the peak density to 40.2 ind. km^{-2} and changed the timing to June.

6.1.12 Flight direction records of Common Guillemot were predominantly on a northwest transit, and prey delivery in that direction further confirmed connectivity with the Fowlsheugh colony. Some birds were also recorded flying southwest towards the Forth Islands. Common Guillemot utilises the entire Alpha and Bravo area with distribution presumably driven primarily by the location of suitable foraging locations and prey abundance. It is the potential displacement of these birds from preferred areas that requires assessment.

6.1.13 Razorbill was present in all surveys, achieving peak density in Alpha and Bravo in July at 14.4 individuals km^{-2} and 12.3 individuals km^{-2} respectively, having fledged chicks and vacated the breeding colonies. The peak densities recorded in 2017 greatly exceeded those described in Alpha and Bravo during 2009-2011 and, as for Black-legged Kittiwake, were driven by an exceptional foraging event. The peak population at this time comprised 11,933 individuals, which is very close to the combined total population of breeding individuals present at Fowlsheugh and Forth Islands SPA. It seems most unlikely that the bulk of the local population would concentrate in the area in preference to other key foraging grounds such as Wee Bankie and dispersing birds from further afield such as colonies in the Moray Firth may have been involved.

6.1.14 A few birds transporting fish to colonies were encountered in 2017 only. As for Common Guillemot, the majority of prey transport was in a northwesterly direction in the direction of Fowlsheugh, although the southwesterly flight path was also represented supporting a link to the Forth Islands colonies. Flight directions of all birds support this view, with the northwesterly transit dominating throughout. As for Common Guillemot It is the potential displacement of Razorbills from foraging areas that requires assessment.

6.1.15 Atlantic Puffin was generally the least numerous auk. Peak mean density was recorded in Bravo during September at 17.7 individuals km^{-2} with a lower peak in Alpha of June at 7.6 individuals km^{-2}. More offshore areas including Bravo supported higher densities in August and September and can be attributed to dispersing juveniles and post-breeding adults.

6.1.16 Within the breeding season, there was evidence of connectivity to breeding colonies, with high proportions of flying birds on northeasterly or southwesterly flightlines indicative of a link to the Forth Islands SPA, the dominant colony in the area. Overall though, there no evidence that the Alpha and Bravo area is an important foraging ground for breeding birds with very few foraging records and just a single bird noted transporting prey.

6.1.17 In general, potential impacts of the development of Alpha and Bravo on breeding birds will have to be carefully evaluated, particularly in a cumulative context. The evidence is that either development within the Seagreen Phase 1 Project is more likely to affect breeding Black-legged Kittiwake, Common Guillemot and Razorbill originating from Fowlsheugh SPA rather than any other SPAs including these species, in keeping with its relative proximity (around 27 km at its closest point) to Alpha and Bravo compared to other large colonies. For Northern Gannet and Atlantic Puffin virtually all (if not all) birds present will originate from the single dominant colony within foraging range including Bass Rock for Northern Gannet and the Isle of May for Atlantic Puffin that both fall within the Forth Islands SPA.

6.1.18 Equally, Neart na Gaoithe, given its location at just 16 km from the from the Isle of May should have the greatest impact on Black-legged Kittiwake, Common Guillemot, Razorbill and Atlantic Puffin originating from the Isle of May and seeking to access key foraging grounds on the Wee Bankie; as well as the Northern Gannets from Bass Rock as they commute to sites such as Fladen Grund in the northeast. Any collision risk for Black-legged Kittiwake, Northern Gannet and European Herring Gull may however be reduced by increasing the airgap between sea surface and the lowest sweep of the rotor blades.

6.1.19 Inch Cape has the potential to affect a combination of species from both Fowlsheugh and Forth Islands seeking to forage in inshore waters and seems likely to be *en-route* for Atlantic Puffin and Black-legged Kittiwakes from the Forth Islands SPA heading for Scalp Bank. As at Neart na Gaoithe, collision risk for Black-legged Kittiwake and Northern Gannet in particular may be reduced by increasing the airgap between sea surface and the lowest sweep of the rotor blades.

6.1.20 Unlike the STW developments the Phase 1 project area, even when divided into sites Alpha and Bravo, has the benefit of a relatively large area providing considerable scope for individual turbine placement and layout, which is of clear benefit in any mitigation strategy that may be required in order to reduce predicted impacts on any species.

7. REFERENCES

Band, B. (2012*). Using a collision risk model to assess bird collision risk for offshore windfarms. Strategic Ornithological Support Services (SOSS), Project SOSS-02*. British Trust for Ornithology, Thetford, UK: 37pp.

Barbraud, C. & Thiebot, J-B. (2009). On the importance of estimating detection probabilities from at-sea surveys of flying seabirds. *Journal of Avian Biology* 40: 1-7.

Benvenuti, S., Dall'Antonia, L. & Lyngs, P. (2001) Foraging behaviour and time allocation of chick-rearing Razorbills *Alca torda* at Græsholmen, central Baltic Sea. *Ibis* 143: 402-412.

BirdLife International (2015). *European Red List of Birds*. Office for Official Publications of the European Communities, Luxembourg.

BirdLife International (2017) *IUCN Red List for birds*. Retrieved on 13 October 2017 from http://www.birdlife.org

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. & Thomas, L. (2001). *Introduction to Distance Sampling: estimating abundance of biological populations*. Oxford University Press, Oxford, UK: 432pp.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. & Thomas, L. (2004). *Advanced Distance Sampling: estimating abundance of biological populations*. Oxford University Press, Oxford, UK: 416pp.

BWPi (2004). *Birds of the Western Paleactic Version 1.0*. Birdguides Ltd. and Oxford University Press, Oxford, UK.

Camphuysen, C.J. (2005). Seabirds at sea in summer in the northwest North Sea. *British Birds* 98, 2-19.

Camphuysen, C.J. (2011). Northern Gannets in the North Sea: foraging distribution and feeding techniques around the Bass Rock. *British Birds* 104, 60-76.

Camphuysen, C.J., Fox, A.D. & Leopold, M.F. (2004). *Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K. A comparison of ship and aerial sampling for marine birds, and their applicability to offshore wind farm assessments*. Report commissioned by COWRIE. Available at http://www.offshorewindfarms.co.uk

Cleasby, I.R., Wakefield, E.D., Bearhop, S., Bodey, T.W., Votier, S.C. & Hamer, K.C. (2015). Three-dimensional tracking of a wide-ranging marine predator: flight heights and vulnerability to offshore wind farms. *Journal of Applied Ecology* 52 1474-1482.

Cook ASCP, Johnston A, Wright L.J. & Burton N.H.K. (2011). *Stategic Ornithological Support Services Project SOSS-02: A review of flight heights and avoidance rates of birds in relation to offshore wind farms*. Draft BTO Research Report.

Coulson, J.C. (2011). *The Kittiwake*. T & AD Poyser, London: 304pp.

Cramp S, Bourne WRP & Saunders D (1974). *The Seabirds of Britain and Ireland*. Collins, London UK.

Daunt, F., Bogdanova, M., Newell, M., Harris, M. & Wanless, S. (2011a). GPS tracking of common guillemot, razorbill and black-legged kittiwake on the Isle of May, summer 2010. Report to FTOWDG, Centre for Ecology and Hydrology, Edinburgh, UK: 65pp.

Daunt, F., Bogdanova, M., Redman, P., Russell, S. & Wanless, S. (2011b). *GPS tracking of black-legged kittiwake and observations of trip durations and flight directions of common* *guillemot at Fowlsheugh and St Abb's Head, summer 2011*. Report to FTOWDG, Centre for Ecology and Hydrology, Edinburgh, UK: 70pp.

Daunt, F., Bogdanova, M., Newell, M., Harris, M. & Wanless, S. (2011c). *Literature review of foraging distribution, foraging range and feeding behaviour of common guillemot, razorbill, Atlantic puffin, black-legged kittiwake and northern fulmar in the Forth/Tay region*. Report to FTOWDG, Centre for Ecology and Hydrology, Edinburgh, UK: 51pp.

del Hoyo, J., Elliot, A., Sargatal, J. (1992). *Handbook of the Birds of the World, vol. 1: Ostrich to Ducks*. Lynx Edicions, Barcelona, Spain.

del Hoyo, J., Elliott, A., and Sargatal, J. (1996). *Handbook of the Birds of the World, vol. 3: Hoatzin to Auks.* Lynx Edicions, Barcelona, Spain.

Eaton M.A., Aebischer N.J., Brown A.F., Hearn R.D., Lock L., Musgrove A.J., Noble D.G., Stroud D.A. and Gregory R.D. (2015). Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and Isle of Man. *British Birds* 108, 708–746.

Embling, C.B., Illian, J., Armstrong, E., van der Kooij, J., Sharples, J., Camphuysen, C.J. & Scott, B.E. (2012). Investigating fine-scale spatio-temporal predator-prey patterns in dynamic marine ecosystems: a functional data analysis approach. *Journal of Applied Ecology* 49: 481-492

Ford, R.G., Ainley, D.G., Casey, J.L., Keiper, C.A., Spear, L.B. & Ballance, L.T. (2004). The biogeographic patterns of seabirds in the central portion of the California Current. *Marine Ornithology* 32: 77-96.

Forrester, R.W., Andrews, I.J., McInerny, C.J., Murray, R.D., McGowan, R.Y., Zonfrillo, B., Betts, M.W., Jardine, D.C. & Grundy, D.S. (eds) (2007). *The Birds of Scotland*. The Scottish Ornithologists' Club, Aberlady: 1634pp.

Frederiksen, M., Wanless, S., Harris, M.P., Rothery, P. & Wilson, L.J. (2004). The role of industrial fishery and oceanographic change in the decline of North Sea black-legged kittiwakes. *Journal of Applied Ecology* 41: 1129-1139.

Frederiksen, M., Moe, B., Daunt, F., Phillips, R.A., Barrett, R.T., Bogdanova, M.I., Boulinier, T., Chardine, J.W., Chastel, O., Chivers, L.S., Christensen-Dalsgaard, S., Clément-Chastel, C., Colhoun, K., Freeman, R., Gaston, A.J., González-Solís, J., Goutte, A., Grémillet, D., Guilford, T., Jensen, G.H., Krasnov, Y., Lorentsen, S.-H., Mallory, M.L., Newell, M., Olsen, B., Shaw, D., Steen, H., Strøm, H., Systad, G.H., Thórarinsson, T.L. and Anker-Nilssen, T. (2011). Multicolony tracking reveals the winter distribution of a pelagic seabird on an ocean basin scale. *Diversity and Distributions* 18: 530-542

Furness, R.W., Ensor, K. & Hudson, A.V. (1992). The use of fishery waste by gull populations around the British Isles. *Ardea* 80: 105-113.

Gibb, R, Shoji, A, Fayet, A.L., Perrins, C.M. & Guilford, T & Freeman, R. (2017). Remotely-sensed wind speed predicts soaring behaviour in a wide-ranging pelagic seabird. *Journal of the Royal Society Interface* 14 (132), 20170262 doi: 10.1098/rsif.2017.0262.

Grémillet, D. & Boulinier, T. (2009). Spatial ecology and conservation of seabirds facing global climate change: a review. *Marine Ecology Progress Series* 391: 121–137.

Hamer, K.C., Phillips, R.A., Wanless, S., Harris, M.P. & Wood, A.G. (2000). Foraging ranges, diets and feeding locations of Gannets *Morus bassanus* in the North Sea: evidence from satellite telemetry. *Marine Ecology Progress Series* 200: 257-264.

Hamer, K.C., Humphreys, E.M., Garthe, S., Hennicke, J., Peters, G., Grémillet, D., Phillips, R.A., Harris, M.P. & Wanless, S. (2007). Annual variation in diets, feeding locations and foraging behaviour of gannets in the North Sea: flexibility, consistency and constraint. *Marine Ecology Progress Series* 338: 295-305.

Hamer, K., Holt, N. & Wakefield, E. (2011). *The distribution and behaviour of northern gannets in the Firth of Forth and Tay area*. A review on behalf of Forth and Tay Offshore Wind Developers Group. Institute of Integrative & Comparative Biology, University of Leeds: 14pp.

Harris, M.P., Bogdanova, M.I., Daunt, F. & Wanless, S. (2012). Using GPS technology to assess feeding areas of Atlantic Puffins *Fratercula arctica*. *Ringing & Migration* 27: 43-49.

Harris, M.P., Daunt, F., Newell, M., Phillips, R.A. & Wanless, S. (2010). Wintering areas of adult Atlantic puffins Fratercula arctica from a North Sea colony as revealed by geolocation technology. *Marine Biology* 157: 827–836.

Harwood, A.J.P., Perrow, M. R., Berridge, R.J. (submitted). Assessing the reliability of seabird flight heights from boat-based surveyors using an optical rangefinder: implications for collision risk at offshore wind farms

Inch Cape Offshore Limited (2017). *Inch Cape Wind Farm New Energy for Scotland Offshore Scoping Report.* UK02-0504-0673-MRP-NNG Scoping Report 2017-RPT-A1. Inch Cape Offshore Limited, Glasgow: 570pp.

Johnston, A., Cook, A.S.C.P, Wright, L.J., Humphreys, E.M. & Burton, N.H.K. (2014). Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. *Journal of Applied Ecology* 51: 3-10.

Joint Nature Conservation Committee (JNCC) (2016). *Seabird population trends and causes of Change: 1986-2015 report*. Joint Nature Conservation Committee. Updated September 2016. Retrieved 1 October 2017 from http://www.jncc.gov.uk/page-3201 on 01/10/17.

Kober, K., Webb, A., Win, I., Lewis, M., O'Brien, S., Wilson, L.J. & Reid, J.B. (2009). *An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs*. JNCC Report, No. 431, Joint Nature Conservation Committee, Peterborough, ISSN: 0963-8091.

Lewis, S., Sherratt, T.N., Hamer, K.C. & Wanless, S. (2001). Evidence of intra-specific competition for food in a pelagic seabird. *Nature* 412: 816-819.

Lloyd, C., Tasker, M.L. & Partridge, K. (1991). *The status of Seabirds in Britain and Ireland*. T & AD Poyser, London: 355pp.

Maclean, I.M.D., Wright, L.J., Showler, D.A. & Rehfisch, M.M. (2009*). A Review of Assessment Methodologies for Offshore Windfarms*. British Trust for Ornithology Report Commissioned by Cowrie Ltd. (COWRIE METH-08-08) ISBN: 978-0-9557501-6-8.

Madden, B. and Newton, S.F. (2004). Herring Gull *Larus argentatus*. In: Mitchell, P.I., Newton, S.F., Ratcliffe, N. & Dunn, T.E. (eds.) *Seabird Populations of Britain and Ireland (Results of the Seabird 2000 Census 1998-2000*: pp. 242-262. T&AD Poyser, London.

Mainstream Renewable Power (2017). *Neart na Gaoithe Offshore Wind Farm Scoping Report*. UK02-0504-0673-MRP-NNG Scoping Report 2017-RPT-A1. Neart na Gaoithe Offshore Wind Farm Limited, Glasgow: 290pp.

Mainstream Renewable Power (2017). *Neart na Gaoithe Offshore Wind Farm Environmental Impact Assessment Report.* UK02-0504-0741-MRP-OFFSHORE_EIAR-RPT-A2. Neart na Gaoithe Offshore Wind Farm Limited, Glasgow: 852pp

Marine Scotland (2014). *Marine Scotland's consideration of a proposal affecting designated Special Areas of Conservation ('SACs") or Special Protection Areas ('SPAs"): Neart na Gaoithe Offshore Windfarm Limited development ("NNGOWL"), Inch Cape Offshore Limited development ("ICOL"), Seagreen Alpha Wind Energy Limited development ("SAWEL") and Seagreen Bravo Wind Energy Limited development ("SBWEL")*. Marine Scotland Licensing Operations Team, Aberdeen: 86pp.

Marine Scotland (2017). *Scoping opinion for the proposed Section 36 consent and associated marine licence application for the revised Seagreen Phase 1 Offshore project*. Marine Scotland Licensing Operations Team, Aberdeen: 166pp.

Mitchell, P.I., Newton, S., Ratcliffe, N. & Dunn, T.E. (2004). *Seabird populations of Britain and Ireland (Results of the Seabird 2000 Census 1998-2000)*. T&D Poyser, London, UK: 511pp.

Murray, S. (2011). An aerial survey of the Bass Rock gannetry in 2009. *Scottish Birds* 31: 220-225.

Murray, S., Harris, M.P. & Wanless, S. (2014). The Bass Rock – now the world's largest Northern Gannet colony. *British Birds* 107 765-769.

Murray, S., Harris, M.P. & Wanless, S. (2015). The status of the gannet in Scotland in 2013-14. *Scottish Birds* 35: 3-18.

O'Brien, S.H., Webb, A., Brewer, M.J. & Reid J.B. (2012). Use of kernel density estimation and maximum curvature to set Marine Protected Area Boundaries: Identifying a Special Protection Area for wintering red-throated divers in the UK. *Biological Conservation* 156: 15-21.

Ouwehand, J., Leopold, M.F. & Camphuysen, C.J. (2004). A comparative study of the diet of Guillemots *Uria aalge* and Razorbills *Alca torda* killed during the Tricolor oil incident in the south-eastern North Sea in January 2003. *Atlantic Seabirds* 6: 147-166.

Parsons, M., Lawson, J., Lewis, M., Lawrence, R. & Kuepfer, A. (2015). *Quantifying foraging areas of little tern around its breeding colony SPA during chick-rearing*. JNCC Report No. 548, Peterborough. 32pp. ISSN 0963 8901.

Perrow, M.R., Harwood, A.J.P, Berridge, R.J. & Skeate, E.R. (2017). The foraging ecology of Sandwich Terns in north Norfolk. *British Birds* 110: 257-277.

R core team (2017). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Available at https://www.R-project.org/.

Ronconi, R.A. & Burger, A.E. (2009). Estimating seabird densities from vessel transects: distance sampling and implications for strip transects. *Aquatic Biology* 4: 297-309.

Seabird Monitoring Programme Online Database (2017). http://www.jncc.gov.uk/smp/ Retrieved 1 September 2017.

Seagreen Wind Energy (2011). *Zone appraisal and planning: Firth of Forth Zone, ZAP update December 2011*. Seagreen Document No. A4MR/SEAG-Z-DEV260-SRP-118, Glasgow: 68 pp.

Seagreen (2012a). *ES volume III (Appendices Part 2) F1- Ornithology Baseline Technical Report for Projects Alpha and Bravo & F2- Offshore Transmission Assets Project – Ornithological Technical Report & F3- Details of the risk matrix of displacement*. Seagreen Wind Energy Ltd A4MR-SEAG-Z-DOC100-SPR-060: 338pp

Seagreen (2012b). *ES volume I. Chapter 10- Ornithology*. Seagreen Wind Energy Ltd A4MR-SEAG-Z-DOC100-SPR-060: 137pp.

Seagreen (2013). *Seagreen Phase 1 Offshore Project Habitat Regulations Appraisal: Information to inform Appropriate Assessment – 2. Ornithology*. Seagreen Wind Energy Ltd: A4MR-SEAG-Z-SRP233 Part 2: 179pp.

Seagreen (2017a). *Seagreen Phase 1 Offshore Project Scoping Report Round 3: Firth of Forth*. Seagreen Wind Energy Ltd: A4MR/SEAG-AB-DEV230-SPR-311: 179pp.

Seagreen (2017b). *Ornithology 2017 technical report for the Phase 1 Project: Firth of Forth Offshore Wind Farm development*. Report to Seagreen Wind Energy Ltd by ECON Ecological Consultancy Ltd: 117pp.

Scott, B.E., Sharples, J., Ross, O.N., Wang, J., Pierce, G.J., Camphuysen, C.J. (2010). Sub-surface hotspots in shallow seas: fine scale limited locations of marine top predator foraging habitat indicated by tidal mixing and sub-surface chlorophyll. *Marine Ecology Progress Series* 408: 207-226.

Skov, H. Durinck, J. Leopold, M.F. & Tasker, M.L. (1995). *Important Bird Areas for seabirds in the North Sea*. BirdLife International, Cambridge, UK; 156pp.

Skov, H., Humphreys, E.M., Garthe, S., Geitner, K., Grémillet, D., Hamer, K.C., Hennicke, J., Parner, H. & Wanless, S. (2008). Application of habitat suitability modelling to tracking data of marine animals as a means of analysing their feeding habits. *Ecological Modelling* 212: 504-512.

Skov, H., Leonhard, S.B., Heinänen, S., Zydelis, R., Jensen, N.E., Durinck, J., Johansen, T.W., Jensen, B.P., Hansen, B.L., Piper, W. & Grøn, P.N. (2012). *Horns Rev 2 Monitoring 2010-2012. Migrating Birds*. Orbicon, DHI, Marine Observers and Biola. Report commissioned by DONG Energy, 134pp.

Silverman, B.W. (1986). *Density Estimation for Statistics and Data Analysis*. New York: Chapman and Hall.

Soanes, L.M., Bright J.A., Carter, D., Dias, M.P., Fleming, T., Gumbs, K., Hughes, G., Mukhida, F. & Green, J.A. (2016). Important foraging areas of seabirds from Anguilla, Caribbean: Implications for marine spatial planning. *Marine Policy* 70: 85–92.

Spear, L.B., Ainley, D.G., Hardesty, B.D., Howell, S.N.G. & Webb, S.W. (2004). Reducing biases affecting at-sea surveys of seabirds: use of multiple observer teams. *Marine Ornithology* 32: 147-157.

Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Reed, T.C, Tasker, M.L, Camphuysen, C.J. & Pienkowski, M.W. (1995). *An atlas of seabird distribution in north-west European waters*. Joint Nature Conservation Committee, Peterborough, UK: 326pp.

Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, P., McLean, I., Baker, H. & Whitehead (eds) (2001). *The UK SPA network: its scope and content*. Three Volumes. JNCC, Peterborough, UK. Available at http://jncc.defra.gov.uk/default.aspx?page=2970.

Tasker, M.L. Jones, P.H., Dixon, T.J. & Blake, B.F. (1984). Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardised approach. *Auk*, 101: 567-577.

Thaxter, C.B, Lascelles, B., Sugar, K., Cook, A.S.C.P, Roos S., Bolton, M., Langston, R.H.W and Burton, N.H.K (2012). Seabird foraging ranges as a tool for identifying candidate marine protected areas. *Biological Conservation* 156: 53-61

Thomas, L., Buckland, S.T., Rexstad, E.A., Laake, J.L., Strindberg, S., Hedley, S.L., Bishop, J.R.B, Marques T.A. & Burnham K.P. (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14.

Tyler, G. (2017). *Explanatory Notes for table of Seasonal Periods for Birds in the Scottish Marine Environment*. Scottish Natural Heritage: 3pp.
Available at https://www.nature.scot/sites/default/files/2017-07/A2332152%20-%20Suggested%20seasonal%20definitions%20for%20birds%20in%20the%20Scottish%20Marine%20Environment%20-%203rd%20February%202017.pdf

Wakefield, E.D., Bodey, T.W., Bearhop, S., Blackburn, J., Colhoun, K., Davies, R., Dwyer, R. G., Green, J.A., Grémillet, D., Jackson, A.L., Jessopp, M.J., Kane, A., Langston, R.H., Lescroël, A., Murray, S., Le Nuz, M., Patrick, S.C., Péron, C., Soanes, L.M., Wanless, S., Votier, S.C. & Hamer, K.C. (2013). Space portioning without territoriality in gannets. *Science* 341: 68–70.

Wanless, S., Harris, M.P. & Greenstreet, S.P.R. (1998). Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. *ICES Journal of Marine Science* 55: 1141–1151.

Wanless, S., Murray, S. & Harris, M.P. (2005). The status of Northern Gannet in Britain & Ireland in 2003/04. *British Birds* 98: 280-294.

Webb, A. & Durinck, J. (1992). Counting birds from ship. In: Komdeur, J. Bertelsen J. & Cracknell, G (eds) *Manual for aeroplane and ship surveys of waterfowl and seabirds*. IWRB Special Publication No. 19, Natural Environmental Research Institute, Kalø, Denmark, pp. 24-35.

Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Siriwardena, G.M. & Baillie, S.R. (2002). *The Migration Atlas: movements of the birds of Britain and Ireland*. T & A D Poyser, London. 884pp.

Wetlands International (2016). *Waterbird Population Estimates*. Available at: wpe.wetlands.org. (Accessed: 12/10/2017).

Worton, B.J. (1989). Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70: 164-168.

8. APPENDIX 1

Assessing the reliability of seabird flight heights from boat-based surveyors using an optical rangefinder: implications for collision risk at offshore wind farms

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ABSTRACT

Bird flight height distributions derived from boat-based surveys currently underpin collision risk assessments for offshore wind farms. However, the ability of surveyors to reliably estimate flight heights of birds had not been tested. This study used a low-cost optical laser rangefinder to provide comparative flight height measurements to assess levels of agreement. The accuracy and precision of the rangefinder was established in a supplementary study. A total of 1,101 rangefinder flight height measurements (to 53 m height and 226 m distance) were paired to surveyor estimates within 5 m flight height categories during boat-based surveys. Overall agreement between rangefinder and surveyors (n=1,235) was 58%, rising to 92% if the adjacent 5 m bands were included, judged to be 'substantial' by weighted Cohen's kappa statistics. There was no clear difference between surveyors. Agreement was linked to bird flight action and body size; being better for consistently low-flying and/or larger species. Surveyors were more likely to underestimate heights with increasing altitude. Adjustment of surveyor derived flight height distributions for two key seabird species, based on the rangefinder observations, increased the proportions at a theoretical collision risk height. Further use of rangefinders is recommended to verify and improve flight height estimates across a broad range of studies to increase confidence in impact assessments and aid in the identification of appropriate mitigation.

INTRODUCTION

At the end of 2017, 4,149 grid-connected turbines had been installed across 92 offshore wind farms in 11 European countries (Wind Europe 2018). With further predicted growth, there is potential for significant cumulative impacts of offshore wind upon vulnerable seabirds (Furness et al. 2013). Estimates of bird flight heights are essential for collision risk modelling (CRM) as an integral part of environmental impact assessment (EIA). Flight heights may be determined by optical laser rangefinders, digital aerial surveys, fixed-beam radar, thermal

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imagery, tag telemetry and LiDAR (light detecting and ranging systems) as well as 'by eye' during boat-based surveys (Camphuysen et al. 2004, Bouten et al. 2013, Corman & Garthe 2014, Stantial & Cohen 2015, Thaxter et al. 2015, Johnston & Cook 2016, Borkenhagen et al. 2018, Skov et al. 2018). In their review of methods, Thaxter et al. (2015) stress the importance of quantifying associated reliability (accuracy and precision). As the largest available data resource, subjective estimates by boat-based surveyors currently underpin generic flight height distributions for seabirds (Johnston et al. 2014) recommended for use in CRM by UK statutory bodies. Many survey programmes place birds within 5 m height bands, although the ability of surveyors to reliably do so remains unquantified (but see Perrow et al. 2017).

This study provides a unique assessment of the ability of surveyors to estimate bird flight heights during boat-based surveys, through comparative measurements, using a low-cost optical laser rangefinder. The accuracy of the rangefinder was verified in a land-based study using an Unmanned Aerial Vehicle (UAV). Surveyor derived flight height distributions were adjusted using the estimated error structures for two species in the study; Black-legged Kittiwake *Rissa tridactyla* (kittiwake hereafter) and Northern Gannet *Morus bassanus* (gannet hereafter), often key species in offshore wind farm EIA. Proportions of birds at collision height (PCH) were compared before and after adjustments and the implications for collision risk discussed.

METHODS

Assessment of Rangefinder Accuracy

A Nikon Forestry Pro laser rangefinder was used throughout the study. To assess performance when measuring flying objects, rangefinder height estimates were compared with those from a UAV. A DJI M200 UAV was used to mimic a flying bird at varying distances and heights from the operator. The trial was undertaken over one day at an abandoned runway that offered an unhindered space and safe working environment. The weather was overcast, with light winds and good visibility.

The UAV, commissioned from BlueSKY UAV, has manufacturer specified dimensions of 88.7 x 88.0 x 37.8 cm when fully deployed. The main body of the UAV was roughly comparable with a Kittiwake, which has a body length of around 39 cm and a wingspan of just over a meter (BWPi 2004). The horizontal and vertical hovering accuracy of the DJI M200, with the Downward Vision System enabled, are quoted to be 0.3 m and a 0.1 m respectively by the manufacturer. The system requires an accurate measurement of altitude for automated manoeuvres and positioning and provided a good reference for the trial.

Attempts were made to record five rangefinder readings from the UAV at horizontal distances of 0, 5, 10, 20, 30, 40, 50, 75, 100, 125 and 150 m from the operator, with the UAV hovering at heights of 5, 10, 15, 20, 30, 40, 50, 75 and 100 m at each. During the trial it was noted that the rangefinder may be sensitive to tilt and, although intuitive, operators were instructed to hold the rangefinder so that the target cross hairs were perpendicular to the horizon at all times. Rangefinder measurements were corrected according to the eye height of the operator. Simple linear regression models were used to investigate whether UAV height or horizontal distance, or an interaction between the two, had a significant effect on the difference between the rangefinder and UAV altitude estimates. A limited dataset, comprised of records at horizontal distances where the full range of heights could be measured, was analysed. Models were checked for linearity and quadratic or cubic functions were trialled as alternatives where appropriate. Model selection was carried out using Akaike information criterion (AIC) in R version 3.4.0 (R Core Team 2017) using the MuMIn package.

Surveyor and Rangefinder Comparison

Ornithological surveys were conducted over 11 days aboard a 17 m vessel in the Firth of Forth, Scotland between 9 May and 27 October 2017. A total transect length of 264-265.5 km between 20 and 63 km from shore was surveyed each day at a speed of 8-10 knots. All birds encountered within two 90° transects, extending to 300 m each side of the vessel, were given a flight height in 5 m height bands (e.g. >0-5 m, >5-10 m etc). An independent surveyor, dictating to a shared data recorder, monitored each side of the vessel.

A further surveyor used the rangefinder to record flight heights of birds (Figure 1). Where a successful measurement was made, one or more of the other surveyors provided a height estimate in 5 m bands. Surveyors also noted when birds were flying at >0 – 1 m. The height and horizontal distance to the target were recorded from the rangefinder and sea state (0-4) was noted. Rangefinder heights were adjusted according to seated surveyor eye heights relative to the sea surface (6.1 or 6.2 m). Only the two surveyors using the rangefinder had the potential to learn through experience, as the other surveyors were not informed of the measurements.

Figure 1. Use of Nikon Forestry Pro laser rangefinder during a boat-based survey.

Rangefinder flight heights were categorised into 5 m bands for pairwise comparisons of agreement with surveyors. Percentage agreement, Cohen's kappa (κ) and weighted kappa statistics were calculated (Cohen 1968, Watson & Petrie 2010). Cohen's kappa represents the chance-corrected proportional agreement between raters based on contingency tables and is thus more robust then simple percentage agreement. Interpretation of κ values is not formalised, but is generally suggested as follows: ≤0 'poor', >0-0.2 'slight', >0.2-

0.4 ‘fair’, >0.4-0.6 ‘moderate’, >0.6-0.8 ‘substantial’ and >0.8-1 as ‘almost perfect’ (Landis & Koch 1977). Weighted κ allows consideration of the extent of disagreement. A linear weighting structure (all levels of disagreement weighted equally) was used because the difference in the error between being one and two bands was likely to be the same as that between two and three bands.

Sub-sets of data were used to investigate variation in agreement statistics between individual surveyors (four with >50 observations), sea states (1, 2 and 3/4 combined) and different species/groups (with >50 records). Kittiwake, Gannet, Common Gull *Larus canus*, ‘large gulls’ (European Herring Gull *Larus argentatus*, Great Black-backed Gull *Larus marinus* and Lesser Black-backed Gull *Larus fuscus*) and ‘auks’ (Common Guillemot *Uria aalge*, Razorbill *Alca torda* and Atlantic Puffin *Fratercula arctica*) were considered in the analysis. Analyses were carried out in R version 3.4.0 (R Core Team 2017) using the package irr (Gamer et al. 2012).

Adjustment of Surveyor Flight Height Distributions

Flight height distributions were used to derive PCH estimates for both kittiwake and gannet. This assumed all birds above 25 m would be at risk of colliding with a turbine. The distributions were then adjusted based on the balance of the proportions of records over- and under-estimated relative to the rangefinder for each 5 m band. The overlapping error distributions derived for each band were used to reallocate surveyor counts at different flight heights. For example, if 25% of the surveyor records under-estimated flight heights in the >10-15 m band by a single band, but 20% of the surveyor records in the >5-10 m band were over-estimated, then the balance would be 5% under-estimation. Thus, 5% of the records in the >5-10 m band would be reallocated to the >10-15 m band. The difference between the unadjusted and adjusted values forms the basis of discussion with respect to potential collision risk.

RESULTS

Rangefinder Accuracy

The UAV rangefinder tests yielded 407 observations. No readings could be obtained when the UAV was <15 m directly above the operator, or <10 m altitude at 5 m horizontal distance. Conversely, it proved difficult to acquire the target (UAV) at >75 m at a horizontal distance of 100 m, >20 m at 125 m and only a single reading could be achieved of the UAV at 5 m altitude at 150 m. More attempts were generally required to generate a reading at the greatest height/distance combinations. However, given the potential variability associated with hitting different parts of the UAV, there was good overall agreement with a mean difference of -0.43 m ±1.28 m 1SD (all observations) between the rangefinder and UAV heights.

Figure 2 illustrates the variation in the mean rangefinder difference relative to the UAV altitude according to height and horizontal distance. The multiple regression, using the limited dataset (*n*=270), suggested a quadratic term provided the best fit between UAV height and rangefinder difference. Horizontal distance, as a single explanatory variable, was not significant (*P*=0.21, r^2=<0.01). In contrast, the quadratic UAV height variable was highly significant on its own (*P* <0.001, r^2=<0.69) and the fit suggested there was a decrease in accuracy above 50 m. However, the most parsimonious model included the statistically significant (*P* <0.001) interaction between the effects of UAV height and horizontal distance. The model residuals appeared to be normally distributed and the fit was very good (r^2=0.72). The inclusion of the interaction suggested there was a more complex combined effect of UAV altitude and horizontal distance, whereby the impact of UAV height reduced with horizontal distance. This reflects a slight increase in rangefinder estimates relative to the UAV at increasing distance, which is not significant in its own right. Limiting the records to a maximum of 100 m horizontal distance and 50 m altitude (at which the UAV could be routinely targeted and performance appeared reliable), the mean difference fell to -0.04 m ±0.70 m 1SD.

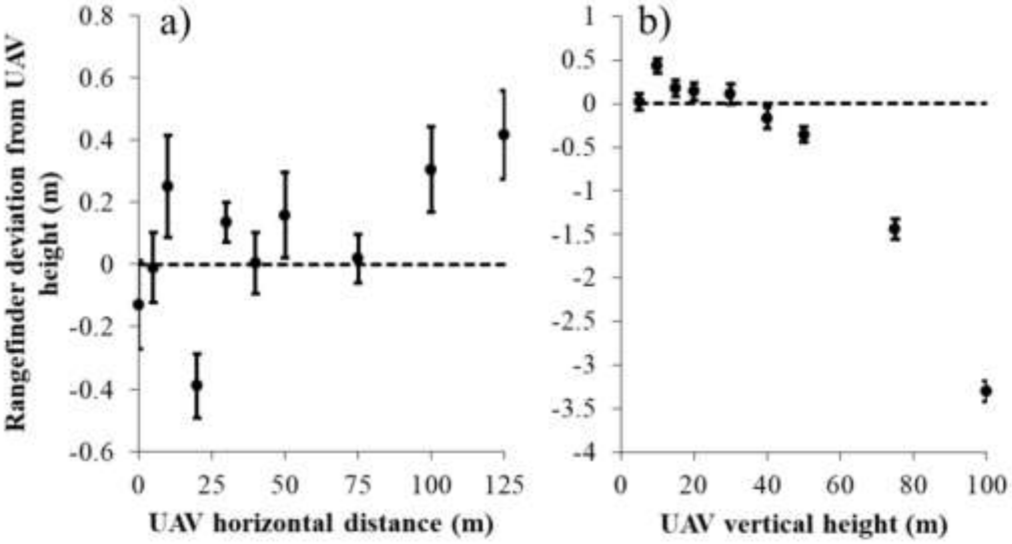

Figure 2. Deviation in rangefinder altitude estimates from UAV estimates according to a) UAV horizontal distance from the operator (excluding measurements of the UAV on the ground) and b) different UAV heights. Error bars represent respective ±2SE.

Comparison of Surveyor and Rangefinder Estimates

A total of 1,101 rangefinder measurements were obtained across 16 species (Table 1). Kittiwake (*n*=539) and gannet (*n*=350) dominated the sample. Corresponding estimates from a single surveyor were recorded in most (89.6%) cases, with some from two (8.5%) or three surveyors (1.8%), to produce a total of 1,235 paired observations. Two of the three surveyors not using the rangefinder contributed the majority (89.5%) of estimates.

Table 1. Number of independent rangefinder records of birds in flight by species (in order of total observations) and corresponding numbers of observations by the five surveyors (1-5).

Species	Latin name	Bird length (m)	Wingspan (m)	Rangefinder records (n)	Horizontal distance range (m)	Corrected height range (m)	Surveyor records					Combined observations
							1	2	3	4	5	
Black-legged kittiwake	*Rissa tridactyla*	0.39	1.08	539	7 - 184.4	-3.1 - 36.3	278	251	33	27	2	591
Northern gannet	*Morus bassanus*	0.94	1.72	350	0 - 226.0	-8.1 - 49.5	182	172	20	9	3	386
European herring gull	*Larus argentatus*	0.60	1.44	43	17 - 201.8	1.5 - 52.9	25	17	7	7	1	57
Common gull	*Larus canus*	0.41	1.20	36	25.8 - 175.0	1.3 - 46.1	26	14			1	41
Fulmar	*Fulmarus glacialis*	0.48	1.07	30	26.6 - 143.4	-5.5 - 5.5	9	22	1			32
Great black-backed gull	*Larus marinus*	0.71	1.58	19	20.8 - 175.4	6.8 - 42.9	15	6	4	3		28
Common guillemot	*Uria aalge*	0.40	0.67	25	39.4 - 176.8	-2.7 - 9.9	14	13		1		28
Razorbill	*Alca torda*	0.38	0.66	20	18.8 - 129.0	-0.7 - 12.5	8	15	1	1		25
Lesser black-backed gull	*Larus fuscus*	0.58	1.42	19	10 - 130.0	-0.5 - 40.4	8	11	2	1		22
Arctic tern	*Sterna paradisaea*	0.34	0.80	12	25.8 - 82.0	3.6 - 23.1	7	5	1	1		14
Atlantic puffin	*Fratercula arctica*	0.28	0.55	3	53.2 - 88.0	0.9 - 12.4	2	1	1			4
Common eider	*Somateria mollissima*	0.60	0.94	1	51.4	-0.2	1		1			2
Manx shearwater	*Puffinus puffinus*	0.34	0.82	1	109.6	-1.4	1		1			2
Great northern diver	*Gavia immer*	0.80	1.37	1	61.8	18.1	1					1
Great skua	*Stercorarius skua*	0.56	1.36	1	62.6	0.1		1				1
Grey heron	*Ardea cinerea*	0.94	1.85	1	161.2	21.9				1		1
Grand Total				1,101	0 - 226.0	-8.1 - 52.9	577	528	72	51	7	1,235

The majority (75%) of rangefinder records were within 100 m of the surveyor, with a peak in records at between 40 and 80 m (Figure 3). The highest flight height recorded was 52.9 m (Table 1 and Figure 3). Some estimates (8.6%) were negative and for analytical purposes were assumed to be in the >0-5 m category. Records for gannet were more evenly distributed than kittiwake with respect to horizontal distance (Figure 3). However, kittiwake was more evenly distributed in relation to flight heights (Figure 3).

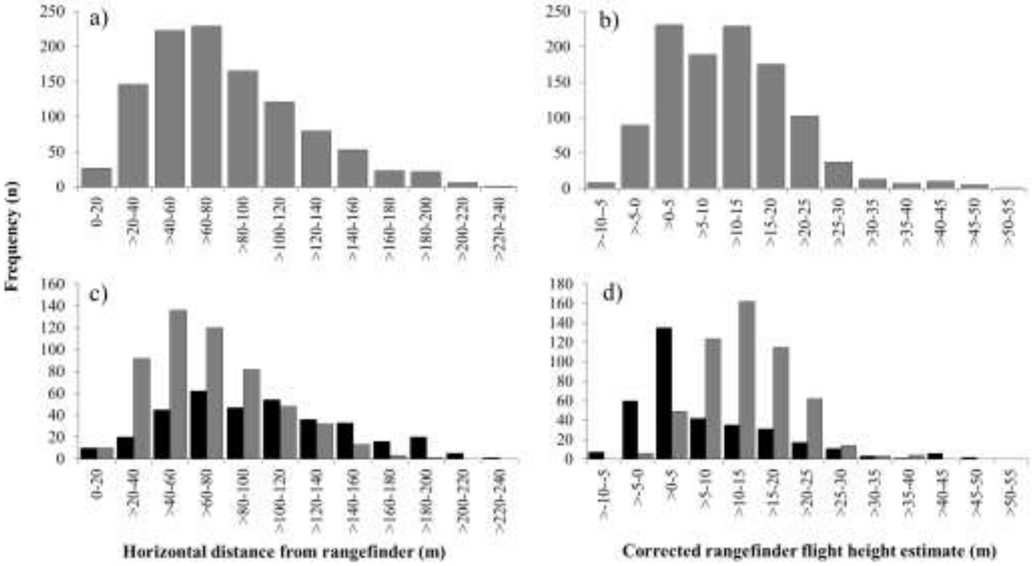

Figure 3. At-sea rangefinder record frequency distributions for all birds (n=1,101) according to: a) horizontal distance and b) corrected flight height estimates. Variation in distributions for northern gannet (black) and black-legged kittiwake (grey) are also shown (northern gannet *n*=350 and black-legged kittiwake *n*=539) according to: c) horizontal distance and d) corrected flight height estimates.

The overall agreement between methods was 58% (Table 2), with 92% of the observations falling within the same or adjacent 5 m band as the rangefinder. Agreement varied between 55 and 67% for different surveyors, with κ values suggesting ‘moderate’ agreement rising to ‘substantial’ for weighted κ. Surveyors with experience of rangefinder outputs achieved the highest and lowest κ scores.

There were considerable differences in agreement between different bird groups ranging from 50% (κ =fair) for kittiwake and common gull to 86% (κ = substantial) for auks. Rangefinder records were distributed evenly across sea states 1 (36.3%), 2 (30.8%) and 3/4 (32.9%) and although agreement was slightly lower for sea states 3/4, this did not reduce the κ and weighted κ ratings.

Table 2. Variation in metrics of agreement between methods for difference surveyors, species and sea states.

Comparison		*n*	% agreement	κ	κ rating	Weighted κ	Weighted κ rating
Surveyor	1	528	59.3	0.497	Moderate	0.737	Substantial
	2	577	56.5	0.452	Moderate	0.700	Substantial
	3	72	66.7	0.588	Moderate	0.783	Substantial
	4	51	54.9	0.470	Moderate	0.709	Substantial
	All	1235	58.1	0.482	Moderate	0.722	Substantial
Species	Kittiwake	591	49.7	0.368	Fair	0.568	Moderate
	Gannet	386	68.9	0.507	Moderate	0.700	Substantial
	Large gulls	107	51.4	0.430	Moderate	0.683	Substantial
	Auks	57	86.0	0.601	Substantial	0.632	Substantial
	Common gull	41	50.0	0.397	Fair	0.532	Moderate
Sea state	1	474	59.5	0.504	Moderate	0.724	Substantial
	2	356	62.4	0.515	Moderate	0.772	Substantial
	3 & 4	405	52.8	0.418	Moderate	0.669	Substantial

Figure 4 shows the surveyor error structure for each height band. For all birds, agreement declined with increasing height from 93% at >0-5 m to 31% at >25-30 m, after which agreement was variable, albeit within a similar range of 35-45% with diminishing sample size (Figure 4a). Similar patterns were evident for both kittiwake and gannet (Figure 4b and c). For surveyor estimates that were not in agreement with the rangefinder (excluding the 0-5 m category that could not be under-estimated), 65% were in bands lower than those identified by the rangefinder. Equivalent values for kittiwake and gannet were 63% and 68% respectively. Surveyors appeared to be more likely to underestimate flight heights with increasing altitude.

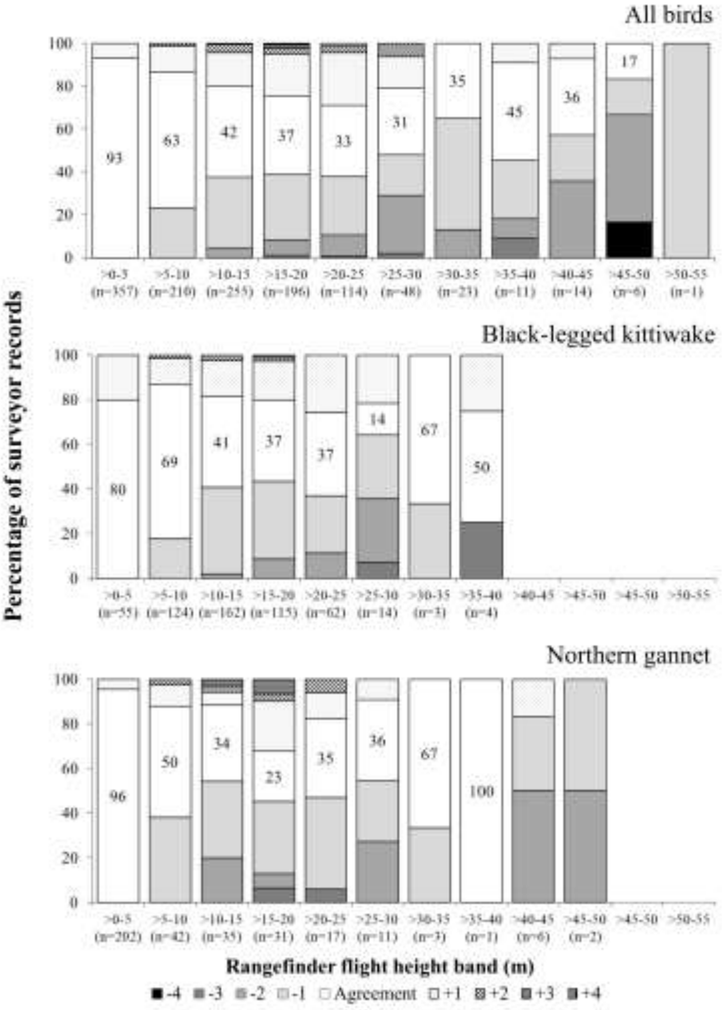

Figure 4. Variability in agreement (percentage of records) between rangefinder and surveyor estimates of flight heights (in 5 m bands) for all birds (n=1,235), black-legged kittiwake (n=539) and northern gannet (n=350). Surveyor error is shown relative to under- and over-estimation by between 1 and 4 bands relative to the rangefinder.

Determination of PCH

The flight height distributions of kittiwake and gannet derived from all surveyor records (Figure 5) resulted in PCH values of 3.9% and 3.7% respectively. Adjustment according to the observed surveyor error structures, approximately doubled the PCH for kittiwake (to 7.9%), but only increased gannet by a factor of 1.26 (to 4.7%).

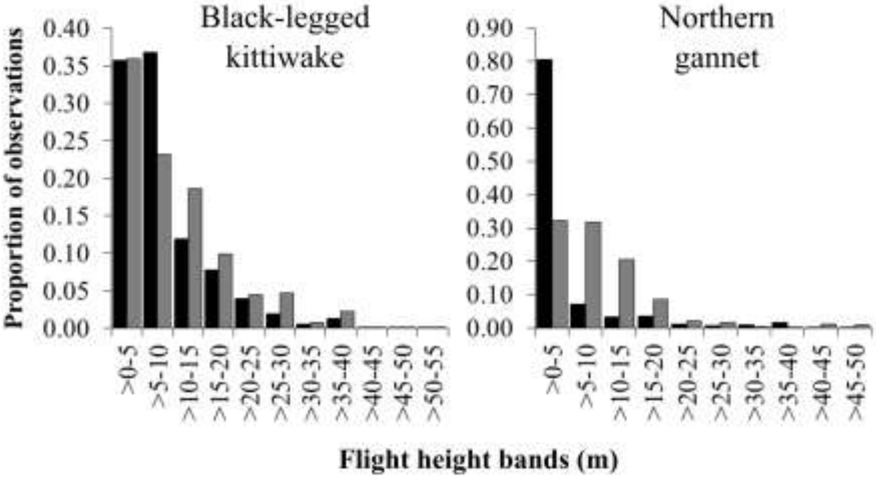

Figure 5. Variation between unadjusted (black) and rangefinder adjusted (grey) surveyor estimated flight height distributions for Black-legged Kittiwake and Northern Gannet.

DISCUSSION

The accuracy of the rangefinder was better than quoted by the manufacturer at ± 1 m at a distance of 300 m within a horizontal distance of 100 m and up to an altitude of 50 m. It was surprising that it was difficult to get a measurement from the UAV at >100 m horizontal distance, as experience had shown that it was possible to target seabirds at much greater distances (over 200 m). Although the UAV appeared to present a relatively large target, the main body was actually quite small in comparison to the target presented by a bird with outstretched wings. If there is a chance to repeat the study, then it is suggested that the UAV could be modified to provide a larger target; allowing accuracy and precision to be assessed over a greater distance. Although this trial was effectively limited to a horizontal distance of 100 m there was little evidence of a serious drop off in accuracy or precision across this range. However, accuracy did diminish above 50 m altitude, but this may still be within acceptable limits depending on the type of study. No birds were recorded above 55 m during the study and, although some were recorded at greater horizontal distance than could be tested with the UAV, the majority were within that range (<100 m).

The rangefinder did however produce some records at negative height, in line with Borkenhagen et al. (2018) using a more sophisticated (expensive) rangefinder (<2% of values to -3 m) and altimeters in GPS tags (0.3% of records to -10 m); and Cleasby et al. (2015) also using within GPS tags (2.7% of flight records at $\leq$ 0 m). The sea is a moving baseline and wave driven vertical boat movement, influencing surveyor eye-height, could have been responsible for the higher proportion of negative height values (8.6%) in this study. Although accounting for this issue could improve the estimates of surveyor performance, the general trends were likely to be unaffected given a lack of apparent bias in rangefinder error.

The surveyors did not differ appreciably in their placement of birds in particular height bands and this was also not obviously influenced by prior experience of heights delivered by the rangefinder or sea state. However, measures of agreement appeared to be influenced by bird flight action and body size. Auks, mostly recorded flying just above sea surface with little deviation in height, showed almost perfect agreement between surveyors and the rangefinder. For the other species/groups that occurred over a greater range of altitudes, there was a tendency for declining agreement with reducing body size from gannet and large gulls to common gull and kittiwake (Table 1).

Irrespective of the considerable size difference, surveyors appeared more likely to underestimate flight heights of gannet and kittiwake with increasing altitude, but even did so at relatively low heights. For example, surveyors recorded a high percentage (81%) of gannets at < 5 m above sea surface, although after adjustment based on the rangefinder records, this reduced to just 32% (Figure 5). This may reveal a tendency for the surveyors to record flight height at the lowest point of the cycle of rapid height changes during the dynamic soaring flight pattern of commuting gannets that dominated our records (80% were on a flight path to and from a single colony). The adjusted distributions for gannet were in closer correspondence with the tagging studies of Cleasby et al. (2015) in the same sea area (Firth of Forth), that derived a modal flight height between 5-10 m (12,989 GPS observations) and a median value of 11.5 m for commuting birds.

In their development of flight height distributions from surveyor records, Johnston et al. (2014) acknowledged the issue of being unable to account for potential errors associated with data collection methods. This study was able to apply a simple method for correcting flight height distributions for collision risk assessment by adjusting flight height distributions using a relatively small sample of paired rangefinder records. This enhances confidence in the use of site-specific flight height distributions, which may otherwise differ from the generic models of Johnston et al. (2014). Although the adjustment appeared more extreme for gannet (Figure 5), it did not influence the PCH as much as for kittiwake, which tended to fly higher to begin with. Any increase in PCH is directly reflected in predicted collision mortality with possible implications for impact assessments.

Given the encouraging results of this preliminary study, further use of rangefinders is recommended to verify and refine the method across a range of sites and species. Larger, more stable survey vessels may also reduce variability in rangefinder measurements. Such studies could aid the evaluation of collision risk for a range of species, including large gulls that are perceived to be particularly vulnerable (Furness et al. 2013). Greater confidence in flight height distributions and collision risk assessments may, in turn, provide reassurance that mitigation measures, such as increasing the air gap beneath turbines, would be effective for vulnerable birds. The use of rangefinders for flight height estimates could equally transfer to routine bird surveys on land and could be used to rapidly generate large datasets. However, an understanding of potential rangefinder related error is essential to any such study to ensure it is fit for purpose.

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LITERATURE CITED

Borkenhagen, K., Corman, A-M. and Garthe, S. (2018). Estimating flight heights of seabirds using optical rangefinders and GPS data loggers: a methodological comparison. Marine Biology 165:17.

Bouten, W., Baaij, E.W., Shamoun-Baranes, J. and Camphuysen, C.J. (2013). A flexible GPS tracking system for studying bird behaviour at multiple scales. Journal of Ornithology 154: 571-580.

BWPi (2004). Birds of the Western Palearctic Version 1.0. Birdguides Ltd & Oxford University Press, Oxford, UK.

Camphuysen, C.J., Fox, A.D. and Leopold, M.F. (2004). Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K.: A comparison of ship and aerial sampling for marine birds, and their applicability to offshore wind farm assessments. COWRIE Report BAM-02-2002 prepared by Royal Netherlands Institute for Sea Research. COWRIE Ltd, London.

Cleasby, I.R., Wakefield, E.D., Bearhop, S., Bodey, T.W., Votier, S.C. and Hamer, K.C. (2015). Three-dimensional tracking of a wide-ranging marine predator: flight heights and vulnerability to offshore wind farms. Journal of Applied Ecology 52: 1474-1482.

Cohen, J. (1968). Weighted kappa: Nominal scale agreement provision for scaled disagreement or partial credit. Psychological Bulletin 70: 213-220.

Corman, A. and Garthe, S. (2014). What flight heights tell us about foraging and potential conflicts with wind farms: a case study in Lesser Black-backed Gulls (*Larus fuscus*). Journal of Ornithology 155: 1037-1043.

Furness, R.W., Wade, H.M. and Masden, E.A. (2013). Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management 119: 56-66.

Gamer, M., Lemon, J., Fellows, I. and Singh, P. (2012). irr: Various Coefficients of Interrater Reliability and Agreement. R package version 0.84. https://CRAN.R-project.org/package=irr

Bartoń, K. (2018). MuMIn: Multi-Model Inference. R package version 1.40.4. htt ps://CRAN.R-project.org/package=MuMIn

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, N.H.K. (2014). Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology 51: 31-41.

Johnston, A. and Cook, A.S.C.P. (2016). How high do birds fly? Development of methods and analysis of digital aerial data of seabird flight heights. BTO Research Report No. 676. BTO, Thetford.

Landis, J.R. and Koch, G.G. (1977). The measurement of observer agreement for categorical data. Biometrics 33: 159-174.

Perrow, M.R., Harwood, A.J.P., Berridge, R.J. and Skeate, E.R. (2017). The foraging ecology of Sandwich Terns in north Norfolk. British Birds 110: 257-277.

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Skov, H., Heinänen, S., Norman, T., Ward, R.M., Mendez-Roldan, S. and Ellis, I. (2018). ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. United Kingdom.

Stantial, M. and Cohen, J.B. (2015). Estimating flight height and flight speed of breeding Piping Plovers. Journal of Field Ornithology 86: 369-377.

Thaxter, C.B., Ross-Smith, V.H. and Cook, A.S.C.P. (2015). How high do birds fly? A review of current datasets and an appraisal of current methodologies for collecting flight height data: Literature review. BTO Research Report No. 666. British Trust for Ornithology, Thetford.

Watson, P.F. and Petrie, A. (2010). Method agreement analysis: A review of correct methodology. Theriogenology 73:1167-1179.

Wind Europe (2018). Offshore Wind in Europe: key trends and statistics 2017. February 2018.

9. APPENDIX 2.

Estimated population sizes of all sensitive species in all areas in all surveys from 2009-2011 and 2017. Birds are divided between birds in flight and birds on the water.

Year	Northern Gannet												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
2009	December	33	0	61	0	32	10	56	18	65	10	96	15
2010	January	62	15	113	27	94	10	163	18	156	25	228	37
	March	260	119	473	216	275	20	479	34	535	138	784	203
	April	145	0	265	0	111	0	194	0	257	0	376	0
	May	1376	167	2504	304	657	31	1145	54	2033	198	2982	290
	June	2405	311	4377	567	947	49	1650	86	3352	361	4915	529
	July	466	108	848	196	916	10	1595	18	1382	118	2026	173
	August	1421	21	2587	38	1081	59	1884	103	2503	80	3670	117
	September	639	20	1162	37	518	108	902	189	1156	129	1696	189
	October	398	78	724	142	502	162	875	282	900	240	1320	352
	November	160	26	291	47	182	35	317	60	342	60	501	88
	December	0	0	0	0	0	0	0	0	0	0	0	0
2011	January	55	10	100	18	31	108	54	188	86	118	126	173
	February	85	46	154	84	155	44	270	77	240	91	351	133
	March	540	162	982	295	411	67	716	117	950	229	1394	336
	April	324	220	589	401	322	333	561	580	645	553	946	811

Year	Northern Gannet												
	Site	Alpha		Alpha + 2 km		Bravo		Bravo + 2 km		Alpha + Bravo		Alpha + Bravo + 2 km	
	Status	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water
	May	1740	101	3166	184	566	20	986	34	2306	121	3381	177
	June	1181	222	2149	403	558	296	972	516	1738	518	2549	760
	July	89	81	162	147	157	10	274	18	246	91	361	134
	August	491	240	893	437	461	363	804	633	952	603	1396	885
	September	344	44	626	80	217	49	378	86	561	93	823	136
	October	87	35	159	64	54	15	95	27	142	51	208	75
	November	21	5	38	9	53	15	93	27	74	20	109	30
2017	May 1	892	169	1653	224	560	163	1119	181	1440	322	2328	363
	May 2	1362	184	1735	218	728	22	1426	44	2015	196	2152	236
	June	1840	23	3338	32	2091	17	3366	27	3835	39	5299	53
	July	514	253	792	678	350	302	653	603	853	538	1290	955
	August	328	23	799	21	210	17	274	49	535	39	930	63

Year	Black-legged Kittiwake												
	Site	Alpha		Alpha + 2 km		Bravo		Bravo + 2 km		Alpha + Bravo		Alpha + Bravo + 2 km	
	Status	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water
2009	December	222	0	597	0	245	0	497	0	467	0	982	0
2010	January	342	232	920	623	385	412	781	836	727	644	1529	1354
	March	1008	152	2713	410	743	75	1507	151	1751	227	3684	477
	April	257	305	692	820	414	248	840	504	671	553	1413	1164
	May	224	269	602	724	411	208	834	421	635	477	1335	1003
	June	646	345	1739	929	593	148	1203	301	1239	494	2608	1039

Year	Black-legged Kittiwake												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
	July	265	116	713	312	131	129	265	261	396	245	832	515
	August	103	122	278	328	65	25	132	50	168	147	354	309
	September	1409	90	3792	241	135	0	274	0	1545	90	3250	189
	October	296	58	795	155	154	0	312	0	449	58	945	121
	November	3993	518	10742	1394	2504	50	5081	101	6497	568	13670	1194
	December	21	0	57	0	32	0	65	0	53	0	112	0
2011	January	209	86	563	232	558	519	1131	1052	767	605	1613	1273
	February	117	457	314	1230	413	373	838	756	530	830	1114	1746
	March	55	209	148	563	249	130	505	263	304	339	639	714
	April	605	521	1629	1403	133	335	270	679	738	856	1554	1801
	May	249	144	669	387	681	25	1382	50	930	169	1957	355
	June	665	1249	1789	3361	681	2132	1382	4325	1346	3381	2833	7114
	July	522	389	1403	1046	409	182	830	369	930	571	1958	1200
	August	115	232	309	623	77	154	156	313	192	386	403	813
	September	11	0	30	0	21	0	42	0	32	0	67	0
	October	677	90	1822	241	436	25	885	51	1113	115	2343	242
	November	42	0	112	0	192	0	389	0	233	0	491	0
2017	May 1	1194	372	2337	490	916	457	2569	765	2064	803	4597	1192
	May 2	454	64	1176	187	525	107	919	204	978	180	1657	451
	June	98	8	274	59	148	8	293	8	239	15	498	65
	July	2426	9706	4237	14410	200	3456	1604	7526	2677	12872	4463	18289
	August	643	561	2174	3039	384	674	880	727	1009	996	2605	3417

Year	European Herring Gull												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
2009	December	67	10	155	24	96	0	69	0	162	10	488	30
2010	January	52	24	121	57	31	5	22	4	83	30	249	89
	March	87	5	202	12	51	0	36	0	138	5	413	15
	April	11	0	26	0	0	0	0	0	11	0	34	0
	May	45	0	104	0	0	5	0	4	45	5	134	15
	June	53	68	123	159	73	10	52	7	126	78	378	234
	July	0	0	0	0	0	0	0	0	0	0	0	0
	August	0	10	0	24	0	0	0	0	0	10	0	31
	September	11	0	26	0	11	0	8	0	22	0	67	0
	October	34	0	80	0	0	0	0	0	34	0	102	0
	November	0	0	0	0	0	15	0	11	0	15	0	44
	December	11	0	25	0	11	0	8	0	21	0	64	0
2011	January	11	5	26	11	0	0	0	0	11	5	33	15
	February	32	5	74	12	10	0	7	0	42	5	126	15
	March	11	5	26	12	0	0	0	0	11	5	33	15
	April	10	0	24	0	0	0	0	0	10	0	31	0
	May	21	10	48	24	21	0	15	0	42	10	125	30
	June	0	57	0	132	0	163	0	116	0	219	0	659
	July	22	0	52	0	0	0	0	0	22	0	67	0
	August	0	0	0	0	0	0	0	0	0	0	0	0
	September	0	0	0	0	0	0	0	0	0	0	0	0
	October	11	0	25	0	11	0	8	0	22	0	66	0
	November	21	0	49	0	0	0	0	0	21	0	63	0

Year	**European Herring Gull**												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
2017	May 1	0	0	0	0	38	0	35	0	36	0	35	0
	May 2	0	0	12	22	0	6	0	5	0	5	12	27
	June	12	0	69	0	12	0	12	0	24	0	79	0
	July	0	34	0	126	0	0	0	21	0	33	0	123
	August	0	0	0	0	0	0	0	0	0	0	0	0

Year	**Common Guillemot**												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
2009	December	22	356	49	781	32	337	55	582	54	693	91	1159
2010	January	41	1679	91	3683	0	1085	0	1875	41	2764	69	4625
	March	1366	1496	2996	3281	1068	5472	1846	9460	2434	6968	4073	11660
	April	56	272	123	596	30	201	52	348	86	473	144	792
	May	78	1001	172	2195	153	505	264	873	231	1506	386	2519
	June	805	4397	1766	9643	198	3381	342	5845	1003	7778	1678	13016
	July	222	646	488	1417	33	855	57	1478	255	1501	427	2512
	August	0	498	0	1093	0	322	0	556	0	820	0	1373
	September	0	1045	0	2292	0	400	0	691	0	1445	0	2418
	October	34	706	75	1549	0	160	0	277	34	866	57	1450
	November	21	159	47	348	0	80	0	139	21	239	36	400
	December	106	215	232	472	43	146	74	252	149	361	249	605
2011	January	110	150	241	329	330	360	571	623	441	510	737	853
	February	456	1923	999	4217	537	1187	928	2052	992	3110	1661	5204

Year	Common Guillemot												
	Site	Alpha		Alpha + 2 km		Bravo		Bravo + 2 km		Alpha + Bravo		Alpha + Bravo + 2 km	
	Status	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water
	March	176	5016	386	11001	443	1914	766	3309	620	6931	1037	11597
	April	250	1178	549	2584	290	1496	501	2586	540	2674	904	4475
	May	207	673	454	1475	136	360	236	623	343	1033	575	1728
	June	642	10169	1408	22301	103	10464	178	18089	745	20633	1247	34525
	July	222	6667	487	14621	63	1430	109	2473	285	8097	477	13550
	August	10	711	23	1558	0	501	0	865	10	1211	17	2027
	September	11	107	24	235	0	20	0	35	11	127	19	213
	October	11	178	24	390	0	42	0	73	11	220	18	368
	November	52	86	114	189	11	63	18	108	63	149	105	249
2017	May 1	313	4374	460	7962	89	3682	200	6764	396	8451	585	12142
	May 2	184	2420	373	4120	96	3032	236	4986	291	5438	529	7716
	June	417	2446	994	6793	297	3092	434	4099	717	5189	1234	9489
	July	0	11221	12	21745	12	12524	11	19836	12	23406	23	33494
	August	13	873	12	2456	0	680	12	1488	12	1544	11	3476

Year	Razorbill												
	Site	Alpha		Alpha + 2 km		Bravo		Bravo + 2 km		Alpha + Bravo		Alpha + Bravo + 2 km	
	Status	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water	In flight	On water
2009	December	0	252	0	610	0	179	0	363	0	431	0	807
2010	January	0	171	0	414	0	152	0	309	0	323	0	605
	March	304	360	734	870	92	440	186	893	395	800	739	1497
	April	0	694	0	1679	30	343	61	695	30	1036	57	1939
	May	11	151	27	366	47	128	95	259	58	279	109	522

Year	Razorbill												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
	June	0	291	0	705	0	97	0	197	0	389	0	727
	July	21	244	51	591	0	583	0	1183	21	828	40	1549
	August	0	1535	0	3713	0	783	0	1587	0	2318	0	4336
	September	0	706	0	1709	0	1279	0	2593	0	1985	0	3715
	October	102	680	248	1645	61	122	125	247	164	801	306	1499
	November	0	900	0	2176	10	245	20	496	10	1144	19	2141
	December	0	73	0	177	21	101	44	206	21	175	40	327
2011	January	88	73	213	176	10	219	21	444	98	292	184	546
	February	148	591	359	1430	72	489	147	992	221	1080	413	2021
	March	242	505	586	1221	54	205	110	415	296	709	554	1327
	April	83	611	202	1478	64	457	130	926	148	1067	276	1997
	May	62	340	150	822	10	146	21	296	73	486	136	909
	June	11	540	28	1306	0	343	0	695	11	882	21	1651
	July	11	2091	27	5058	0	512	0	1037	11	2603	21	4869
	August	0	342	0	827	0	203	0	411	0	545	0	1020
	September	0	461	0	1116	10	973	21	1973	10	1435	19	2684
	October	66	25	159	61	54	0	111	0	120	25	225	47
	November	42	73	101	177	11	25	22	51	52	99	98	185
2017	May 1	84	346	130	570	51	487	106	649	156	805	199	1020
	May 2	37	237	58	450	0	299	24	407	35	534	69	707
	June	37	153	91	538	87	220	117	371	119	380	181	798
	July	12	6130	12	12750	0	6065	11	9627	12	11921	11	18910
	August	0	1487	0	4794	0	697	0	2868	0	2140	0	6793

Year	**Atlantic Puffin**												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
2009	December	0	51	0	92	0	42	0	81	0	93	0	145
2010	January	0	0	0	0	0	0	0	0	0	0	0	0
	March	11	395	20	717	31	221	59	426	41	617	64	962
	April	0	155	0	281	10	201	19	387	10	356	16	555
	May	0	68	0	122	0	84	0	162	0	152	0	237
	June	180	1454	327	2638	42	571	80	1099	222	2025	346	3158
	July	64	376	115	682	33	681	63	1310	96	1057	150	1648
	August	69	2012	125	3649	54	1516	104	2917	123	3528	192	5501
	September	11	1317	20	2389	11	1458	22	2804	22	2775	35	4327
	October	34	1174	62	2131	0	1498	0	2883	34	2673	53	4168
	November	43	1535	77	2785	10	1858	19	3574	53	3393	82	5291
	December	0	94	0	171	0	63	0	120	0	157	0	245
2011	January	0	81	0	147	0	200	0	385	0	281	0	439
	February	11	138	19	250	0	81	0	155	11	218	17	340
	March	11	135	20	245	0	63	0	121	11	198	17	309
	April	94	229	170	415	150	543	289	1044	244	772	381	1203
	May	0	65	0	118	0	80	0	154	0	145	0	226
	June	115	2672	208	4848	52	5386	99	10361	166	8058	259	12565
	July	11	608	20	1102	10	442	20	850	22	1050	34	1637
	August	31	785	57	1423	0	633	0	1218	31	1418	49	2210
	September	11	1462	20	2652	21	5355	40	10303	32	6817	50	10630
	October	22	270	40	490	11	253	21	486	33	523	51	815

Year	Atlantic Puffin												
	Site	**Alpha**		**Alpha + 2 km**		**Bravo**		**Bravo + 2 km**		**Alpha + Bravo**		**Alpha + Bravo + 2 km**	
	Status	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**	**In flight**	**On water**
	November	0	163	0	297	0	125	0	241	0	289	0	450
2017	May 1	0	124	12	181	0	116	0	330	0	245	12	413
	May 2	0	89	0	181	24	135	47	230	23	229	46	379
	June	37	63	57	118	12	154	12	181	48	210	57	268
	July	60	571	93	1052	25	591	80	991	83	1152	160	1734
	August	0	1491	12	2860	12	1539	48	3251	12	3027	46	4775