Environmental Statement
Volume III: Appendices

Appendix F1

Baseline Technical Report for Projects Alpha & Bravo

Round 3 Zone 2
Firth of Forth
Offshore Wind Farm Development

RESTRICTED COMMERCIAL

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1. INTRODUCTION

1.1.1 The Firth of Forth constitutes Zone 2 (of 9) under 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) is 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 target 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 an area generally of deeper water in the south of the Zone where no development is currently planned (Figure 1.1). Phase 1 in the North of the Zone is located from approximately 23 km offshore east of the Angus coastline to the west of Scalp Bank, extending up to 60 km offshore. For technical reasons, (e.g. ease of connection to the grid) Phase 1 was considered the least constrained and is therefore currently the focus for the first stage of development.

1.1.3 Following the Zonal Assessment Process (ZAP) required by The Crown Estate, Seagreen determined that part of Phase 1, the area around Scalp Bank, was to remain undeveloped at this stage (Seagreen Wind Energy 2011a) as a result of its sensitivity from the perspective of fisheries and thus as a focus of interest for seabirds and marine mammals (Figure 1.1). The rest of Phase 1 was divided into two sites named Alpha and Bravo of approximately equal area, with each to contain up to 75 turbines.

1.1.4 Alpha and Bravo are broadly triangular in shape and abut each other in an overall arrangement that is roughly rectangular, save for the omission of a few areas of water considered to be of excessive depth (> 60 m) for development (Figure 1.1). The two sites are similar in area at 197.2 km^2 for Alpha and 193.7 km^2 for Bravo (Table 1.1).

1.1.5 Two Scottish Territorial Water (STW sites) are also proposed within the Outer Forth of Forth bordering the western part of the Zone; namely Neart na Gaoithe to be developed by Mainstream Renewable Power Ltd and Inch Cape to be developed by Repsol Nuevas Energias UK Limited. The area and transmission entry capacity (TEC) of size of each of these developments is shown in Table 1.2. Alpha and Bravo have relatively large area for their individual TEC 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 impacts on birds.

Figure 1.1 Firth of Forth Round 3 Zone 2

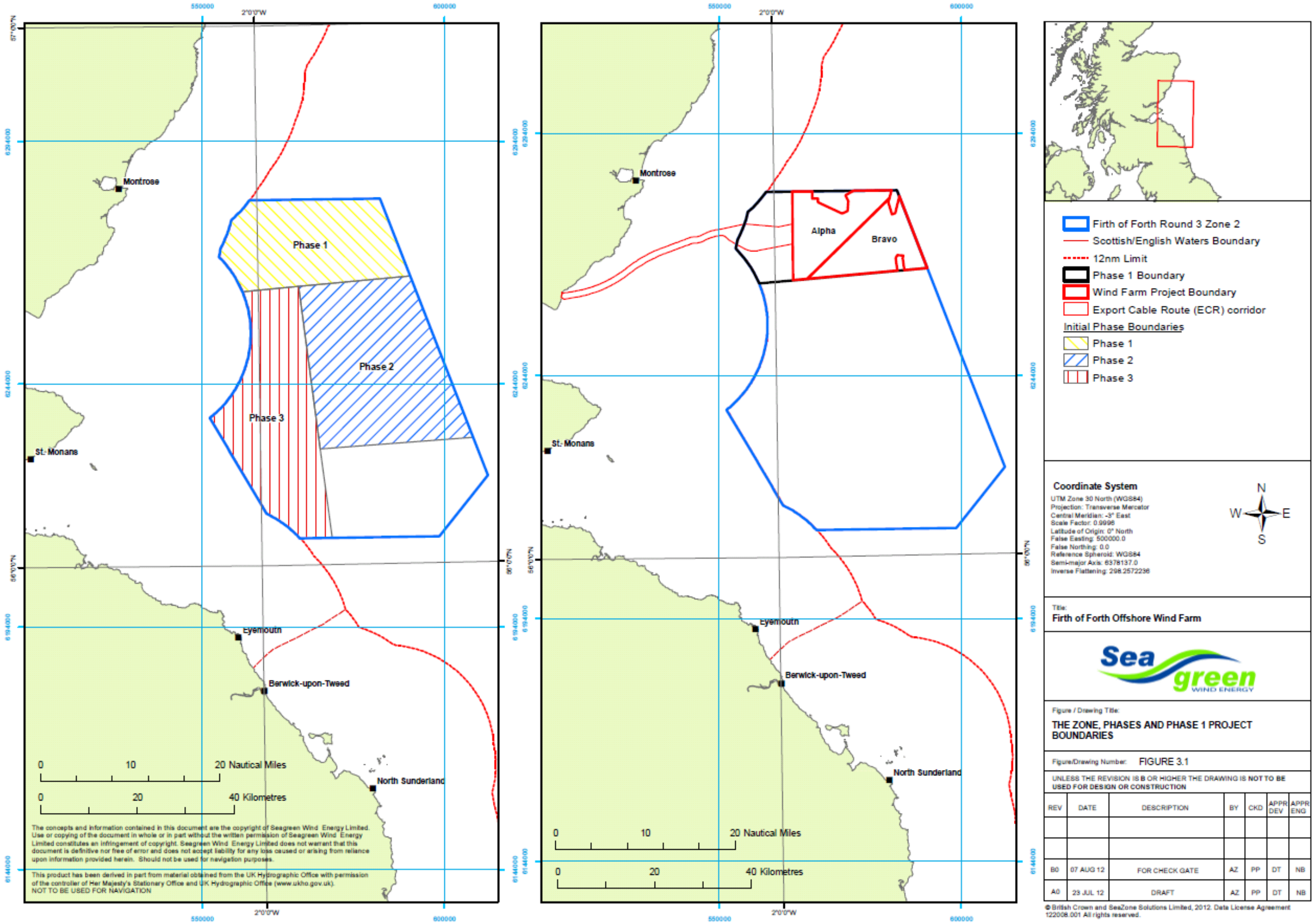


Table 1.1 Details of the proposed Alpha and Bravo sites within Phase 1 in comparison with the Scottish Territorial Waters sites bordering the Zone. Information for STW sites as defined by Mainstream Renewable Power (2012) and Repsol (*pers comm*.)

Development	Site	Area (km^2)	Maximum number of turbines	Maximum transmission entry capacity (MW)
Zone	Alpha	197.2	75	525
	Bravo	193.7	75	525
Scottish Territorial Waters	Neart na Gaoithe	105	128	450
	Inch Cape	150	286	1029

1.1.6 The locality of the STW developments within 12 nm of the coast immediately suggests they would maintain a higher density of breeding seabirds as they commute to and from colonies, depending on their location. This is notwithstanding that the areas of development could also actually be used as foraging grounds. The relative contribution of any development to any ecological impact is likely to be higher where the density of birds is greater

1.1.7 To illustrate the point, Neart na Gaoithe, begins 16 km from the Isle of May in the Forth Islands SPA, a site supporting 113,734 Atlantic Puffin (hereafter Puffin in text) *Fratercula arctica* (latest count in 2009), 15,691 Common Guillemot (hereafter Guillemot in text) *Uria aalge* (in 2011), 6,422 European Herring Gull (hereafter Herring Gull in text) *Larus argentatus* (in 2010), 5,370 Black-legged Kittiwake (hereafter Kittiwake in text) *Rissa tridactyla* (in 2011), 4,716 Lesser Black-backed Gull *Larus fuscus* (in 2010) and 3,102 Razorbill *Alca torda* (in 2011) and smaller numbers of four other species of seabird. Many of these species are known to forage on Wee Bankie and Marr Bank during the breeding season (Wanless *et al*. 1998), with Neart na Gaoithe lying on a direct route between these areas and the colony. In a proof of concept modelling approach of displacement and barrier effects, McDonald *et al*. (2012) indicated that time and energy budgets of a model species, Guillemot, could be affected by the presence of Neart na Gaoithe with potential consequences for breeding performance and/or survival.

1.1.8 In relation to Inch Cape, the site sits in inshore waters midway between the Isle of May (33 km) and Fowlsheugh SPA (34 km). In 2009, the latter site supported 50,556 Guillemot, 28,386 Kittiwake and 4,632 Razorbill amongst other species. Inch Cape is in close proximity inshore of Scalp Bank one of the sites of the former sandeel (mainly Lesser sandeel *Ammodytes marinus*) fishery and thus likely to be another key foraging area for birds in the Forth of Forth (Wanless *et al*. 1998). Alpha lies to the west of Scalp Bank and begins at a similar distance from Fowlsheugh with Bravo at greater distance. Inch Cape thus also has the potential for significant ecological impact, especially in a cumulative context.

1.1.9 As well as breeding seabirds, more inshore species such as divers (e.g. Red-throated Diver *Gavia stellata*), grebes and seaduck, as well as wetland/coastal species such as waterfowl and waders making landfall and undertaking coastal movements, were also thought likely to be more prevalent in sites closer to land.

2. BACKGROUND INFORMATION

2.1 Importance of the Firth of Forth for seabirds

2.1.1 The Firth of Forth falls within the Aberdeen-Tees area ranked within the top three areas for seabirds in the North Sea (Skov *et al*. 1995). Wee Bankie and Marr Bank (Figure 2.1) encompassed by the Zone, but falling outwith Alpha and Bravo, are viewed as particularly important (Wanless *et al*. 1998, Camphuysen 2005). Scalp Bank, which abuts Alpha and Bravo (Figure 2.1), was also a focus of the sandeel fishery (Wanless *et al*. 1998) and is thus also likely to be a feeding ground for many seabirds (S Greenstreet *pers comm*) targeting sandeels as well as other species, although it falls outwith the area sampled in the studies of the interaction between seabirds and sandeels (Wanless *et al*. 1998, Daunt *et al*. 2008).

2.1.2 The Outer Forth/Wee Bankie/Marr Bank area was recognised by Kober *et al*. (2009) as being of international importance and thus potentially qualifying as an offshore Special Protection Area (SPA) for multiple seabird species. Only three other areas of sea around the UK were thought to be capable of achieving this status.

2.1.3 In the Forth the species involved were breeding Northern Gannet *Morus bassanus* (hereafter Gannet), Guillemot and Puffin as well as 'all species' in summer and wintering Kittiwake. Some near-qualifying areas were also recorded for Guillemot (wintering and additional season) and Puffin (breeding) and 'all species' when breeding.

2.1.4 Internationally important SPA seabird colonies border the Firth of Forth (Figure 2.1) with these SPAs often comprised of several nationally important Sites of Special Scientific Interest (SSSIs). In the estuary, The Imperial Dock Lock SPA currently supports the second largest Common Tern colony in Britain (SMP Online Database 2012). Further seaward within the Firth itself, The Forth Islands SPA comprised of a series of islands constitutes one of the UK's premier areas for breeding seabirds with some 90,000 individuals at the time of designation (Stroud *et al.* 2001) (Table 2.1), although there have been considerable changes in abundance since.

2.1.5 According to Natura 2000 (see http//:www.jncc. gov.uk), the SPA holds internationally important breeding numbers of Gannet, Puffin, European Shag *Phalacrocorax aristotelis* (hereafter Shag), Lesser Black-backed Gull , and Arctic *Sterna paradisaea*, Roseate *Sterna dougalii*, Common *Sterna hirundo* and Sandwich *Sterna sandvicensis* Terns. Nationally important numbers of Razorbill, Guillemot, Kittiwake, Herring Gull, Great Cormorant *Phalacrocorax carbo* (hereafter Cormorant) and Northern Fulmar *Fulmarus glacialis* (herafter Fulmar) are also present.

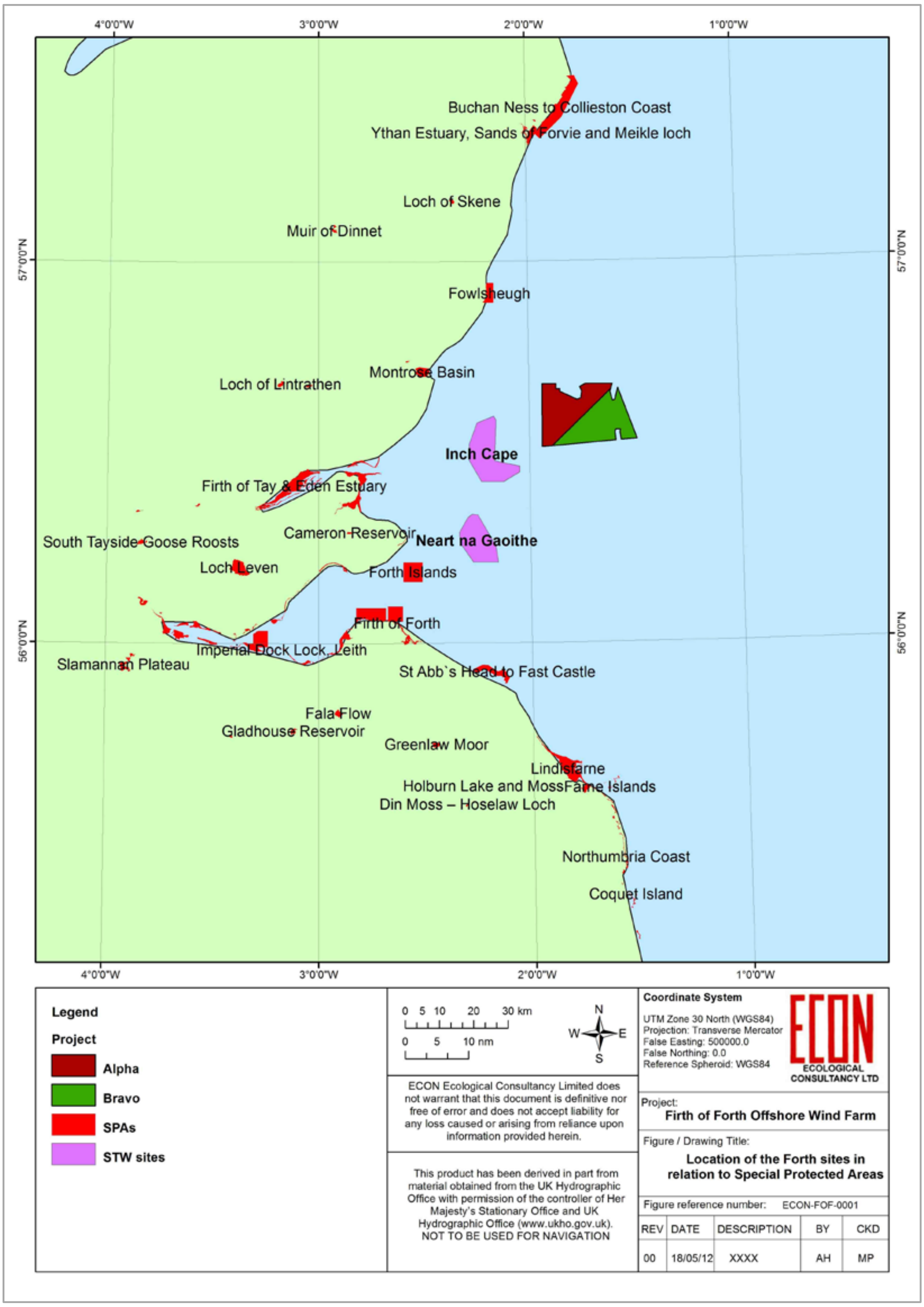


Figure 2.1 Location of Alpha and Bravo and STW sites in relation to SPAs for both seabirds and other species from Northumbria in the south to Peterhead in the north.

2.1.6 Within the Forth Island SPA, the Gannet colony on the Bass Rock is the largest of the three colonies on the east coast of the UK. The colony increased rapidly from

8,077 pairs in 1970 (Cramp *et al.* 1974) to 48,065 pairs in 2004 (Wanless *et al*. 2005a) and then to 55,482 breeding pairs in 2009 and set to overtake St Kilda as the largest colony in the World within a few years if the rate of growth continues (Murray 2011).

2.1.7 The nearby Isle of May supports ~150,000 individual seabirds, including 56,867 pairs of Puffin in 2009, making it probably the fourth largest colony in Britain for this species (SMP Online Database 2012). Other significant breeding species include Guillemot, Razorbill and Kittiwake. Herring and Lesser Black-backed Gulls used to breed in significant numbers on the island but were subject to an intense culling programme between 1972 and 1981 that depressed numbers (Forrester *et al*. 2007).

2.1.8 Fowlsheugh SPA, situated within 30 km to the north-west of Alpha, contained the third largest Guillemot colony in Britain in Seabird 2000. In 2009, 50,556 individual Guillemots were present (SMP Online Database 2012 - Table 2.1). Further north at 85 km from Alpha, Buchan Ness to Collieston Coast SPA currently (2007) supports around 63,000 individual seabirds, including Guillemot, Kittiwake, Herring Gull, Shag and Fulmar. Some 70 km to the south of the Bravo, St Abb's Head to Fast Castle SPA currently supports around 58,000 breeding birds (SMP Online Database 2012). Designated species include Razorbill, Guillemot, Kittiwake, Herring Gull and Shag (Stroud *et al.* 2001).

2.1.9 The Farne Islands SPA, a minimum of 101 km from Bravo and some 47 km further south along the coast from St Abb's is comprised of at least 15 islands (increasing to 28 depending on the state of the tide). There are over 20 species of breeding seabird, of which six species are designated within the SPA. This includes four species of tern – Arctic, Sandwich, Common and Roseate – as well as Guillemot and Puffin. The latter is the more abundant of the designated species with 36,835 pairs in 2008 (SMP Online Database 2012), amongst the 140,930 seabirds overall.

2.1.10 Some 45,000 visitors take the boat trip to the Farne Islands per annum. This public interest is also mirrored in the Forth Islands SPA, with more than 250,000 visitors a year visiting The Scottish Seabird Centre at North Berwick that has interactive webcams within various parts of the SPA.

2.1.11 Seabirds tend to have large foraging ranges when breeding, with this varying considerably according to body size and morphology within the different phylogenetic groups. For example, shearwaters and petrels tending to have large ranges according to size and gulls, terns and some cormorants/shags having relatively small ranges. Gannet, Fulmar and Manx Shearwater have the largest maximum ranges of seabirds breeding in the UK, at 580 km, 590 km and 330 km respectively according to Thaxter *et al*. (2012) meaning that birds from much more distant colonies may be recorded within the area occupied by Alpha and Bravo. This greatly increases the number of breeding seabirds that potentially may be affected by the development.

Table 2.1 Numbers of breeding seabirds (individuals) of each species designated within each SPA bordering the Firth of Forth and/or within ~100 km of Alpha and Bravo, as defined in Natura 2000 or Stroud *et al.* (2001) where Natura was updated (marked with *). Species in the assemblage for which no population size is given are marked +. The sites are in order of their minimum distance to either development as shown in parentheses. Note that the populations will invariably have changed over time, with the most recent counts for any species at any colony as defined by the Seabird Monitoring Programme (SMP) used elsewhere in this document.

Species	Fowlsheugh (29 km)	Firth of Forth Islands (53 km)	St. Abb's to Fast Castle (68 km)	Buchan Ness to Collieston Coast (84 km)	Imperial Dock Lock (96 km)	Farne Islands (101 km)	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		+	8,984
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*				4,140	4,184
Common Tern		1,600			1,116	460	3,176
Roseate Tern		18*				6*	24
Arctic Tern		1,080				5,680	6,760
Common Guillemot	80,280*	32,000	31,750	17,280		46,998*	208,308
Razorbill	5,800	2,800	2,180				10,780
Atlantic Puffin		42,000*				69,420	111,420
Total	164,540	191,952	79,710	92,388	1,116	126,704	656,410

2.1.12 An idea of the number of breeding seabirds that are in range of Alpha and Bravo was gained by using the respective foraging range of any seabird and then totalling the number of individuals represented within the colonies in range. However, in order to provide a more sensible measure for wide ranging Gannet and Fulmar, only those colonies within 120 km were included, likely to fit with the majority of foraging birds and providing a sensible geographical context (i.e. including the Gannet colony at Troup Head and thereby just reaching but not including the Moray Firth). The total number of breeding seabirds from latest counts conducted between 1998 and 2011 (SMP Online Database 2012) was 766,439 breeding individuals.

2.1.13 Outside the breeding season, seabirds range extremely widely. For example, Frederiksen *et al*. (2011) have recently shown that the median position of Kittiwakes carrying geolocators that had bred at 19 North Atlantic colonies including the Isle of May, was typically between 2,000-4,000 km away by December. However, birds from a few colonies remained close to those same colonies. Therefore, the 50% kernel contours showing the core of habitat use of birds from the Isle of May were split between one area of the northwestern North Sea and another a significant distance away in the Central and West Atlantic.

2.1.14 Guilford *et al*. (2011) showed that Puffins from Skomer (Wales) did not have a common wintering area but individuals undertook different patterns of dispersal that ranged from the western Atlantic to the central Mediterranean. The bird reaching the latter by late winter spent the autumn south of Iceland. In contrast, Harris *et al*. (2010) also using geolocators showed that Puffins breeding on the Isle of May mainly wintered in the northwestern North Sea although most individuals made excursions into the east Atlantic in the early winter.

2.1.15 Birds present in the Forth of Firth and within respective development areas outside the breeding season may thus originate from a large proportion of the biogeographic population and breeding range of the species, as well as representing birds of much more local provenance. Considerable care must be taken when attempting to interpret the origin of any birds present in relation to the impact upon a particular population (e.g. a specific SPA). Specific information from tracking studies may be required to reduce the considerable uncertainty in many cases.

2.2 Importance of the Firth of Forth for non-seabirds

2.2.1 The Forth is a complex estuary, stretching for over 100 km from the River Forth at Stirling eastwards past Edinburgh and along the coasts of Fife and East Lothian to a wide mouth. The estuary contains a broad range of coastal and intertidal habitats, including saltmarshes, dune systems, maritime grasslands, heath and fen, cliff slopes, shingle and brackish lagoons. Extensive mudflats occur particularly in the Inner Firth, notably at Kinneil Kerse and Skinflats on the south shore and at Torry Bay on the north shore, which support a rich invertebrate fauna and plants such as Eelgrass *Zostera* spp. In the Outer Firth the shoreline diversifies, with sandy shores, mussel beds and some rocky outcrops and artificial sea walls. The North Berwick coast includes cliffs and dune grassland, with extensive dune systems at Aberlady.

2.2.2 The large range of habitats and particularly the extensive mudflats invariably support large numbers of migrating and wintering waterbirds. The Firth of Forth SPA, which covers most of the shoreline of the Forth Estuary above the low water mark, is an important overwintering site for a wide range of waterfowl. The estuary regularly supports 86,067 birds each year according to Stroud *et al*. (2001) including important numbers of Red Knot (hereafter Knot in the text) *Calidris canuta*, Pink-footed Goose *Anser brachyrhynchus*, Common Redshank (hereafter Redshank in the text) *Tringa totanus*, Shelduck *Tadorna tadorna*, Ruddy Turnstone (hereafter Turnstone in the text) *Arenaria interpres*, Bar-tailed Godwit *Limosa lapponica*, European Golden Plover (hereafter Golden Plover in the text) *Pluvialis apricaria*, Red-throated Diver and Slavonian Grebe *Podiceps auritus*, and an assemblage including Great Crested *Grebe Podiceps cristatus*, Cormorant and other species of duck, goose and wader. The SPA also includes Sandwich Tern on passage (Stroud *et al.* 2001).

2.2.3 The Firth of Tay and Eden Estuary SPA lies 72 km immediately west of Alpha and Bravo. As well as supporting breeding Little Tern *Sternula albifrons* and Marsh Harrier *Circus aeruginosus*, in winter the site regularly holds 34,074 waterfowl, including Pink-footed Goose, Greylag Goose *Anser anser*, Bar-tailed Godwit and Redshank. Montrose Basin SPA, ~30 km to the north, is important for wintering Pink-footed Goose and Greylag Goose, along with ducks and waders, supporting 54,917 individual birds (Stroud *et al.* 2001).

2.2.4 The Ythan Estuary, Sands of Forvie and Meikle Loch SPA is located approximately halfway between Aberdeen and Peterhead some 73 km from Alpha and Bravo. Meikle Loch is an important winter roost site for Pink-footed Geese, while the SPA also supports important wintering numbers of Common Eider (hereafter Eider in text) *Somateria mollissima*, Northern Lapwing (hereafter Lapwing in the text) *Vanellus vanellus* and Redshank, which together total 51,265 individual birds (Stroud *et al*. 2001). The Sands of Forvie supports important numbers of breeding terns, including the largest Sandwich and Little Tern colonies in Scotland, totalling 590 and 36 pairs respectively in 2011 (SMP Online Database 2012).

2.2.5 Inland of the Firth of Forth itself, the Slamannan Plateau SPA supports the largest of only two regular wintering flocks in Britain of Taiga Bean Goose *Anser fabalis fabalis*, which migrate to Scotland from their Arctic breeding grounds in Scandinavia and Western Russia.

2.2.6 On the west coast, on the border between England and Scotland, the Upper Solway Flats and Marshes SPA forms one of the largest continuous areas of intertidal habitat in Britain and supports virtually all of the Svalbard population of Barnacle Goose *Branta leucopsis* during the winter. Satellite tracking has shown that in the autumn these geese come ashore at various locations along the east coast of Scotland, before moving southwest towards the Solway Firth (Griffin *et al*. 2011).

2.2.7 Westwater, Fala Flow and Gladhouse Reservoir SPAs located in the hills of southern Scotland are important wintering sites for Pink-footed Geese regularly supporting 31,127, 6,719 and 3,068 individuals respectively (Stroud *et al*. 2001). Pink-footed Geese breed in Iceland and Greenland, and therefore probably at least some cross the Firth of Forth on their migration.

2.2.8 Further north, inland from the Tay Estuary, South Tayside Goose Roosts, Loch Leven, Cameron Reservoir and Loch of Kinnordy SPAs also support wintering Pink-footed Geese regularly supporting 43,300, 18,230, 16,233 and 4,760 individuals respectively. Both South Tayside Goose Roosts and Loch of Kinnordy SPAs also support wintering Greylag Geese, numbering 3,667 and 1,000 respectively (Stroud *et al*. 2001).

2.2.9 Important wintering populations of Greylag Geese also occur at Loch of Lintrathen (3,098 individuals) in Angus, and Muir of Dinnet (29,458 individuals) and Loch of Skene (10,840 individuals) further north in Aberdeenshire (Stroud *et al*. 2001). These Greylag Geese breed in Iceland, so again like Pink-footed Geese, at least some probably cross the Firth of Forth each spring and autumn.

2.2.10 Migrating Whooper Swans may also cross the Firth of Forth as they migrate along the east coast (Griffin *et al*. 2010, 2011). The SPAs at Lindisfarne, Loch Leven and Loch Skene support 79, 101 and 203 individuals respectively, with larger numbers (963 individuals) at the Ouse Washes SPA on the border between Norfolk and Cambridgeshire (Stroud *et al*. 2001).

2.2.11 As well as waders and waterfowl heading for sites within or in the vicinity of the Forth of Firth, the developments may fall within the migration flyways for other species such as passerines and raptors heading to/from the east coast of Scotland and England from northerly breeding grounds. Whilst these may not be attributable to a particular designated site, these species must also be considered during Environmental Impact Assessment (EIA).

3. AIMS & OBJECTIVES

3.1.1 The aim of this technical report was to present detailed information on the distribution, abundance (both density and population size) activity and behaviour of birds, both on the water as well as in flight, in the sea areas to be occupied by the Alpha and Bravo developments. This information was then to be interrogated further for the purposes of EIA and for Habitat Regulations Assessment (HRA) in relation to designated species within European sites (SPAs in relation to birds) where required. In relation to both processes, estimates of the numbers of flying birds could be used to assess collision risk and numbers of both birds on the water and in flight provided the basis of the number of birds that may be displaced.

3.1.2 This report builds on information previously presented in an interim report of the two-year characterisation of the wider Zone (Seagreen Wind Energy 2011b) and within the sections on ornithology in the ZAP report for the Crown Estate (Seagreen Wind Energy 2010) and its update (Seagreen Wind Energy 2011a).

3.1.3 As well as providing an overall analysis of all bird species recorded within the Alpha and Bravo development areas, a key objective of this technical report was to outline which species would be taken forward as sensitive receptors into the EIA presented within the relevant ornithological chapter of the Environmental Statement (ES). In theory this could be composed of any combination of the following groups:

- Breeding seabirds;
- Overwintering seabirds; and
- Migratory species - be they seabirds and/or terrestrial/coastal species migrating to inland/coastal SPAs.

3.1.4 The same groups could also feature within the HRA process where these form part of the designation of seabird breeding colonies or estuarine/wetland sites associated with the coast or even further inland (see section 2.2 above). Whilst any species meeting particular criteria of abundance or rarity could be a sensitive receptor in EIA, only designated species within a potentially affected European site could trigger the HRA process.

3.1.5 Moreover, whilst some species may be involved in either process (e.g. a numerically abundant species that was also part of relevant SPAs), some may be a part of one process and not the other. For example, a non-designated species occurring in important numbers may be an important focus of EIA but not HRA, whereas a designated species that was rarely recorded in surveys may still be a focus of HRA but may be scoped out of EIA. In theory, and dependent on the selection criteria for EIA in particular, either process could involve species that were not actually recorded on site.

3.1.6 The primary source of information was a specific boat-based monitoring programme of 23 monthly surveys from December 2009 – November 2011 inclusive. The periods surveyed corresponded with over-wintering, spring passage, breeding season and autumn passage for both seabirds and migratory coastal, wetland and terrestrial species.

4. METHODOLOGY

4.1 Reference information

4.1.1 Overall, the area encompassed by the Zone in which Alpha and Bravo are situated, is data-rich from an ornithological perspective. Sources of information include the following:

- The European Seabirds at Sea (ESAS) database maintained by the JNCC in the UK contains 3.5 million records of seabirds and cetaceans. Historic versions of the database are represented in *An atlas of seabird distribution in north-west European waters* (Stone *et al*. 1995) and *Important Bird Areas for seabirds in the North Sea* (Skov *et al*. 1995). Kober *et al*. (2009) also used the database as the basis of their analysis to identify potential areas for offshore SPAs for seabirds.
- Data on the abundance and distribution of seabirds from 1991 to 2004 gathered as a supplement to the International Council for the Exploration of the Sea

(ICES) annual stock assessments undertaken aboard RV Tridens. Camphuysen (2005) presents general information on a range of species, with further information specific to Gannet in association with Bass Rock presented in Camphuysen (2011).

- The Natural Environmental Research Council's (NERC) Centre for Ecology and Hydrology (CEH) has undertaken a wealth of research on a range of breeding seabirds, particularly on the Isle of May covering many aspects of their biology including effects of climate change, annual survival rates and breeding success, foraging ecology and the impacts of commercial fisheries (e.g. Wanless *et al*. 1990, 1998, 2005a, Frederiksen *et al*. 2004, 2007). Species with a particular focus of interest include Kittiwake (e.g. Daunt *et al*. 2002, Bogdanova *et al*. 2011), Puffin (e.g. Wanless *et al*. 1990, Harris *et al*. 2010) and Guillemot (e.g. Wanless *et al*. 1998, 2005a).
- The Gannets of Bass Rock have also attracted considerable research interest mainly from the team led by Professor Keith Hamer at the University of Leeds. Particular attention has been given to the foraging movements from the colony (Hamer *et al*. 2000, 2001, 2007) with subsequent modelling of habitat association (Skov *et al*. 2008), and how foraging trip duration is linked with provisioning behaviour (Lewis *et al*. 2004) and colony size (Lewis *et al*. 2001).
- The IMPRESS project (interactions between the marine environment, predators and prey), joint funded by the EU and CEH and carried out between 2000 and 2004 took a multidisciplinary bottom-up approach to investigating declines at seabird colonies by studying the effect of climate change and hydrography on temporal and spatial patterns in sandeel abundance and on the foraging performance of seabirds (Greenstreet *et al*. 2006, 2010, Scott *et al*. 2006, 2010, Daunt *et al*. 2008).

4.1.2 More general information on the distribution and size of all seabird colonies in the region as defined by county, is documented by the results of the Seabird 2000 Census 1998-2002 reported by Mitchell *et al*. (2004). More up to date information for selected colonies is provided by the Seabird Monitoring Programme (SMP) database (http://jncc.defra.gov.uk/smp) which may then provide an indication of the trends for species and colonies. The location of a colony coupled with foraging radii (range) analysis indicates whether seabirds from particular colonies may be expected to reach the development site.

4.1.3 The size and trends of wider scale national and international breeding populations are summarised in BirdLife International (2004), Baker *et al*. (2006), Wetlands International (2006), BirdLife International *et al*. (2007) and Musgrove *et al*. (2011) These publications provide information on population sizes during the breeding season and in some cases outside the breeding season, typically in wintering populations (e.g. Musgrove *et al*. 2011).

4.1.4 Other works of reference such as *The Birds of Scotland* (Forrester *et al*. 2007) were utilised to provide general ecological information of relevance for some species to provide further insight into likely patterns of seasonal and temporal use. For non-breeding species and waterfowl as well as land birds, *The Migration Atlas:*

movements of the birds of Britain and Ireland (Wernham *et al*. 2002) provides useful information on possible dispersion and migration patterns that may be of relevance.

4.1.5 Griffin *et al*. (2010, 2011) provide more detailed information on the migratory routes of swans (specifically Whooper Swan *Cygnus cygus*) and several species of geese. The latter included Barnacle Goose *Branta leucopsis* originating from Svalbard thought likely to cross the Forth on their way to wintering grounds on the Solway Firth off the west coast of Scotland.

4.1.6 Strategic Ornithological Support Services (SOSS) for the wind farm industry managed by the British Trust for Ornithology (BTO) compiled all available information on migratory routes for 101 species and races to allow the risks of any specific offshore wind farm for particular species to be assessed (Wright *et al*. 2012). How this information is used within a theoretical framework in relation to potential collision risk is detailed below.

4.1.7 In the specific case of seabirds, despite a considerable amount of reference data, there was a relative paucity of relevant information on the abundance and distribution of seabirds within the Zone, and thus Alpha and Bravo, and the relative importance of these areas compared to STW. Gap analysis by Pollock & Barton (2006) for the Department of Trade & Industry[1] showed that of the data gathered from 1980 to 2003, some 77% were >10 years old with only 7% of data gathered from 1999-2003 and that highest coverage was in July with the lowest in December.

4.1.8 The validity of this data for assessment of current developments was in question and in a bid to fill data gaps to inform the Strategic Environmental Assessment (SEA) process, the Department of Energy & Climate Change (DECC) commissioned aerial surveys of selected areas around the UK, which included all of the R3 Firth of Forth Zone in two separate seasonal periods. The latter were the summer of 2009 (May – August 2009) and the winter of 2009/10 (November 2009 – March 2010).

4.1.9 Aerial survey data were analysed as a supplement to the primary data gathering technique of boat-based surveys to provide additional information about bird distribution within Alpha and Bravo, the wider Zone and the surrounding area not covered by the boat surveys and thus help set a regional context of density and population size of birds within Alpha and Bravo. The methods employed of aerial surveys are outlined below (see 4.3) with the findings of these surveys set out briefly below.

4.1.10 In keeping with the need to generate information specific to the relative importance of Alpha and Bravo, the wider Zone and STW sites, the Forth and Tay Offshore Wind Developers Group (FTOWDG) comprised of Seagreen, Mainstream Renewable Power and Repsol facilitated by The Crown Estate, commissioned CEH to undertake tracking studies of particular seabird species at a range of colonies around the Firth

[1] superseded by the Department for Business, Enterprise and Regulatory Reform (BERR) and thence by the Department of Energy & Climate Change (DECC).

of Forth in 2010 and 2011. The methods of these studies are described below (see 4.4) with findings detailed below.

4.1.11 Both the aerial surveys and especially the tracking studies provided supplementary material to support the specific and intensive boat-based survey programme conducted over the entire Zone including the proposed Alpha and Bravo developments (see **4.2 below).**

Collision risk modelling as a screening tool

4.1.12 A number of species such as waders and waterfowl designated within the many SPAs bordering the Firth of Forth were thought unlikely be recorded during boat-based surveys at all, or in such small numbers to prohibit meaningful estimation of the numbers crossing the area. With no estimate of passage rate there could be no assessment of risk required by HRA for these designated species.

4.1.13 Following discussion and advice from the statutory advisors, three species of migratory geese – Barnacle Goose originating from Svalbard, the Taiga race of Bean Goose and Pink-footed Goose – and thirteen species of wading bird – Eurasian Oystercatcher (hereafter Oystercatcher in the text) *Haematopus ostralegus*, Common Ringed Plover (hereafter Ringed Plover in the text) *Charadrius hiaticula*, Golden Plover, Grey Plover *Pluvialis squatarola*, Lapwing, Knot, Sanderling *Calidris alba*, Dunlin *Calidris alpina*, Black-tailed Godwit *Limosa limosa*, Bar-tailed Godwit, Eurasian Curlew (hereafter Curlew in the text) *Numenius arquata*, Redshank and Turnstone – linked to one or more SPAs to be included in HRA (Seagreen Wind Energy Ltd. 2011c).

4.1.14 The likelihood of populations of these 16 species to be impacted as a result of collision with the turbines in Projects Alpha and Bravo was explored through theoretical collision risk modelling (CRM) using reference information and following guidance provided by the Strategic Ornithological Support Services (SOSS) supplied by the British Trust for Ornithology (BTO) (Wright *et al.* 2012). Guidance provides the size of the migratory population and a map showing the main migration flyway for each of the 16 species of interest here.

4.1.15 The numbers of geese and waders in their respective specific migratory flyways used in modelling as defined and adapted from Wright *et al*. (2012) are shown in Table 4.1. Pink-footed Goose was by far the most numerous goose with 360,000 individuals in the national wintering population (Wright *et al.* 2012), followed by the 33,000 Svalbard Barnacle Geese all wintering at the Upper Solway Flats and Marshes SPA, with just 410 Taiga Bean Geese in two small flocks in Broadland SPA in Norfolk, England and on the Slamannan Plateau SPA in the vicinity of the Firth of Forth. At the latter site, there were 260 birds in winter of 2009/10 (Holt *et al.* 2011).

4.1.16 According to Wright *et al*. (2012) the northerly limit of the flyway of Taiga Bean Goose lies some 20 km to the south of Alpha and Bravo meaning that collision risk was automatically zero. Considering the large flyway proposed, this could not be justified and the flyway was assumed to include Alpha and Bravo in this modelling exercise. Moreover, an alternative and highly precautionary approach was adopted in relation to the specific part of the population of Taiga Bean Goose comprised of 260 individuals overwintering at the Slamannan Plateau. The entire population was assumed to fly through both Alpha and Bravo separately in both autumn and spring.

4.1.1 It was also possible to model the collision risk for migrating Barnacle Goose more realistically using data from satellite-tracking studies (Griffin *et al.* 2011), that showed birds migrated over a narrower front of 281 km perpendicular to the direction of travel measured across the wind farm footprint, than the 587 km presented in the SOSS guidance (Wright *et al*. 2012). The two potential flyways are shown in Figure 4.1. Griffin *et al.* (2011) also showed that only 30.2% of Barnacle Geese flew at potential risk height while migrating over the sea compared with an assumed value of 75% by Wright *et al*. (2012) (see below).

4.1.2 Amongst the migratory wading birds, a number of species also breed within the UK, with some of these individuals migrating to winter elsewhere. Wright *et al*. (2012) supply a generic migratory route for breeding Oystercatcher, Ringed Plover, Golden Plover, Dunlin, Black-tailed Godwit, Curlew and Redshank. No route is supplied for Lapwing, which thus assumes that breeding birds will remain in the UK.

4.1.3 In all these cases, consideration of the breeding range in relation to the migratory route from the UK, suggests that not all, or indeed any, individuals could cross the Firth of Forth. A precautionary assumption of 50% of the population of any species that at least had the potential to cross the Forth was applied to the populations used in modelling (Table 4.1). An exception to this was breeding Dunlin as all of 1,007,500 individuals of the races *schinzii* and *arctica*, that either breed in Britain and Ireland or pass through on migration from Iceland and Greenland were pooled and all assumed to have the potential to cross the Firth of Forth.

4.1.4 For Redshank, 50% of breeding *britannica* and all of the 275,000 individuals of *robusta* breeding in Iceland and the Faeroes and were incorporated into modelling, the flyway of the *totanus* race breeding in Continental Europe does not cross the Firth of Forth according to Wright *et al*. (2012) and these were excluded.

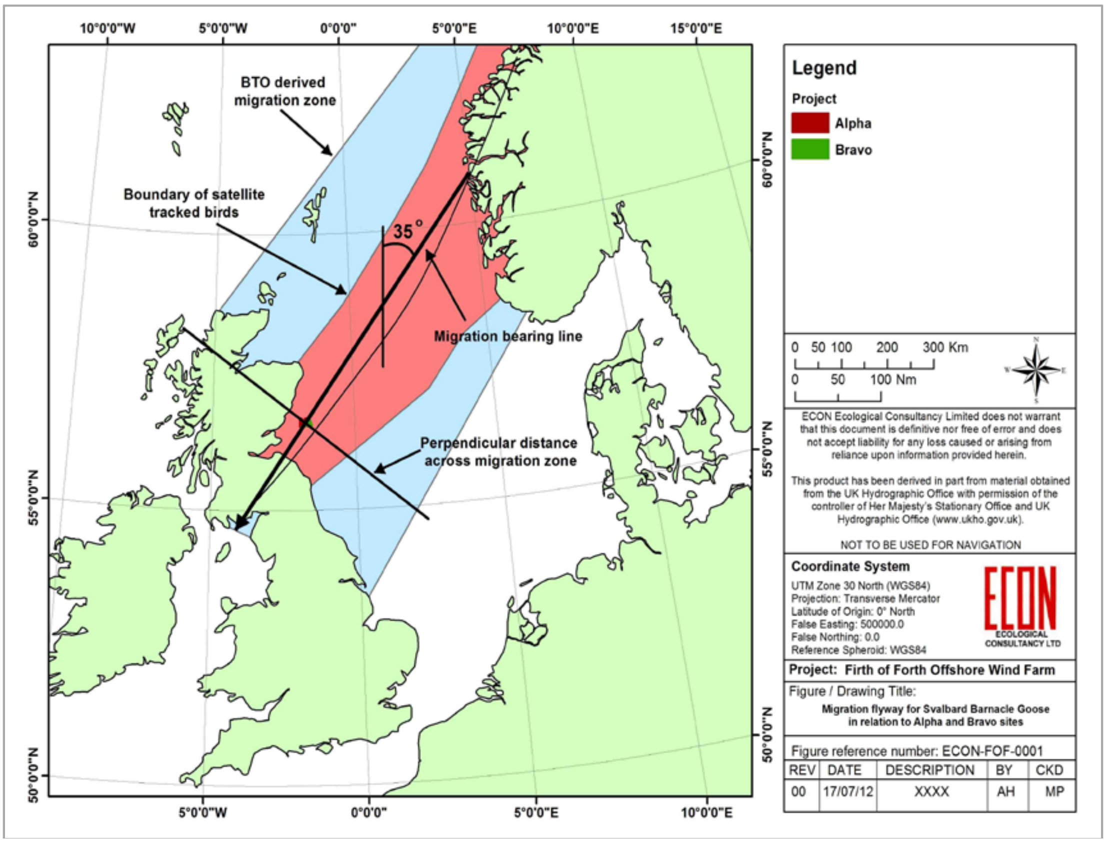


Figure 4.1 Migratory flyway of Svalbard Barnacle Goose according to Wright *et al.* (2012) in relation to the actual route used by $n = 26$ individuals satellite tracked by Griffin *et al.* (2011). Additional lines detail the methodology of Wright *et al.* used to calculate the bearing and width of the migration front in relation to Alpha and Bravo and thus the numbers of birds crossing the wind farms.

4.1.5 In addition, for Ringed Plover, the flyway of birds breeding in Arctic Canada, Greenland and Iceland (73,000 individuals) is centred on the west coast of the UK, although Wright *et al*. (2012) suggest that some southwards migration also occurs along the east coast of Britain during the autumn, probably also involving birds from Scandinavia. Thus, as a precautionary view, 50% of the flyway population was assumed to pass along the east coast in the autumn and thus have the potential to cross the Firth of Forth. But, in accordance with Wright *et al*. (2012), the entire population was assumed to migrate northwards along the west coast in spring, with no link to the Firth of Forth.

Table 4.1 Width of migratory front (km), bearing (degrees) of spring migration and mean distance and maximum width (km) across both Alpha and Bravo all perpendicular to the bearing of migration for the 16 species of migratory waterfowl assessed. Data derived from Wright *et al*. (2012) apart from Holt *et al*. (2011) in relation to the Taiga Bean Geese of the Slammannan Plateau SPA.

Species	Race, population, or fraction of population	Numbers of individuals in modelled flyway population	Width of migratory front (km)	Bearing of spring migration	Mean distance across site (km)		Maximum width across site (km)	
					Alpha	Bravo	Alpha	Bravo
(Svalbard) Barnacle Goose	Svalbard	33,000	587	35	11.51	10.31	15.24	15.88
Taiga Bean Goose		410	613	95	9.90	10.87	18.45	15.38
	Slammannan Plateau	260	15-18	95	9.90	10.87	18.45	15.38
Pink-footed Goose		360,000	505	327	7.37	7.69	24.31	24.50
Eurasian Oystercatcher	breeding	113,000[1]	754	335	7.52	8.01	22.72	24.02
	non-breeding	274,620	1473	351	8.70	7.94	20.79	24.56
Common Ringed Plover	breeding	5,438[1]	745	336	7.52	8.01	22.72	24.02
	non-breeding	36,500	1006	223[2]	13.02	11.90	15.09	15.75
European Golden Plover	breeding	22,600[1]	745	335	7.52	8.01	22.72	24.02
	non-breeding	566,700	1084	333	7.52	8.01	22.72	24.02
Grey Plover		49,315	958	33	11.51	10.31	15.24	15.88
Northern Lapwing		827,700	957	33	11.51	10.31	15.24	15.88
Red Knot		338.970	1358	358	9.21	7.75	20.51	23.26
Sanderling		22,680	1347	358	9.21	7.75	20.51	23.26
Dunlin	*schinzii* and *arctica*	1,007,500	882	334	7.52	8.01	22.72	24.02
	alpina	438,480	838	90	9.90	10.87	18.45	15.38
Black-tailed Godwit		56,880	1148	327	7.37	7.69	1148	24.50
Bar-tailed Godwit		54,280	970	64	11.49	12.08	970	15.98

Species	Race, population, or fraction of population	Numbers of individuals in modelled flyway population	Width of migratory front (km)	Bearing of spring migration	Mean distance across site (km)		Maximum width across site (km)	
					Alpha	Bravo	Alpha	Bravo
Eurasian Curlew	breeding	107,000[1]	707	337	7.52	8.01	707	24.02
	non-breeding	194,650	1059	81	11.08	12.24	1059	15.22
Common Redshank	breeding *britannica*	38,800[1]	1176	313	7.45	7.71	1176	22.85
	non-breeding *robusta*	275,000	1138	326	7.37	7.69	1138	24.50
Ruddy Turnstone		59,810	1342	334	7.52	8.01	1342	24.02

[1] Following the assumption that 50% of the British breeding population is migratory with the potential to cross the Forth of Forth.

[2] Bearing of autumn migration only as passage birds do not cross Alpha in spring.

4.1.6 The methodology used to calculate collision mortality to migrating populations derived from SOSS guidance consisted of the following stages:

- Estimate the number of birds crossing the wind farm at any height by calculating the proportion of the width of the migratory front perpendicular to the bearing of migration (and on the plane where it crosses the wind farm) occupied by the maximum width of the respective wind farm (see Figure 4.1 & Table 4.1).
- Assuming these birds cross the wind farm footprint once each during spring and autumn, derive a spring and autumn density using the mean distance across the wind farm in the direction of travel and the mean flight speed of the species.
- Feed densities and an estimate of the proportion of birds flying at risk height, into the model (Band 2011) to derive an annual collision mortality.

4.1.7 The bearing of migration was determined by drawing a straight line from the geographic centre of the migration zone where it reaches the coast using the maps from Wright *et al*. (2012). The maximum distance across both Alpha and Bravo perpendicular to this bearing, the mean distance across Alpha and across Bravo parallel to this bearing, and the width of the migratory zone perpendicular to the bearing at the point that it crosses Alpha and Bravo were then calculated (Figure 4.2)

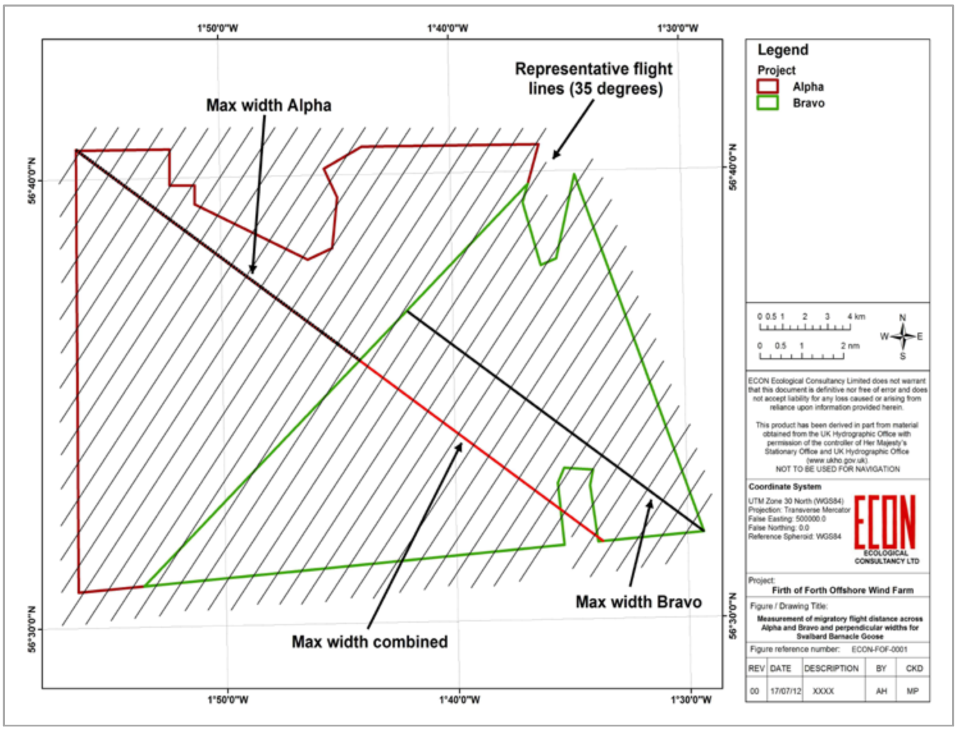


Figure 4.2 Method for estimating the maximum distance of travel for a migratory species across Alpha and Bravo from representative flight lines, relative to the maximum width of each site and combined. An example of Svalbard Barnacle Goose with a southbound flight bearing of 35° is used.

4.1.8 Using (Svalbard) Barnacle Goose as an example, the bearing of migration was calculated as 35° (Figure 4.2). The maximum distance across Alpha perpendicular to the 35° bearing line was calculated to be 15.24 km and across Bravo to be 15.88 km. With the width of the migratory zone perpendicular to the bearing line at the point that it crosses Alpha and Bravo measured at 587 km the proportion of the migratory population crossing Alpha in spring and again in autumn was calculated to be 15.24 / 587 = 2.60%, and for Bravo to be 15.88 / 587 = 2.71%.

4.1.9 Either spring or autumn migration can be used to set the bearing of migration since it is assumed that birds undertake the reciprocal route in either direction. For (Svalbard) Barnacle Goose the 35° bearing of spring migration was 35 + 180° = 215° in autumn. The single exception in this exercise was Ringed Plover where the available evidence from Wright *et al*. (2012) suggests that there is no autumn migration on the same route as in spring (see 4.15 above and Table 4.1).

4.1.10 For each species to be modelled, the Band model requires the length and wingspan of the species as well as flight speed and a percentage flying at risk height. As recommended in the guidance from SOSS the percentage flying at risk height was assumed to be 75% for both goose and wader species, which is likely to be highly precautionary. The other parameters were sourced from the literature (Table 4.2).

Table 4.2 Morphological and behavioural parameters of passage species used in collision risk modelling.

Species	Bird length (m)[1]	Wingspan (m)[1]	Flight speed (ms^{-1})[2]
(Svalbard) Barnacle Goose	0.64	1.385	17.0
Taiga Bean Goose	0.75	1.585	17.3
Pink-footed Goose	0.675	1.525	17.3
Eurasian Oystercatcher	0.425	0.83	13.0
Common Ringed Plover	0.19	0.525	19.5
European Golden Plover	0.275	0.715	13.7 [3]
Grey Plover	0.285	0.77	17.9
Northern Lapwing	0.295	0.845	12.8
Red Knot	0.24	0.59	20.1
Sanderling	0.205	0.425	15.3 [4]
Dunlin	0.18	0.405	15.3
Black-tailed Godwit	0.42	0.76	18.3 [5]
Bar-tailed Godwit	0.38	0.75	18.3
Eurasian Curlew	0.55	0.90	16.3
Common Redshank	0.28	0.625	12.3 [6]
Ruddy Turnstone	0.23	0.535	14.9

[1] Data from BWPi (2004). [2] Data from Alerstam *et al*. (2007). [3] Assumed same as closely-related American Golden Plover *Pluvialis dominica*. [4] Assumed same as related Dunlin. [5] Assumed same as related Bar-tailed Godwit. [6] Assumed same as related Common Greenshank *Tringa nebularia*.

4.1.11 The worst-case scenario for each of Alpha and Bravo, involving the installation of 75 wind turbine generators (WTGs) in each site, was modelled. These turbines have a maximum rotor diameter of 167 m, a maximum chord length of 6.6 m and are likely to operational for 88% of the time (Seagreen data). These parameters, together with the estimated mean monthly rotor speeds based on available wind resource data calculated by Seagreen (Table 4.3), are incorporated in the Band model.

Table 4.3 Mean monthly rotor speeds (RPM) of the 7 MW wind turbine generators to be used in both Alpha and Bravo.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
11.2	10.9	10.8	10.5	10.2	10.3	10.1	10.0	10.7	11.0	11.1	10.9

4.2 Boat-based surveys

4.2.1 Whilst both boat-based and aerial (aeroplane) surveys have been extensively used to assess the distribution and abundance of marine birds (e.g. Briggs *et al*. 1985, Dean *et al*. 2003, Ford *et al*. 2004, Mason *et al*. 2007), it is understood that the different methods have associated advantages and disadvantages (Henkel *et al*. 2007). When conducted with observers boat-based surveys allow more time to identify birds to species, record behaviour and provide the opportunity to collect additional data on oceanographic conditions. In contrast, aerial surveys allow for the faster coverage of a survey area, are less limited by sea state and avoid the requirement for corrections associated with birds following or avoiding the boat (Spear *et al*. 2004).

4.2.2 It has proved difficult to compare density estimates produced by the two methods due to the inherent differences in survey speed and thus ability to truly compare observations of birds that are not stationary in space or time. Briggs *et al*. (1985) attempted to conduct 'simultaneous' surveys that still encompassed delays of up to four hours, which led to a decrease in correlation between counts derived from aerial and boat-based surveys with increasing delay.

4.2.3 The species of bird will also play a large role in determining the success and thus comparability of each method (Briggs *et al*. 1985, Ford *et al*. 2004). In the study of Henkel *et al*. (2007), the density of all the birds combined and the density of Western *Aechmophorus occidentalis* and Clark's *A. clarkii* Grebes was greater from the air, whereas boat-based surveys produced higher estimates of Brandt's Cormorant *Phalacrocorax penicillatus*. There were no significant differences for four other taxa including Marbled Murrelet *Brachyramphus marmoratus*, the focus of the study, which displayed virtually identical estimates between surveys.

4.2.4 The recent development of high definition imagery for surveying seabirds and marine mammals (see Thaxter & Burton 2009) has been purported to improve the level of species identification and even offer flight height information. However, experience shows that the level of species identification amongst important groups such as auks and gulls is variable at best and cannot match the resolution and quality of boat-based data, although they do appear to be superior to visual techniques at least for some species (Buckland *et al*. 2012). At the onset of the survey programme, digital camera techniques were considered to be under development and were not considered further in relation to the characterisation of the avifauna of Alpha and Bravo.

4.2.5 Boat-based surveys were selected as the primary survey technique to characterise the Alpha and Bravo sites within the Zone as a result of their ability to provide a high degree of species identification coupled with specific information on the behaviour (i.e. feeding, resting, etc.) of the birds observed including interactions with other species.

Survey vessel & logistics

4.2.6 The 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. Conditions on the Zone reaching ~70 km offshore were predicted to be challenging.

4.2.7 To meet the challenge, a high-specification research vessel, the *MV Clupea,* the former Fisheries Research Vessel (FRS) of the area, exceeding COWRIE recommendations (Camphuysen *et al*. 2004) at 32.1 m, was chartered (Figure 4.3)[2]. 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.

4.2.8 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 wood bench seating secured to the deck (Figure 4.3). Similar seating was also installed within a bespoke designed and constructed observation area on top of the wheelhouse, offering a minimum of 6.2 m eye height when sitting (i.e. >7 m when standing).

[2] The *Clupea* suffered a significant fault and was out of service for the March (survey 3) and April (survey 4) surveys in 2010 (see Table 4.1). The *MV Dornoch* was used as a replacement. This 24.34 metre vessel has an eye-height of 5 m from an observation area in front of the wheelhouse on the upper deck providing an unrestricted view both forward and to 90° on either side of the vessel.

Figure 4.3 The survey vessel, the *MV Clupea* (below), the upper survey platform (above) and (left) bird survey team in operation (with additional 'guest' observer in the background)

4.2.9 It is preferable to cover all transects across the Zone in one continuous time period in any one month to reduce the possibility of redistribution of birds over time leading to 'double-counting', notwithstanding that the potential for this phenomenon was judged to be low as it was expected that many species would show distinct preferences for particular areas, perhaps linked to the known small-scale patchiness of primary productivity in the Firth of Forth (Scott *et al*. 2010).

4.2.10 However, continuous survey was thought unlikely to be possible especially in the winter months, simply because weather 'windows' especially outside more stable summer conditions, are often short (3-4 days at most) offshore in the North Sea in the north of Britain.

4.2.11 As a contingency for periods of poor weather the Zone was divided into four different survey areas broadly corresponding to the likely Phases of development − Phases 1, 2 and 3 − and the South area not initially proposed for development[3], with the aim of completing at least one of these in any weather window.

4.2.12 A further tactic to allow a continuous a survey as possible was to wait for appropriate conditions to provide the chance to complete as much of the Zone as possible. An initial short weather window may therefore not have been taken when there was a prospect of a more suitable opportunity a short time later. This required experience of forecasting using a number of forecasting systems (e.g. XC weather, Magic Seaweed, Windguru) and towards the end of the survey period using information from the wave height readings from the buoys installed on site. Seagreen were ultimately responsible for the selection of weather windows, with the skipper of the vessel deciding if the conditions were likely to be workable in advance, as well as maintaining complete control of working conditions whilst at sea.

4.2.13 It is of note that boat-based survey intervals proved to compare favourably with those delivered by previous aerial surveys in the Forth despite the speed of the aerial platform. This could be because aerial surveys are more sensitive to specific weather conditions or have other logistical constraints.

Survey design and route

4.2.14 The basic requirement of the survey programme was to undertake one survey per month of both Alpha and Bravo (as well as the wider Zone) for a total of 24 surveys over a two-year period from December 2009 to November 2011 inclusive (Table 4.4).

4.2.15 To ensure high data resolution, a survey route incorporating transect spacing of 3 km was designed. Orientation of transects was northwest to southeast to intercept the likely main axis of bird movement across the Zone, such as the movement of Gannets 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 (Figure 4.4).

[3] The initial surveys prior to the development of the Phase boundaries used the similar areas of 'North', 'East', 'West' and 'South'. Data from these areas was adjusted to the Phase boundaries (Seagreen 2011a).

Table 4.4 Details of transect route used, proportion of survey completed and date of each boat-based survey of Alpha and Bravo between December 2009 and November 2011 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
	3	4	26	21 February 2010
	4	4	100	20 – 21 March 2010
Breeding	5	4	100	3 – 4 April 2010
	6	1	100	19 – 20 May 2010
	7	3	100	16 June 2010
	8	4	100	10 July 2010
Dispersal	9	4	100	5 August 2010
	10	1	100	18 – 19 September 2010
	11	3	100	7 – 8 October 2010
	12	4	100	6 – 7 November 2010
Wintering	13	2	100	3 – 4, 6 December 2010
	14	3	100	13 – 14 January 2011
	15	4	100	10 – 11 February 2011
	16	1	100	1 – 3 March 2011
Breeding	17	2	100	9 April 2011
	18	3	100	4 May 2011
	19	4	100	10 June 2011
	20	1	100	9, 12 July 2011
Dispersal	21	2	100	1 August 2011
	22	3	100	17 – 18 September 2011
	23	1	100	27 – 28 October 2011
	24	2	100	5 – 7 November 2011

4.2.16 The northwest to southeast axis was preferred to any other potential environmental gradient such as bathymetry, partly as the latter is highly complex with a series of shallower areas (e.g. Scalp Bank, Wee Bankie and Marr Bank) across the area that could influence the distribution of birds across this prospective gradient. 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.

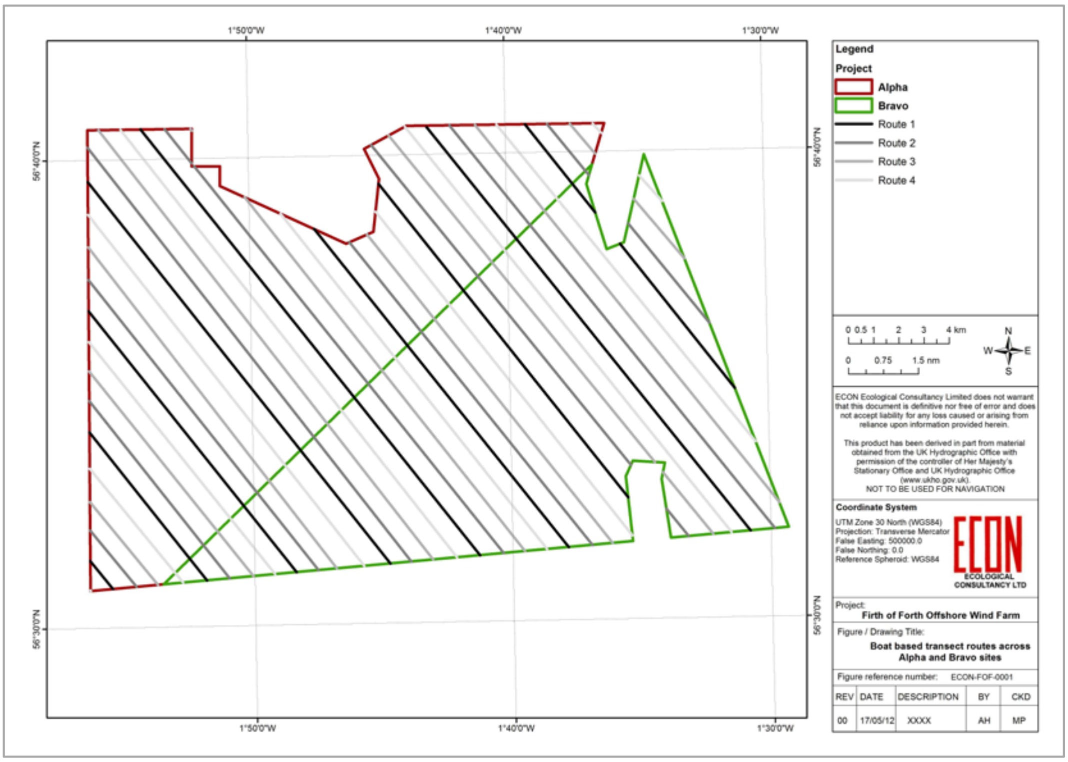


Figure 4.4 The different boat-based transect routes across Projects Alpha and Bravo.

4.2.17 There was high potential for fine-scale distribution of birds in the mosaic of habitat types, bathymetry and water circulation patterns resulting in the patchy distribution of prey across the Zone. 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. With transect spacing of 3 km, as much as 80% of the area would go unsurveyed (i.e. only a 600 m strip would be covered between transects at 3,000 m apart) greatly diminishing the chances of sampling small important patches.

4.2.18 To achieve the desired high level of coverage and thus best describe the spatial distribution, density and population size of birds across the Zone, four different survey routes of 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 (Figure 4.2). The random allocation of different routes (see Table 4.5) was then undertaken within 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. Thus, in any one phenological period, 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 routes. Surveys of Alpha and Bravo were incomplete in January 2010 and these surveys were amalgamated with February 2010 to provide 100% coverage in this period (Table 4.4). Other than this there was no imbalance of survey coverage within the different phenological periods (Table 4.4). A slightly reduced survey effort in winter did require consideration when assessing distribution patterns.

4.2.19 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 4.4). There was a need for this to also be considered when interpreting distribution patterns.

4.2.20 On any one survey, eight or nine individual transects were undertaken on any one survey covering Alpha and Bravo dependent on the route followed (Table 4.5). 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 4.6).

Table 4.5 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

4.2.21 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 that could play a significant role in overall site selection through ZAP (Seagreen Wind Energy 2011b) as well as macro- and micro-siting of turbines during EIA to reduce potential impacts. Moreover, EIA tends to be based on peak and mean populations of birds rather than specifically use any change in seasonal abundance.

4.2.22 Moreover, large-scale change in abundance of many species (e.g. breeding birds leaving the Zone outside the breeding season) was thought likely, meaning that seasonal changes were still likely to be detected by the reasonable number of transects (eight or nine) available as replicates in each of Alpha and Bravo (Table 4.6).

Data Collection and Survey

4.2.23 The methodology adopted on the survey was undertaken according to the following COWRIE recommendations (Camphuysen *et al*. 2004) that stem from the European Seabirds at Sea (ESAS) protocol (see Tasker *et al*. 1984, Webb & Durinck 1992):

- Vessel length of 32.1 m in relation to the requirement for length in excess of 20 m in a range of 20-100 m.
- Minimum eye-height of 6.2 m on the upper platform when sitting (more if standing) with 5 m on the lower platform, compared to the requirement for >5 m in the range of 5-20 m**.**
- Whenever possible, the ship speed was ~10 knots as required, although this varied between 5 – 11 knots depending on sea state while on transect;
- Birds were initially detected by eye with identification aided by the use of high quality binoculars;
- All birds recorded on the sea surface were placed within a distance band (A-E) perpendicular from the boat noting the side of the vessel (port or starboard): A = 0-50 m, B = 50 – 100 m, C = 100-200 m, D = 200-300 m (i.e. all within transect) and E= 300+ m (i.e. outside the transect area);
- Sea state (1 – 5) and other variables (glare, cloud cover and precipitation) that may affect observer efficiency were recorded. In addition, a general visibility score classified 1 – 5 was also recorded by surveyors from survey 9 onwards;
- Two competent observers (for seabirds) were provided as required, with these supported by a dedicated data recorder. The task of data recording was then rotated between the three surveyors. The surveyors had all been trained by experienced ornithologists' in-house, meeting a minimum of ESAS requirements.

4.2.24 A number of specific modifications to the standard methods were also incorporated, for the sole purpose of enhancing the value of the data for the assessment of wind farms. These have been routinely employed by ECON in previous surveys and as noted in the recent update of methods by COWRIE (Maclean *et al*. 2009):

- Line transect counts were conducted on both, rather than one side of the vessel where conditions allowed (e.g. glare did not severely hamper viewing along one side). Two surveyors were present on each survey covering a 300 m strip on each side of the boat, giving a total strip width of 600 m (Figure 4.5). Birds were however allocated to the specific side of the vessel so that data could be separated if required. Survey of both sides was employed to increase site coverage enhancing the understanding of the distribution of birds, to avoid underestimation of bird species occurring at low density and to make cost-effective use of resources, particularly vessel time. This also had the advantage of eliminating any 'heaping' (or 'lumping') of birds in band A which occurs when surveyors are forced to only survey one side of a transect line and violates one of the basic assumptions of any DISTANCE analysis used (Buckland *et al*. 2001, 2004, Thomas *et al*. 2010);

- Snapshot counts for flying birds were conducted ahead of the vessel (i.e. 180°) using radial distance bands to a maximum of 300 m (in the same divisions of A-D as noted above) rather than within a 'box' of 300 x 300 m (Tasker *et al*. 1984, Camphuysen *et al*. 2004). The ESAS method carries an underlying anomaly in that birds are recorded to a maximum of 424 m from the observers even where detection distance is set at 300 m (Figure 4.5). An unknown fraction of birds beyond 300 m distant are thus included as though they were within 300 m within the area of 0.18 km^2 sampled where both sides of the vessel are surveyed;

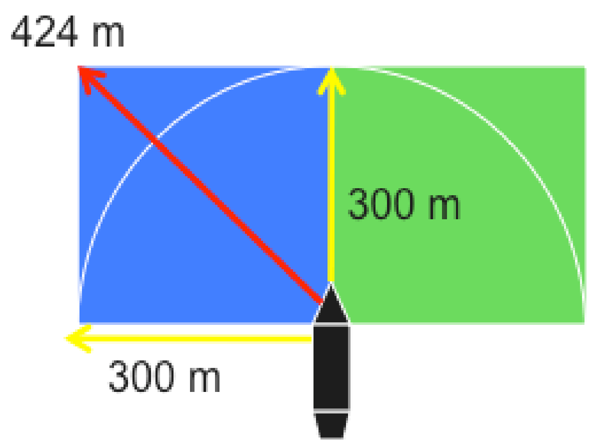


Figure 4.5 Diagrammatic representation of the area surveyed by the 'radial' method compared to the 'box' method each assuming a detection distance of 300 m. Birds are actually recorded to a distance of 424 m in the latter. The blue area represents survey of one side of the vessel often adopted by ESAS, whereas both sides of the vessel (blue and green areas) within radial bands were surveyed at Alpha and Bravo.

- The use of a radial method means that birds taken forward for density estimates are all within 300 m of observers within an area of 0.141 km^2 (both sides of the vessel surveyed) as adopted elsewhere (see Spear *et al*. 2004). Recording in distance bands also provides the potential for correction in DISTANCE as recent studies (e.g. Barbraud & Thiebot 2009) have shown that not all flying birds of any size are detected to a distance of 300 m, violating the basic assumption that all birds in flight are recorded to 300 m of the standard ESAS method. Even if distance correction cannot be achieved and densities remain uncorrected the potential for underestimation using the radial method is lower than using the 'box' method;
- Snapshots were conducted at 500 m intervals (~ 2 minute intervals) rather than timed along the specified transect lines, thereby compensating for any changes in vessel speed according to variable currents or sea state within and between

surveys. A consistent number of snapshots were therefore provided on each survey route with this varying to some extent between routes (122-135 on Alpha and 117-136 on Bravo) with further minor contribution as a result of the direction of travel and changes to navigational equipment in the course of the project);

- Snapshots are thus treated as discrete sample units and there is no assumption of complete coverage as in the ESAS method. The consistency of snapshots enabled the density of flying birds to be calculated accurately (essential in the calculation of collision risk) and also allowed the accurate plotting of bird location;
- Rather than assigning records to time bins, the time (to the second) at which each bird (or mammal - see below) was first seen, coupled with its location on either side of the vessel (port or starboard) was recorded, to allow accurate positioning in a Geographical Information System (GIS – ArcGIS v10);
- Flying birds were divided into three flight height bands: 1= <20 m (below potential strike height), 2 = 20-120 m (within potential strike height[4] and 3 = >120 m (above potential strike height) (in practice for larger turbines bands 2 & 3 may be combined).
- The direction of flight of all flying birds was recorded using eight compass directions or no specific direction, often indicative of foraging activity or association with other individuals or the vessel;
- Information on the age, sex and plumage of all birds was recorded coupled with their location on each side of the vessel and distance band. Their, interactions with other species or the vessel, foraging or feeding activity was also recorded wherever possible. Additional notes were made upon any feature of interest, and;
- Routine overhead and forward scanning was carried out especially for migrant passerines, waterfowl and waders in key migration periods.

4.2.25 Ornithological surveyors also routinely recorded all sightings of marine mammals both within the same format as for birds (i.e. species and sex wherever possible, side of vessel, distance band and activity) as well as providing a bearing (to within 10^0) and estimated distance (m) in an analogous manner to the JNCC methodology, to allow more accurate positioning.

4.2.26 These records supplemented those made by the dedicated and independently operating marine mammal observer (MMO) on the lower observation platform at all times (Figure 4.1). The double survey platform potentially allowed a comparison in the performance of a single MMO with bird observers as well as an absolute abundance estimate of marine mammal abundance (Borchers *et al*. 1998). Double

[4] In fact, this is a precautionary estimate of flight height as turbine blades are not designed to sweep to below 22 m from mean high water level, which also means the height above sea surface may be ~ 25 m at some states of tide. The proportion of birds of particular species may decline rapidly above 20 m.

platform is the preferred approach for marine mammal monitoring in relation to marine renewable energy developments (SMRU Ltd. 2010).

4.2.27 Vessel activity, including name, number, position, size, type and estimated speed of any vessels within or close to Alpha and Bravo was recorded on a specific form by the vessel crew.

4.2.28 An on-board Navmaster computer system automatically recorded time of day, vessel position coordinates, water depth and vessel speed every 1-2 seconds from survey 9 onwards. Before survey 9 these variables were manually recorded by the vessel crew at each snapshot location. Wind speed, wind direction and vessel visibility continued to be recorded by the crew at the start of each transect line or as conditions changed

Density and population estimation

4.2.29 The notation used during data collection meant that there was minimal 'double counting' of birds in the line transect and snapshots and the different data sets were handled separately to produce density and population estimates for birds on the water and for birds in flight in each of Alpha and Bravo separately.

4.2.30 Densities of birds in the different modes were estimated in a number of ways including: 1) standard density calculation for birds on the water and birds in flight using the area sampled assuming all birds were seen, 2) the same but incorporating correction factors for some species on the water and 3) the use of DISTANCE software (Buckland *et al*. 2001, 2004, Thomas *et al*. 2010) for birds on the water wherever possible (see below). Densities or population sizes from the different methods were combined where necessary to provide the most representative overall estimate for each species in each survey.

4.2.31 Standard calculation of density for any species according to ESAS methods involves adding the density of birds on the water to the density of birds in flight to provide an overall estimate of density for each species (ind. km^{-2}). Total population size in each study site is then estimated by overall density × total area of the site.

4.2.32 The density of birds on the water is calculated from the number of birds in transect encompassing perpendicular distance bands A to D according to birds in bands A – D) / line transect area km^2 (derived from transect length multiplied by [×] the transect width = 600 m).

4.2.33 The density of flying birds was calculated from snapshot data using radial distance bands A to D (see Figure 4.5) according to the number of flying birds in transect / total snapshot area (derived from total number of snapshots × area of 180° scan = 0.141 km^2). Snapshots reduce the effect of movement bias, present in continuously collected data for flying individuals moving faster than the survey platform (Tasker *et al*. 1984, van Franeker 1994).

4.2.34 For some bird species on some occasions, particularly when few records were available, the methods outlined could not be used to estimate bird densities. In these, cases extrapolation of the count data (total study site area / transect area × total counts) was used to provide a crude estimate of population size.

4.2.35 The ability of surveyors to detect birds is known to decrease with increasing distance from the vessel and thus result in the underestimation of the population (e.g. Skov *et al*. 1995, Ronconi & Burger 2009). For birds on the sea surface, most notably auks, two methods were used to account for decreasing detectability: 1) simple correction factors and 2) the use of more sophisticated DISTANCE software.

4.2.36 Simple correction factors assume that equal numbers of birds on the water are present in each 100 m band (i.e. bands A and B combined, C and D). These were calculated for the principal auk species, Guillemot, Razorbill, and Puffin as derived from substantial datasets (14,568, 9,158 and 9,472 birds respectively) pooled over surveys specifically conducted from the *Clupea* in the Firth of Forth. The large dataset allowed correction factors to be derived for different sea states, with the detectability of birds on the sea surface likely to decrease even more markedly with increasing wave height.

4.2.37 Detectability of birds also changes with group size and to avoid inflating density estimates, birds seen in large groups (10 or more) were not included in correction factors. Despite this, the occurrence of birds in smaller groups coupled with the patchy distribution of many species means that correction factors may overestimate population size and therefore estimates based on this method should be viewed as precautionary.

4.2.38 For species where enough data was collected, the decrease in detection rate with distance from the observer was corrected using the program DISTANCE (version 6.0). The advantage of DISTANCE analysis over basic density calculation and the use of simple correction factors is that it provides upper and lower 95% confidence intervals for the predicted densities and is less likely to overestimate population size when the underlying assumptions (see below) are met. In addition, the effect of cluster size increasing the ability of surveyors to detect larger groups of birds at greater distance and covariates such as sea state or other weather conditions affecting detectability may all be incorporated into models.

4.2.39 DISTANCE 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). Moreover, 60-80 records are generally needed to generate a model (Thomas *et al*. 2010), although a robust analysis can be run with fewer records than this. For the current analysis a minimum of 50 records was set for each species within each site from all of the surveys, allowing at least global models to be produced when insufficient data was present for individual surveys.

4.2.40 There was no reason to suspect that the first assumption above was violated during surveys and although birds may be aggregated, for example when feeding upon shoaling fish, there was no evidence that this was unequally distributed between distance bands. Even if the vessel caused displacement of any birds when close to the transect line, this was only after birds had already been recorded, especially within a feeding group. In relation to the second assumption, clusters of birds are incorporated into analysis (see below). On the third assumption there was no reason to suspect that all birds in band A were not detected. Moreover, it is known that detection of all birds in band A relies on accurate positioning of band A. The fact that both sides were surveyed (and thus band A was 100 m wide) meant there was less risk of falsely allocating birds to A ('heaping') as occurs when only one side of the vessel is surveyed as it is often difficult to predict that a bird ahead of the vessel will ultimately fall into A on one side of the vessel only.

4.2.41 Using the count data from distance bands A to D, DISTANCE was used to generate models for the decrease in detection from band A for birds on the water. The resulting detection function was then used to derive corrected density. For each analysis, the most appropriate model was chosen based on the lowest value of Akaike's Information Criterion (AIC), indicating the best model fit (Burnham & Anderson 2002). Covariates such as wave height (sea state) were also included in models to account for any effects these might have on detection where data allowed and where the inclusion of such covariates improved model fit.

4.2.42 The minimum data requirement meant that DISTANCE analysis was restricted to more commonly seen species even where attempts were made to maximise the number of species analysed by pooling data across surveys to generate a detection function based on a global model. Where sufficient data was present within individual surveys for a species, and a satisfactory model could be built this was used in preference to global model estimates for individual surveys. DISTANCE corrected estimates for birds on the water only were therefore achieved for Guillemot, Razorbill, Puffin, Little Auk and Kittiwake for both Alpha and Bravo, and Fulmar for Alpha only. Gannet or any of the species of large gulls could not be corrected using DISTANCE, although it should be noted that these large and mostly white or contrasting species were generally easily detected even at considerable distance.

4.2.43 As outlined above, Brabraud & Thiebot (2009) showed that the ability of surveyors to detect flying birds of all species to the size of albatrosses decreased with distance from the survey vessel over a strip half-width of 300 m, the typical strip width used in seabird surveys, even with an eye-height of 17.5 m. Both bird size and type of flight (i.e. erratic and low to the sea surface) were important parameters in species-specific relationships. Detection was 0.869 (SE = 0.115) for large-sized (albatross sized) seabirds, 0.725 (SE = 0.096) for medium sized seabirds (petrels) and 0.693 (SE = 0.091) for small seabirds. Eye-height on the vessel used was 17.5 m, far higher than the typical 5-8 m used in most seabird surveys associated with wind farms. Detection may thus tend to be even lower in typical surveys but this will also depend on flight speed and action of the birds in question as well as the nature of the prevailing conditions.

4.2.44 The assumption of standard ESAS methodology that all birds are seen up to 300 m from the survey vessel is thus likely to be violated especially for smaller, fast-flying species, although it may broadly hold for large conspicuous species such as Gannet and large gulls notwithstanding that the behavioural attributes of some species also create issues for analysis of flying birds in snapshot data. Attraction to survey vessels is a known problem for several groups of seabirds including procelliformes (petrels and shearwaters) and gulls (Hyrenbach 2001, Camphuysen *et al*. 2004). Attraction of birds to the vessel increases the number of individuals seen in closer distance bands to the observer which is reflected in the initial model thereby artificially inflating the density estimate.

4.2.45 The instantaneous nature of snapshots in which birds are recorded in a relatively large area in a few seconds of observation is likely to be an important component of reduced detection of even what may be thought of as relatively conspicuous species such as Kittiwake. Moreover, there is some debate whether snapshots are best conducted with prior knowledge (i.e. birds are tracked before snapshots) or best conducted 'blind' without prior knowledge of the presence of a bird. Certainly, the probability of detection is known to increases in the case of the former (Riddle *et al*. 2010). In practice, although some birds may have been 'tracked' during a survey also incorporating a line transect, many flying birds will have been detected without specific prior knowledge in the snapshot.

4.2.46 In the absence of specific guidance on the issue by the JNCC and given the potential difficulty correcting for birds in flight using DISTANCE (but see Rexstad & Buckland 2012), no attempt was made to correct density estimates of flying birds for this report. It should be noted however that even the use of uncorrected density estimates does not compensate for the underestimate of flying bird density from any survey using the ESAS 'box' method. As a minimum any density derived from ESAS should 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), which cannot be the case assuming a constant detection distance.

4.2.47 For the purposes of comparison of population size against a particular population scale in any survey (see below), the population of birds on the water derived from the mean DISTANCE-corrected density estimate was added to the population of birds in flight derived from snapshots as the most accurate representation of the total population of any particular species present. Where a DISTANCE-corrected density estimate was not available for the fraction of birds on the water where these were present, the uncorrected estimate of density derived from the line transect was used in combination with snapshots.

Relative importance of population size

4.2.48 The relative importance of the population of any species estimated to be present in either Alpha or Bravo (or both in a cumulative context) on any survey occasion may be derived through comparison with international, national and regional population estimates derived at different times of year. Comparison is achieved through use of the 1% criterion i.e. the population would be internationally important if it exceeded 1% of the European population, or nationally important if it exceeded 1% of the national population. The 1% criterion, whilst not necessarily of biological relevance, has been used as a standard for designating areas conservation interest for some time and Skov *et al*. (2007) point out there is no obvious reason to use another measure.

4.2.49 In general terms, seabirds have relatively clearly defined phenological periods including the breeding season, post-breeding dispersal leading to autumn passage, wintering, and spring passage before breeding. As spring passage is often not as readily defined as autumn passage, this may be absorbed in wintering and breeding seasons for those species that occur over most or all of the year. For facultative migrants (e.g. terns) spring passage may be seen to fall immediately before breeding, even if it is nor specifically defined.

4.2.50 For the seabirds occurring in Alpha and Bravo (see Appendix F1 Annex 1) the breeding, autumn passage and wintering periods were defined according to the general literature (e.g. Birds of the Western Palearctic – BWPi 2004) although the different periods may overlap according to information presented by different sources (Appendix F1 Annex 2). After some refinement according to latitude relevant to birds in Scottish colonies (mainly after Forrester *et al*. 2007), and incorporating the view of Marine Scotland (issued after the FTOWDG developers meeting of 19 August 2011) the defined breeding, passage and wintering periods for the seabirds occurring in Alpha and Bravo are shown in Table 4.6.

Table 4.6 Defined breeding, autumn passage and wintering periods for seabirds known to occur within the Alpha and Bravo development sites in the relevant period (see Appendix F1 Annex 2). The breeding and/or wintering periods incorporate any spring passage for species that are not clearly defined migrants. Information from BWPi (2004) with the Scottish context from Forrester *et al.* (2007).

Species	Breeding	Autumn passage	Wintering
Common Eider[1]	April - June	July – August	September – March
Red-throated Diver[1]	March – August	September - November	December - February
Northern Fulmar	April - September	October	November - March
Great Shearwater[1]		August - October	
Sooty Shearwater[1]		July - November	
Manx Shearwater	May - September	October	-
European Storm-petrel	May - October	November	December - March
Northern Gannet	April - September	October - November	December - March
Great Cormorant	March - September	October	November - February
European Shag	March - October		November - February
Pomarine Skua[1]		July - November	
Arctic Skua	May - August	September - October	-
Great Skua	May - September	October	-
Black-legged Kittiwake	April - August	September - October	November - March
Black-headed Gull	April - July	August - October	November - March
Little Gull[1]		June - November	

Species	Breeding	Autumn passage	Wintering
Common Gull	April - July	August - October	November - March
Lesser Black-backed Gull	April - August	September - October	November - March
European Herring Gull	April - August	September - October	November - March
Great Black-backed Gull	April - August	September - October	November - March
Sandwich Tern	May - August	September	-
Common Tern	May - August	September	-
Arctic Tern	May - August	September - October	-
Common Guillemot	April - July	August - October	November - February
Razorbill	April - July	August - October	November - February
Black Guillemot	April - August	September - November	December - March
Little Auk[1]			October – February
Atlantic Puffin	April - August	September- October	November - February

[1] Periods taken from Forrester *et al*. (2007)

Breeding season

4.2.51 For breeding seabirds, comparison of population size recorded in surveys with populations of international importance is straightforward as a result of the information provided by BirdLife International (2004) and Wetlands International (2006). International breeding data is shown alongside the national population data for the United Kingdom provided by Baker *et al*. (2006) in Table 4.7. National and regional data for breeding species is also available through national seabird census, with the most recent of these being Seabird 2000 between 1998-2002 (Mitchell *et al*. 2004). Data from wider census also feeds into the Seabird Monitoring Programme (SMP) that also provides the most recent information (http://jncc.defra.gov.uk/page-1550) for more important colonies, which are well represented in the Firth of Forth.

Table 4.7 International (European) and National (United Kingdom) breeding population estimates from BirdLife International (2004) and Baker *et al*. (2006) respectively, alongside the appropriate 1% criteria for each population scale. Regional breeding populations and associated 1% criteria as defined from analysis of foraging range from the Alpha and Bravo development sites that includes known colonies of known size (according to latest counts in the SMP database) are shown for comparison.

	European breeding population	1%	National breeding population	1%	Regional breeding population[3]	1%
Northern Fulmar	7,200,000	72,000	1,009,512	10,095	958,556	9,586
Manx Shearwater	740,000	7,400	599,424	5,994	0[1]	
European Storm-petrel	940,000	9,400	51,300	513	0[1]	
Northern Gannet	610,000	6,100	437,092	4,371	153,022	1,530
European Shag	156,000	1,560	54,954	550	120	1
Arctic Skua	90,000	900	4,272	43	-	

Great Skua	32,000	320	19,268	193	-	
Black-legged Kittiwake	5,100,000	51,000	759,784	7,598	124,684	1,247
Black-headed Gull	3,700,000	37,000	276,028	2,760	40	<1
Common Gull	2,090,000	20,900	97,440	974	408[2]	4
Lesser Black-backed Gull	650,000	6,500	224,148	2,241	39,546	396
European Herring Gull	2,160,000	21,600	278,618	2,786	47,164	472
Great Black-backed Gull	290,000	2,900	34,320	343	288[2]	3
Sandwich Tern	212,000	2,120	24980	250	0[1]	
Common Tern	840,000	8,400	23,676	237	67	<1
Arctic Tern	1,400,000	14,000	106,776	1,068	58	<1
Common Guillemot	4,700,000	47,000	1,420,900	14,209	206,736	2,067
Razorbill	1,200,000	12,000	188,576	1,886	19,395	194
Atlantic Puffin	13,000,000	130,000	1,161,598	11,616	232,828	2,328

[1] Latest counts show no birds are present at the colony in range. [2] From mean maximum range.

4.2.52 A list of breeding species known to occur in the region was derived from records in the intensive boat-based surveys conducted during the breeding season (see Appendix F1 Annex 1) that mainly falls within the range of March to September (Table 4.6), although with variation according to species. Species with the potential to occur included those that have colonies within the broad area between the Farne Islands in the south and Peterhead in the north that encapsulates the entire area of the Firth of Forth. A total of 23 species were initially identified (see Table 4.8).

Table 4.8 Mean, mean maximum ± 1SD and maximum foraging ranges (km) of breeding seabirds (from Thaxter *et al.* 2012) with the potential to occur or are known to occur within the Alpha and Bravo development sites.

	Mean (±1SD) foraging range (km)	**Mean (±1SD) maximum foraging range (km)**	**Maximum foraging range (km)**
Northern Fulmar	47.5 ± 7.7	400.0 ± 245.8	580
Manx Shearwater	2.3 ± 0.8	>330	>330
European Storm-petrel			>65
Northern Gannet	92.5 ± 59.9	229.4 ± 124.3	590
Great Cormorant	5.2 ± 1.5	25 ± 10.0	35
European Shag	5.9 ± 4.7	14.5 ± 3.5	17
Arctic Skua	6.4 ± 5.9	62.5 ±17.7	75
Great Skua		86.4	219
Black-legged Kittiwake	24.8 ± 12.1	60.0 ± 23.3	120
Black-headed Gull	11.4 ± 6.7	25.5 ± 20.5	40
Common Gull	25	50	50
Lesser Black-backed Gull	71.9 ± 10.2	141.0 ± 50.8	181
European Herring Gull	10.5	61.1 ± 44.0	92

Great Black-backed Gull		~100[1]	
Little Tern	2.1	6.3 ± 2.4	11
Sandwich Tern	11.5 ± 4.7	49.0 ± 7.1	54
Roseate Tern	12.2 ± 12.1	16.6 ± 11.6	30
Common Tern	4.5 ± 3.2	15.2 ± 11.2	30
Arctic Tern	7.1 ± 2.2	24.2 ± 6.3	30
Common Guillemot	37.8 ± 32.3	84.2 ± 50.1	135
Razorbill	23.7 ± 7.5	48.5 ± 35.0	95
Black Guillemot		12[2]	55[2]
Atlantic Puffin	4.0	105.4 ± 46.0	200

[1] Derived from an approximation of the maximum range of the ecologically similar European Herring Gull and an approximation of the mean of the mean maximum foraging ranges of both Herring Gull and Lesser Black-backed Gull. [2] Taken from Birdlife International (http://seabird.wikispaces.com/Black+ Guillemot).

4.2.53 All species known to occur (i.e. occurring in surveys in the breeding season) and with the potential to occur (i.e. at a colony in range) were then subject to analysis of known foraging radius from colonies in accordance with the concept of central-place foraging adopted when adults are at nest and subsequently provisioning dependent chicks prior to fledging. The process was designed to also capture long-ranging species with colonies outside the Farnes to Peterhead area, that occurred occasionally in the breeding season (e.g. Manx Shearwater *Puffinus puffinus*). Although the breeding status of individuals cannot generally be definitely identified (possibly unless an adult is seen carrying a prey item in the direction of a colony), even those species with just a single record of a potentially breeding adult in either Alpha or Bravo during their breeding season were included for the sake of completeness (Appendix F1 Annex 1).

4.2.54 Foraging ranges expressed as radii were derived from the latest amalgam of seabird ranging data presented by Thaxter *et al*. (2012). A foraging radius effectively assumes that the use is constant in all directions within a broad arc from the colony, which may hardly ever be true considering the highly patchy nature of resources. Moreover, there is often considerable difference in range of the same species at different colonies also dependent on the distribution and abundance of resources, that may also be partly governed by the size of the colony (Lewis *et al*. 2001). Birds nesting at larger colonies may thus be forced to have a greater range than those at smaller colonies.

4.2.55 The maximum range of a species perhaps derived from one study at one colony and perhaps representing just a few individuals may be a poor indicator of more typical range for the species. Alternatively, the mean range may be heavily influenced by a larger number of short foraging trips and not illustrate the potential for movement. For these reasons, the metric of mean maximum range was thought to be most representative measure of foraging range (Table 4.8).

4.2.56 However, in correspondence to Marine Scotland (dated 31 January 2012), JNCC have requested that an additional error margin be placed around this metric as a result of 'variation' in the mean value. The addition of one standard deviation (SD) as presented by Thaxter *et al*. (2012) was suggested, albeit with no regard for the fact that this resulted in a larger value than the maximum recorded range for some species (e.g. Fulmar has a mean maximum range of 400 km and ± 1 SD of 245.8 km = 645.8 km which is greater than the maximum of 580 km). Mean maximum foraging range ± 1SD for the 23 species identified is also shown in Table 4.8.

4.2.57 Rather than plot mean maximum and mean maximum ± 1SD range from each colony of each species known to occur or with the potential to occur in the development sites, a more concise way of estimating the overlap with particular colonies was to plot the range around the combined development sites within GIS and then record overlap with any colonies. The location of all colonies was downloaded from the SMP database. In this, the positions of start and end grids of all colonies within a 'master site' are typically given and colony positions taken as a mean point when both start and end positions were present. The resulting plots are presented within the sensitive species accounts below where the species proved to be sensitive, or are otherwise displayed in Appendix F1 Annex 3.

4.2.58 It was assumed that seabirds did not cross extensive landmass to reach more distant parts of their potential range. Therefore, for wide-ranging species with potential to reach the west coast of Scotland from colonies along the east coast, the remaining range was expressed as an approximate linear distance rather than an arc, to avoid part of the range appearing as a distinct area along the western seaboard. Some of the plots (e.g. Fulmar) are therefore not comprised of exact arcs from the development sites (Appendix F1 Annex 3).

4.2.59 For each species, the total number of birds within each colony within the mean maximum range ± 1SD was summed to provide an estimate of the regional breeding population of that species, and to derive the 1% criterion for regional importance (Table 4.8). Great Cormorant, Little Tern, Roseate Tern and Black Guillemot *Cepphus grylle* that were neither in range nor occurring in the breeding season, were excluded.

4.2.60 Regional population size could then be readily compared with known national and international breeding population estimates (Table 4.7). Such comparison highlights the importance of the region as defined by the range of the birds themselves for Fulmar, Gannet, Puffin, Lesser Black-backed Gull, Herring Gull, Kittiwake and Guillemot, with >15% or more of the national population contained within the defined region.

Passage and wintering period

4.2.61 Comparison was also desirable for wintering and passage populations, with the latter potentially more problematic than the former, although a passage population is invariably some derivative of the breeding population. For example, multiplication of the breeding population (individuals) by 1.5 to account for non-breeding and immature birds could be used as a passage population if the origin and flyways of the birds concerned can be established. Moreover, the wintering population of an area is likely to partly the passage population to and from the area. Further means of deriving passage populations are discussed below.

International population estimates

4.2.62 The size of international wintering populations of seabirds is much less well defined than for breeding populations. The available estimates from Birdlife International (2004) shown in Table 4.9 have a wide range, and if any data is supplied at all there is often considerable variation in the quality of data between countries, even for common species. As a result, confidence in these estimates is low.

4.2.63 In a similar vein to international population estimates, the latest national (Great Britain excluding any part of Ireland) wintering population estimates from Musgrove *et al*. (2011) that update Baker *et al*. (2006), are generally limited to species that are either coastal or even terrestrial in occurrence such as gulls (Table 4.9).

4.2.64 The lack of population estimates at the international or national scale for seabirds belies the existence of the ESAS database incorporating both boat-based and aerial surveys. In fact, using the database Skov *et al*. (1995) generated population estimates of selected seabirds in the North Sea. As the North Sea is bordered by a number of European countries the estimates provide some international context. However, as the North Sea does not represent the coastal waters if all European waters, the population estimates provided should be best viewed as 'sub-International' or 'super-National' estimates.

Table 4.9 International (European) and sub-International (North Sea) wintering population sizes (individuals) from BirdLife International (2004) and Skov *et al.* (1995) respectively and appropriate 1% criteria, in comparison with National (Great Britain[1]) estimates derived from Musgrove *et al.* (2011), for seabirds occurring within the Alpha and Bravo development sites in winter (defined as December to March).

	European wintering population	**1%**	**North Sea wintering populatio n**	**1%**	**National wintering population**	**1%**
Common Eider	>1,700,000	17,000	462,590	4,626	55,000	550
Red-throated Diver	>51,000	510	48,495[2]	485	17,000	170
Northern Fulmar	>1,500,000	15,000	1,872,000	18,720	-	-
Manx Shearwater	-	-	-	-	-	-
European Storm-petrel	-	-	51,300	513	-	-
Northern Gannet	-	-	157,800	1,578	-	-
Great Cormorant	>420,000	4,200	14,315	143	35,000	350
European Shag	>92,000	920	29,115	291	110,000	1,100
Great Skua	-	-	1,000	10	-	-
Black-legged Kittiwake	>200,000	2,000	1,032,690	10,327	-	-
Black-headed Gull	>3,200,000	32,000	276,028	2,760	2,200,000	22,000

Little Gull	>11,000	110	5,370	54		
Common Gull	>910,000	9,100	175,530	1,755	700,000	7,000
Lesser Black-backed Gull	>130,000	1,300	15,315	153	120,000	1,200
European Herring Gull	>800,000	8,000	971,700	9,717	730,000	7,300
Great Black-backed Gull	>150,000	1,500	299,900	2,999	76,000	760
Common Guillemot	>4,300,000	43,000	1,562,400	15,624	-	-
Razorbill	>500,000	5,000	324,000	3,240	-	-
Little Auk	-	-	852,690	8,527	-	-
Atlantic Puffin	-	-	74,600	746	-	-

[1] as UK not available. [2] Includes Black-throated Diver *Gavia arctica*.

4.2.65 Skov *et al*. (1995) present population estimates in different periods for the different species and estimates in the most relevant season (e.g. September-April, October-March, November-February, December-February, December-March, February-March or even 'all year' in the case of European Shag). These were interrogated to provide wintering estimates for the North Sea, which are presented in Table 4.9. It is noteworthy that the more specific dataset of Skov *et al*. from surveys at sea produced higher populations from a subset of the area, compared to those representing the full international context (e.g. for Fulmar and Kittiwake – Table 4.9), reinforcing the value of using information from the North Sea alone.

National population estimates

4.2.66 In order to provide national population estimates for seabirds in both winter and passage periods in a similar way to that achieved by Skov *et al*. (1995) for the wider North Sea, information previously derived from the ESAS database was used. This took the form of the work of Stone *et al*. (1995), who present an atlas of the abundance of seabirds in different sea regions around the entire coast of Great Britain and Ireland, albeit extending to different distances offshore in different areas (Figure 4.6).

4.2.67 With knowledge of the areas of the different sea regions (C. Stone *pers comm*.), the population of any species in any sea region in any month was calculated by multiplying density by area. The sum of these totals provides an overall estimate of the national (Great Britain and Ireland) population in any month (Appendix F1 Annex 4).

4.2.68 A potential shortcoming of this approach was the need to exclude an area of the southwest North Sea around the Thames estuary because this incorporates not only the area of the North Sea associated with the southeast coast of the UK, but also the seas around north-west Europe extending across the entire Baltic Sea. Inclusion of this area was thought to bias the results more than the exclusion of this area. In any case, a lower population estimate would be more precautionary as it would be easier to exceed a specific threshold value.

4.2.69 In recognition of the age of the data gathered between 1979 and 1994, estimates were adjusted according to the current ten-year population trend (2000-2010) for each species derived from selected colonies (JNCC 2011 http://jncc.defra.gov.uk/) assuming that passage and wintering populations in national waters are in step with the national breeding population. In other words, that birds originating from other countries have not significantly increased or decreased their respective contribution.

4.2.70 No trend data were available for Manx Shearwater, Storm Petrel, Gannet, Great Skua, Common Gull, Puffin and an adjustment could not be applied.

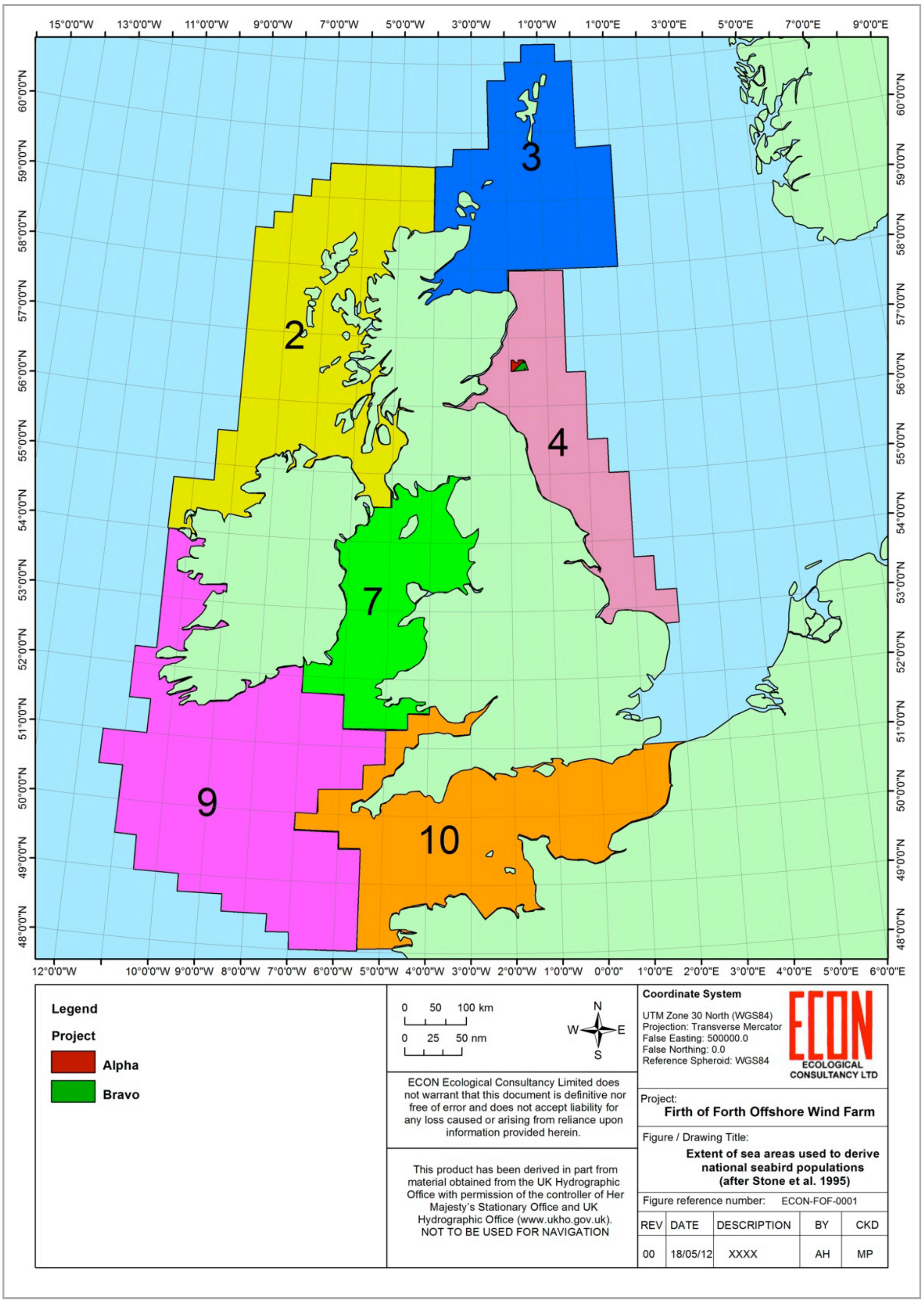


Figure 4.6 Map of the sea areas for which Stone *et al.* (1995) provide monthly density estimates of the more commonly occurring seabirds in Great Britain and all-Ireland.

4.2.71 The largest declines have been recorded for Herring Gull (-38%), Lesser Black-backed Gull (-36%), Arctic Skua (-34%) and Kittiwake (-30%). Smaller declines have also been recorded for, Shag (-15%), Great Black-backed Gull (-14%), Sandwich Tern (-7%), and Cormorant (-7%). In contrast, populations of Fulmar (+1%) and Common Tern (+3%) remained stable in the period. For Guillemot, Razorbill and Arctic Tern whilst colonies in the north of the UK declined there was some redistribution of birds and colonies further south have grown accordingly. As a result there has been little net overall change for Razorbill (+1%), with some growth in the population of Arctic Tern (+7%) and moderate increase in the case of Guillemot (+17%). Black-headed Gull (+29%) showed the greatest increase amongst the sample species.

4.2.72 Adjustments were made according to the proportional change recorded. For increasing species, an increase of, for example, 1%, was applied by multiplying the population generated from Stone *et al*. (1995) by 1.01. For decreasing species the population was multiplied by the remaining fraction after subtracting the fraction lost. For example, a decline of 7% represents 93% of the population remaining. In this case, the population generated from Stone *et al*. (1995) would therefore be multiplied by 0.93.

4.2.73 In the surveys of Stone *et al*. (1995) a proportion of birds remained unidentified and were assigned to generic groups. Some of these groups were relatively abundant and thus a species also contained within a group may be underestimated. For this reason, unidentified groups including auks, terns and gulls were apportioned according to the proportions of the different species recorded in the appropriate month and sea region. The tendency for divers to be recorded as a generic group meant that the relative abundance of different species could not be readily determined and for the purposes of this exercise, all divers were recorded as the most abundant species, Red-throated Diver.

4.2.74 Apportioning between species was particularly complex in the case of gulls and the separate group for unidentified large gull was also apportioned to the ratio between the constituent species (Great Black-backed, Herring and Lesser Black-backed Gulls). The ratio between Common and Arctic terns embraced by 'Commic' terns could not be determined from Stone *et al*. (1995) and the ratio between these species in Seabird 2000 (0.21:0.79) was used instead. Density and population estimates of any species were then adjusted accordingly.

4.2.75 For each species, separation of passage and wintering periods from the breeding season were as defined above in Table 4.6, as well as in more detail in Appendix F1 Annex 2.

4.2.76 Insufficient data was available in Stone *et al*. (1995) to derive population estimates for a few species including Eider in winter and Great Shearwater *Puffinus gravis* and Pomarine Skua *Stercorarius pomarinus* on passage. Otherwise, a maximum or peak population size for every relevant seabird species in any defined period was derived. The maximum population was used as this is compared with the peak population recorded in the development sites in the surveys. Mean (± 1 standard error) populations around these estimates in any defined period are provided in Appendix

F1 Annex 4. Estimates for the passage and wintering populations are shown in Table 4.10 alongside the estimate for the breeding season.

Table 4.10. Maximum national (Great Britain and Ireland) breeding, passage and wintering population estimates (individuals) and appropriate 1% criteria as derived from Stone *et al*. (1995), for seabirds occurring within the Alpha and Bravo development sites. Population estimates are adjusted according to known recent (2000-2010) trends in breeding populations according to the JNCC (2011).

	Maximum breeding population	**1%**	**Maximum passage population**	**1%**	**Mean wintering population**	**1%**
Red-throated Diver	14,301	143	11,388	113	15,226	152
Northern Fulmar	1,650,367	16,504	1,655,086	16,551	1,730,997	17,301
Sooty Shearwater			30,630	306	39,746	398
Manx Shearwater	1,327,147	13,271	14,013	140		
European Storm-petrel	497,541	4,975	11,813	118		
Northern Gannet	468,401	4,684	562,246	5,622	442,520	4,425
Great Cormorant	5,310	53	3,058	31	13,754	138
European Shag	111,049	1,110			94,809	948
Arctic Skua	2,672	27	5,306	53		
Great Skua	29,148	291	27,440	274	11,489	115
Black-legged Kittiwake	668,378	6,684	867,574	8,676	1,212,789	12,128
Black-headed Gull	6,851	69	119,230	1,192	35,900	359
Little Gull			15,690	157		
Common Gull	24,620	246	11,139	5,541	115,488	1,155
Lesser Black-backed Gull	460,861	4,609	142,047	1,420	802,032	8,020
European Herring Gull	695,089	6,951	547,751	5,478	1,167,259	11,672
Great Black-backed Gull	433,444	4,334	437,821	4,378	442,201	4,422
Sandwich Tern	2,622	26				
Common Tern	10,781	108	2,589	26		
Arctic Tern	43,358	434	10,412	104		
Common Guillemot	2,394,761	23,948	3,707,483	37,074	1,433,771	14,337
Razorbill	348,144	3,481	1,009,109	10,091	216,484	2,165
Little Auk					97,567	976
Atlantic Puffin	859,307	8,593	61,088	611	34,025	340

4.2.77 As a test of the likely accuracy of the estimates derived from Stone *et al*. (1995), a comparison was made between the estimates for the breeding population and the known breeding populations in Britain and Ireland combined, as reported by BirdLife International (2004). Comparison was made through assessment of the relative difference between the two estimates (Table 4.11). To achieve valid comparison, the estimates from BirdLife International were adjusted by a factor of 1.5 as suggested by Wetlands International (2006), to estimate the non-adult portion of the population that would also be recorded in the dataset of Stone *et al*. (1995).

Table 4.11. Comparison (proportionate difference - %) between maximum national (Great Britain and Ireland) population estimates (individuals) in the breeding season as derived from Stone *et al.* (1995) compared to adjusted known breeding population estimates from BirdLife International (2004), for seabirds occurring within the Alpha and Bravo development sites. Population estimates from Stone *et al.* (1995) have been adjusted according to known recent (2000-2010) trends in breeding populations according to JNCC (2011). Adjusted estimates from Birdlife International are derived by scaling by a factor of 1.5 to account for the presence of undistinguished non-breeders and immature birds as undertaken by Wetlands International (2006).

	Maximum breeding season estimate derived from Stone *et al.* (1995)	**Breeding population from BirdLife International (2004)**	**Adjusted breeding population from BirdLife International (2004)**	**Difference (± %)**
Northern Fulmar	1,650,367	1,078,000	1,617,000	+ 2.1
Manx Shearwater	1,327,147	667,000	1,000,500	+ 32.7
European Storm-petrel	497,541	254,500	381,750	+ 30.3
Northern Gannet	468,401	519,200		- 9.8
Great Cormorant	5,310	27,300	40,950	- 87.1
European Shag	111,049	64,600	96,900	+ 14.6
Arctic Skua	2,672	4,200	6,300	- 57.1
Great Skua	18,936*	9,602	14,402	+ 31.5
Black-legged Kittiwake	668,378	413,000	619,500	+ 7.9
Black-headed Gull	6,851	283,800	425,700	- 98.4
Common Gull	24,620	49,760	74,640	- 67.0
Lesser Black-backed Gull	460,861	233,800	350,700	+ 31.4
European Herring Gull	284,178*	299,000	448,500	- 36.6
Great Black-backed Gull	135,690*	39,400	59,100	+ 129.6
Sandwich Tern	2,622	28,600		- 91.0
Common Tern	10,781	29,000		- 62.8
Arctic Tern	43,358	112,200		- 61.3
Common Guillemot	2,394,761	2,080,000	3,120,000	- 23.2
Razorbill	348,144	286,800	430,200	- 19.1
Atlantic Puffin	859,307	641,000	961,500	-10.6

* Mean rather than maximum values

4.2.78 Species such as terns were not adjusted as it is known that age classes up to the age of at least two and often three years remain in wintering grounds. Gannet may also not show a full mixture of age classes in the vicinity of colonies as Gannets do not breed until at least five years of age and although some younger birds do attend colonies (Brown & Grice 2005) most immatures may be dispersed widely (Skov *et al.* 1995, Votier *et al.* 2010) including off the west coast of Africa where many adults also gather in the winter (Kubetzki *et al*. 2009). As a result, gannet population figures were also not adjusted.

4.2.79 Despite the potential limitations of the data, the population sizes estimated appear to be broadly reasonable given what is known from breeding populations (Table 4.11) The difference between the two estimates was variable between species, being closely aligned (± 10%) for Fulmar, Kittiwake, Gannet and Puffin (Table 4.11) and with reasonable similarity (± 35%) for many other species including Guillemot, Razorbill, Fulmar, Lesser Black-backed Gull and Shag likely to be represented in the Firth of Forth.

4.2.80 There was however considerable discrepancy between estimates for all tern species, Black-headed and Common Gulls, Great Cormorant and Arctic Skua. In all cases, the data from Stone *et al*. (1995) suggested far fewer than were recorded in colony counts. An explanation for this pattern may be the occurrence of these species in coastal waters or even inland compared to occurrence in the open sea typically surveyed by Stone *et al*. (1995). Apart from the terns and Arctic Skua these species were not thought to be of primary concern for the assessment.

4.2.81 Of more relevance to assessment of the developments, the estimates for Great Black-backed and Herring Gulls and Great Skuas also showed considerable discrepancy between the estimates, with far more being seen in the surveys of Stone *et al*. (1995) than would be expected from reference to the breeding population. Part of this appeared to be the result of particularly high peaks in the data and as a result, the mean values (Appendix F1 Annex 4) were used instead.

4.2.82 The use of mean values brought the estimate for Great Skua to within 35% suggested as reasonable for other species. The estimate for Herring Gull was also brought to within similar range to other species (e.g. Lesser Black-backed Gull), but with fewer birds recorded in Stone *et al*. (1995) than anticipated. The preference of Herring Gull for more inshore waters in the breeding season (Brown & Grice 2005) may explain this pattern.

4.2.83 A large discrepancy between the estimates for Great Black-backed Gull remained with more in the estimates of Stone *et al*. (1995) than for the known adjusted breeding population. This seems likely to be linked to the prevalence of non-breeding immature birds in the wider population. The fact that Great Black-backed Gulls do not breed until at least five years of age and a large proportion of non-adult birds including from other populations including the stronghold of the species in Norway, suggests that a greater scale of adjustment than 1.5 may be required.

4.2.84 Overall, the general similarity of estimates between those derived from existing surveys at sea and the counts within breeding colonies with appropriate adjustment for immature birds not distinguished in seabirds surveys at sea, increased confidence in the use of the estimates derived from Stone *et al*. (1995) in the passage and winter periods. However, caution was attached to the use national passage and winter population criteria for Great Black-backed Gull at sea, that could be set too high leading to the assumption that the species does not occur in important numbers, when in fact it does. The opposite problem (i.e. suggesting populations exceed national threshold values when they do not) for Arctic Skua, Black-headed and Common Gulls and terns is less important, as this fits with the use of the precautionary principle.

Regional population estimates

4.2.85 Reasonable confidence in the estimates derived from Stone *et al*. (1995) at a national population scale reinforced the use of Stone *et al*. (1995) to derive regional populations. Importantly, this would allow judgment of the relative importance in regional terms of any population of any species occurring in Alpha or Bravo in passage or wintering periods.

4.2.86 In the absence of a specific area relating to the Firth of Forth in Stone *et al*. (1995), regional populations could only be derived relatively crudely from the very large Western North Sea area (64,577 km^2) from Fraserburgh in the north to Norfolk in the south incorporating the Firth of Forth (Figure 4.3). Such an area perhaps best represents a 'super-region'. Even if data were adjusted, the fact that this super-region incorporates only relatively few colonies but with the exception of the Farne Islands (and Coquet Island) and the Flamborough Head and Bempton Cliffs SPA may mean that the relative contribution of populations within Alpha and Bravo is diminished to an unreasonable extent from the perspective of a regional population.

4.2.87 In an attempt to partly combat the problem of too large an area being used as a region, the area sampled by specific aerial surveys of the Forth of Firth (5,754 km^2) was used to define the size of the region. The mean density of each species obtained in the surveys of Stone *et al*. (1995) was then simply multiplied by this area to define a regional population size for each species in each period (Table 4.12). It should be noted that the aerial surveys themselves could also be viewed as a means of establishing regional population size given sufficient coverage.

4.2.88 The potential limitations of the method were illustrated by a comparison of the regional population estimate in the breeding period as compared with those obtained by the foraging range approach for a number of species known to breed within range of Alpha and Bravo (see Table 4.8), and by aerial surveys in the summer for a limited number of species/groups (Table 4.12).

Table 4.12. Comparison between regional breeding population estimates (individuals) and appropriate 1% criteria for seabirds occurring within the Alpha and Bravo development sites, derived from 1) foraging radii (see Table 4.8), 2) density estimates from Stone *et al*. (1995) from the Western North Sea adjusted to the Firth of Forth area surveyed by aerial surveys (5,754 km^2), and 3) from the aerial surveys themselves. The latter estimates are derived from DISTANCE.

Species	Foraging radii	1%	Stone *et al*. (1995)	1%	Aerial surveys	1%
Red-throated Diver			115	1		
Northern Fulmar	958,556	956	26,212	262		

Manx Shearwater	0	0	1,841	18		
European Storm-petrel	0	0	115	1		
Northern Gannet	153,022	1,530	4,719	47	16,333	163
Great Cormorant			54	<1		
European Shag	120	1	1,125	11		
Arctic Skua			38	<1		
Great Skua			518	5		
Black-legged Kittiwake	124,684	1,247	18,288	183	15,315	153
Black-headed Gull	40	<1	223	2		
Common Gull	408	4	459	5		
Lesser Black-backed Gull	39,546	396	403	4	2,384	24
European Herring Gull	47,164	472	5,167	52		
Great Black-backed Gull	288	3	1,937	19		
Sandwich Tern	0	0	107	1		
Common Tern	67	<1	280	3		
Arctic Tern	58	<1	1,125	11		
Common Guillemot	206,736	2,067	55,072	551		
Razorbill	19,395	194	5,920	59	76,113	761
Atlantic Puffin	232,828	2,328	11,500	115		

4.2.89 The means of generating an estimate from the survey approaches were very similar for all auks combined with a factor of 1.05 in favour of for Stone *et al*. (1995) relative to aerial estimates), less so for Kittiwake (1.2-fold) and considerably different for gulls combined (3-fold) and Gannet (3.5-fold).

4.2.90 The foraging radii approach invariably produced much higher estimates for breeding species even with a relatively short foraging range (>30 km) that could at least reach the sites, as this lead to the inclusion of many colonies potentially containing many thousands of individuals. The area contained within this foraging range was also much larger than the 'regional' area defined by the surveys.

4.2.91 The difference in the foraging radius approach and the highest estimate of a survey based measure for the more common species was at its best 3-fold for Razorbill, nearly 4-fold for Fulmar and Guillemot, >8-fold for Kittiwake, >9-fold for Gannet and Herring Gull, 20-fold for Puffin, and at its worst, at 99-fold for Lesser Black-backed Gull (Table 4.12). Only where few birds occurred in low numbers leading to 1% criteria of 20 birds or less were the estimates essentially similar.

4.2.92 Comparison reinforced the use of the foraging radius approach as the preferred method of defining regional population estimates in the breeding season. Further comparison was then made between wintering population estimates derived from Stone *et al*. (1995) with the results of the aerial surveys (Table 4.13).

Table 4.13. Regional passage and wintering population estimates (individuals) and appropriate 1% criteria for seabirds occurring within Projects Alpha and Bravo. Density estimates from Stone *et al.* (1995) from the Western North Sea adjusted to the Firth of Forth area surveyed by aerial surveys (5,754 km^2) are compared with the wintering population estimates from the aerial surveys for a limited number of species/groups derived from DISTANCE.

<table>
<tr><th></th><th>Maximum passage population</th><th>1%</th><th>Maximum wintering population</th><th>1%</th><th>Aerial surveys</th><th>1%</th></tr>
<tr><td>Red-throated Diver</td><td>11,388</td><td>113</td><td>15,226</td><td>152</td><td></td><td></td></tr>
<tr><td>Northern Fulmar</td><td>17,552</td><td>176</td><td>5,986</td><td>60</td><td></td><td></td></tr>
<tr><td>Sooty Shearwater</td><td>288</td><td>3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Manx Shearwater</td><td>58</td><td><1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Northern Gannet</td><td>2,877</td><td>1,841</td><td>4,143</td><td>41</td><td>887</td><td>9</td></tr>
<tr><td>Great Cormorant</td><td></td><td></td><td>54</td><td><1</td><td></td><td></td></tr>
<tr><td>European Shag</td><td></td><td></td><td>2,005</td><td>20</td><td></td><td></td></tr>
<tr><td>Arctic Skua</td><td>228</td><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Great Skua</td><td>863</td><td>9</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Black-legged Kittiwake</td><td>13,212</td><td>132</td><td>6,002</td><td>60</td><td>8,774</td><td>88</td></tr>
<tr><td>Black-headed Gull</td><td>223</td><td>2</td><td>75</td><td><1</td><td rowspan="6">3,441</td><td rowspan="6">34</td></tr>
<tr><td>Little Gull</td><td>1,072</td><td>11</td><td></td><td></td></tr>
<tr><td>Common Gull</td><td>80</td><td><1</td><td>1,784</td><td>18</td></tr>
<tr><td>Lesser Black-backed Gull</td><td>506</td><td>5</td><td>202</td><td>2</td></tr>
<tr><td>European Herring Gull</td><td>1,469</td><td>15</td><td>18,724</td><td>187</td></tr>
<tr><td>Great Black-backed Gull</td><td>10,126</td><td>101</td><td>11,856</td><td>119</td></tr>
<tr><td>Common Tern</td><td>54</td><td><1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Arctic Tern</td><td>196</td><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Common Guillemot</td><td>107,127</td><td>1,071</td><td>34,030</td><td>340</td><td rowspan="4">38,059</td><td rowspan="4">381</td></tr>
<tr><td>Razorbill</td><td>16,252</td><td>163</td><td>3,961</td><td>40</td></tr>
<tr><td>Little Auk</td><td></td><td></td><td>6,234</td><td>62</td></tr>
<tr><td>Atlantic Puffin</td><td>11,500</td><td>115</td><td>2,741</td><td>27</td></tr>
</table>

4.2.93 In a similar way to the comparison in the breeding season, there was a moderate difference in the estimates between auks (a factor of 1.2) and Kittiwake (1.5), with a considerable difference for Gannet (4.6 fold) and very large discrepancy for gulls (9.5 fold). The differences were not entirely consistent between the two methods although only for Kittiwake did aerial surveys produce a higher estimate.

Selection of appropriate population information

4.2.94 Comparison of the population size of all seabirds recorded within Alpha or Bravo in the breeding season, passage and winter periods could be broadly achieved by using a combination of different estimates generated from a number of sources. The hierarchy of the selection of the different methods developed to derive population estimates at different population scales, is summarised in Table 4.14.

Table 4.14. Summary of the preferred means of deriving the importance of a particular population at different scales for any seabird recorded in the Alpha and Bravo development sites.

Period	**Population scale**		
	International	**National**	**Regional**
Breeding	BirdLife International (2004)	Baker *et al*. (2006)	Foraging radii from Thaxter *et al*. (2012)
Passage	BirdLife International (2004) scaled x 1.5 according to Wetlands International (2006)	Derived from density from Stone *et al*. (1995) adjusted according to known population change	Derived from density in Western North Sea from Stone *et al*. (1995) and adjusted to size of region – with sense check from Forrester *et al*. (2007)
Winter	North Sea wintering population from Skov *et al*. (1995)	Musgrove *et al*. (2011) where available - otherwise derived from density in Stone *et al*. (1995) adjusted according to known population change	Aerial survey where available - otherwise derived from density in Western North Sea and adjusted to size of region from Stone *et al*. (1995) – sense check from Forrester *et al*. (2007)

4.2.95 In the breeding season, at the international and national population scale, comparison was straightforwardly achieved with values defined in the literature (Table 4.15). Similarly, the literature could be used to define international passage and winter populations, although in the latter case, this could only be achieved for the North Sea at a sub-international scale. In a similar way, amalgamated and adjusted data from Stone *et al*. (1995) was used to derive national passage and wintering populations, with the use of Musgrove *et al*. (2011) where this was available for a few species.

4.2.96 At the regional scale, the comparison in breeding population estimates between those derived from Stone *et al*. (1995) and both aerial surveys and the foraging radii approach was relatively unfavourable, probably mainly as a result of the different basis of the approaches resulting in estimates over different areas. In these circumstances, the foraging radii approach was deemed to provide the most appropriate measure.

4.2.97 In the winter period, the estimates from Stone *et al*. (1995) did not compare particularly favourably with those from aerial surveys, although those for auks and Kittiwake were broadly comparable. Although the use of estimates from aerial surveys would be preferred as they are taken from actual surveys, the lack of species identification makes this problematic. Also, no estimates were specifically available from the passage period. As a result, the estimates from Stone *et al*. (1995) were thought to have some value, although confidence in these estimates was relatively low.

4.2.98 A key issue was the generation of low numbers of birds as 1% criteria. In this circumstance, the recording of just a few (often <5 individuals) or even a single individual would be described as a regionally important population. An attempt to avoid this anomaly and the spurious definition of an important population was achieved by using Forrester *et al*. (2007) where descriptions of numbers and timing of birds in particular locations allows broad definition of local, regional or national interest. Species of apparent regional importance but occurring in low numbers were subject to this ‘sense check’.

Origin of birds

4.2.99 The broad origin of birds present in the breeding season may be defined as within range of particular colonies. However, an indication of the potential connectivity between breeding colonies and the birds recorded on the development sites was also gained through ageing. In simple terms, birds aged as adults could form part of the breeding population of a particular colony, notwithstanding that it may not be definitively stated that any adult was actually breeding. Some clue that this was the case is the display of particular behaviours (e.g. carrying prey in the direction of a colony). Conversely, whilst immature birds may be connected with a colony (i.e. were born there or have the intention to breed there in the future), they are not included with the designated component of a SPA colony for example.

4.2.100 In general, all gulls and Gannet may be readily aged into different calendar years. In addition, juvenile auks are readily identifiable for a month or two after leaving the colony. Immature birds that do not display adult full breeding plumage (i.e. less deep bills in the case of Razorbill, incomplete and less brightly coloured bill plates in the case of Puffin and retention of immature feathering generating a ‘patchy’ pattern in all species) may also be detected in some circumstances. The details of the sample size of birds aged and the proportions of adults are shown in the species accounts.

4.2.101 The origin of birds on passage and in winter remains extremely difficult to determine. In correspondence to Marine Scotland (dated 31 January 2012), JNCC recognise that they are ‘still considering possible approaches to HRA for seabird species during post-breeding, passage and overwintering periods’.

4.2.102 Specific information on particular species reinforces the difficulty of determining the origin of birds outside the breeding season. For example, Kittiwakes, from the Isle of May are now known to reach the West Atlantic over 3,000 km away during the winter and that this strategy was particularly employed by unsuccessful breeders that had left the colony early (Bogdanova *et al*. 2011). Birds of both groups also remained within the North Sea. As breeding success may show considerable inter-annual variation, wintering strategies are also likely to vary between years, meaning that the proportion and thus population size of birds remaining within European (used as international) and national waters may also vary considerably between years.

4.2.103 Further research on other species such as Gannet by Kubetzki *et al*. (2009) also reinforces that different individuals from the same population may employ different wintering strategies. In the study of adults from Bass Rock, 18% wintered in the North Sea and English Channel, 27% in the Bay of Biscay and Celtic Sea, 9% in the Mediterranean and 45% off West Africa. Thus, around 45% wintered outside of Europe, with 55% within European (international) waters and 18% within national waters. Different strategies may link to age, with adult Gannets thought to be more likely to winter at higher latitude (Skov *et al*. 1995), although how this may vary between adults of different age and thus experience is unclear. Moreover, it is becoming increasingly clear that individuals may tend to repeat previously successful strategies, as has recently been shown for Atlantic Puffin (Guilford *et al*. 2011).

4.2.104 In the absence of specific information (e.g. tracking of long-distance flightlines of geese and swans by Griffin *et al*. 2010, 2011; or dispersal patterns of seabirds such as that by Kubetzki *et al*. 2009, Bogdanova *et al*. 2011, Frediriksen *et al*. 2011 and Guilford *et al*. 2011), any approach to assessing effects of development upon seabirds outside the breeding season for EIA or HRA is only likely to be based on a scaling approach. In this, the area of influence (i.e. the possible origin of birds) is set, thus providing a total population, with the birds affected from a particular colony derived from the relative contribution this makes to the whole.

4.2.105 Given the flexibility of movement of seabirds and the relative speed with which this seems to occur (see Kubetzki *et al*. 2009, Guilford *et al*. 2011), it seems best to assume that any seabird present in the passage and especially winter period could originate from anywhere in the UK as a minimum. In fact, it may be reasonable to suggest the origin could be anywhere within the range of the biogeographic population range. However, the population within this range may be uncertain as a result of poor coverage and there may always be a tendency for birds with a physically closer origin to be better represented. The assumption that origin falls within the range of the national population is thus a precautionary standpoint and may be used to express the potential risk to the population (i.e. a risk-based approach) and should not be seen as a definitive measure. The actual methods for EIA are described in the resultant ES.

Spatial distribution

4.2.106 The actual location and group size of birds recorded was interpolated from the time of records relative to the vessel track. Birds were finely located according to the side of the vessel and midpoint of the distance band in which they were recorded (i.e. at 75 m from the vessel in band B which occupies the area 50 – 100 m from the vessel). The spatial distribution of individuals of any species on any survey occasion was determined by plotting in ArcGIS v.10.

4.2.107 For less common species, plots of all pooled records irrespective of the mode of activity of individuals (i.e. in flight or on the water) may be the only means of showing even basic patterns of distribution. However, for the more abundant species where there is more likelihood of demonstrating meaningful links with habitat use, steps to compensate for the differing detectability of birds from the transect line, for any differences in survey effort and to separate birds in flight compared to those on the water need be taken. Furthermore, where there are many records, any gaps in coverage (i.e. between survey lines) may be falsely interpreted as no birds were present, rather than there was no data.

4.2.108 Spatial interpolation such as kriging (Cressie 1993) provides a means of providing estimates for areas that have not been sampled from a model using the weighted average of neighbouring values. Van der Meer & Leopold (1995) provide an example of kriging for seabird data, with further discussion of the techniques by McSorley *et al*. (2005). Poisson kriging is more appropriate than ordinary kriging for data that is zero inflated and overdispersed, but the use of the former is technically very demanding and is not appropriate for simple representation of distribution patterns such as in this report. SNH have suggested the use of density surface modelling, available as an extension through DISTANCE as a more appropriate alternative to ordinary kriging. This technique is however geared to express changes in distribution patterns in statistical terms and does not produce readily interpretable plots.

4.2.109 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, 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 1 km^2 grid over the sites within GIS.

4.2.110 The aim was then to express the abundance of birds within each 1 km^2 'cell'. 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. Thus for Fulmar, Gannet, Kittiwake, Herring Gull, Lesser Black-backed Gull and Great Black-backed Gull which tend to be recorded in flight during surveys, only these records were used. In contrast, for Guillemot, Razorbill, Puffin and Little Auk, whose primary mode of activity is swimming, only those birds seen on the water were used in the analysis.

4.2.111 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.

4.2.112 According to the methods of Ford *et al*. (2004), a weighted mean of estimated abundance was then calculated for each period of interest (see below) 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.

4.2.113 To eliminate the need for differential distance correction 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).

4.2.114 The approach was vindicated by the similar numbers of birds recorded in band A relative to band B, each of 50 m width. For example within Alpha and Bravo there were 732 observations of Guillemot in band A and 826 in band B. In the case of Puffin there were 654 in band A and 591 in band B, and for Razorbill there were 215 records in band A and 201 records in band B. It was thought that the eye-height of the vessel at ~8 m aided the detection of birds to this distance. (100 m either side of the vessel).

4.2.115 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 true density (individuals' km^{-2}).

4.2.116 For flying birds, density can only be derived from snapshot data that takes movement bias into account. This was too spatially limited to be of specific value to assess 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 and not density. 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), and thus records from the full strip transect width of 600 m (300 m either side of the vessel) could be used.

4.2.117 For selected species, data could then be partitioned between or within periods to assess whether there were any obvious trends in the distribution of birds within different periods. The periods included all surveys, surveys limited to respective breeding seasons (see Table 4.6), surveys limited to wintering/passage periods (see Table 4.6), surveys in year 1 (surveys from December 2009 – December 2010), surveys in year 2 (surveys from January 2011 – November 2011), breeding periods in year 1 and breeding periods in year 2.

4.2.118 The resolution of a 1 km^2 grid appeared to be compatible with the survey design (see 4.2.18 above), generating similar survey effort across the whole area of both Alpha and Bravo, irrespective of whether data for birds on the water from a 200 m wide strip generated from bands A and B combined (typically >6% total coverage) or data for flying birds generated from the entire transect width of 600 m (typically >20% total coverage) was used (Figure 4.7).

4.2.119 There was however some evidence of 'banding' with slightly higher survey effort along the actual routes. As the process outlined above (see 4.2.99) compensates for survey effort, any slight differences in intensity of survey effort generated by the grid size selected were considered unlikely to affect the results and there was confidence in the analysis to show realistic patterns of distribution.

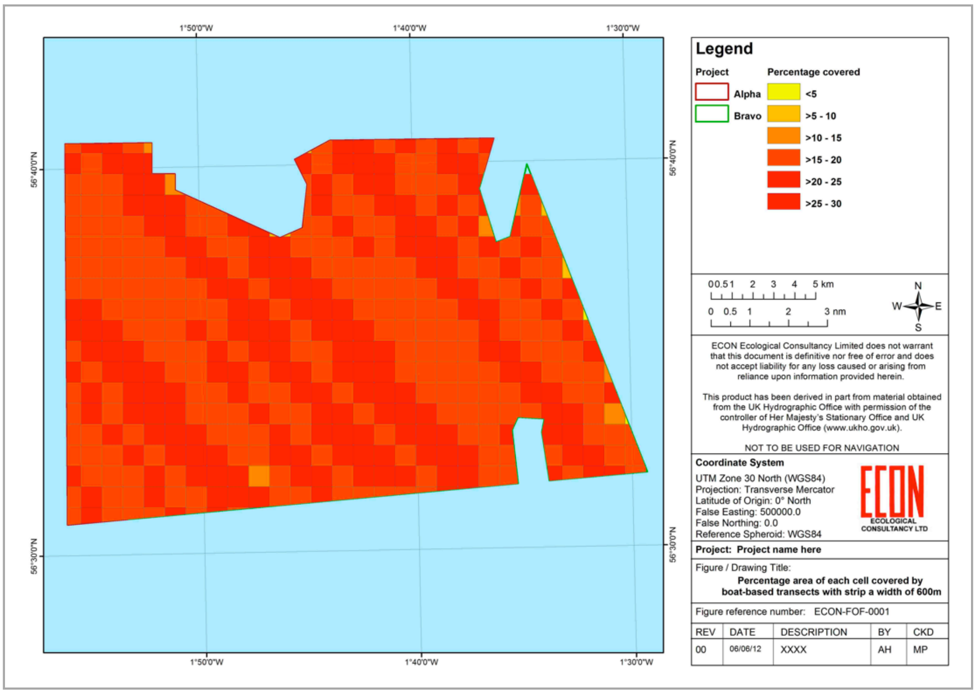
4.3 Aerial surveys

Survey design and route

4.3.1 A programme of aerial surveys conducted during 2009/10 covered Alpha and Bravo within both the context of the Zone as well as a wider area of 5,755 km^2 incorporating more inshore waters (Figure 4.8). The programme comprised three summer (May–August) and four winter (November 2009 – February 2010) surveys (Table 4.15).

4.3.2 The summer surveys were divided into five adjoining blocks (1 to 5) with transect spaced at 2 km apart ranging in length from 20–65 km. Survey 1 of the summer season only surveyed sections 1 to 4. In addition, section 5 was repeated in the second summer survey (03/07/09) and sections c and f were repeated in the fourth summer survey (20/03/10). This repeat data has not been included in this report.

4.3.3 Winter surveys were divided into six routes (a to f) along transects ranging from 8 – 90 km also spaced at 2 km intervals (Figure 4.8). Survey 3 of the winter season failed to sample routes c and f. Route c of survey 2 only surveyed the starboard side.



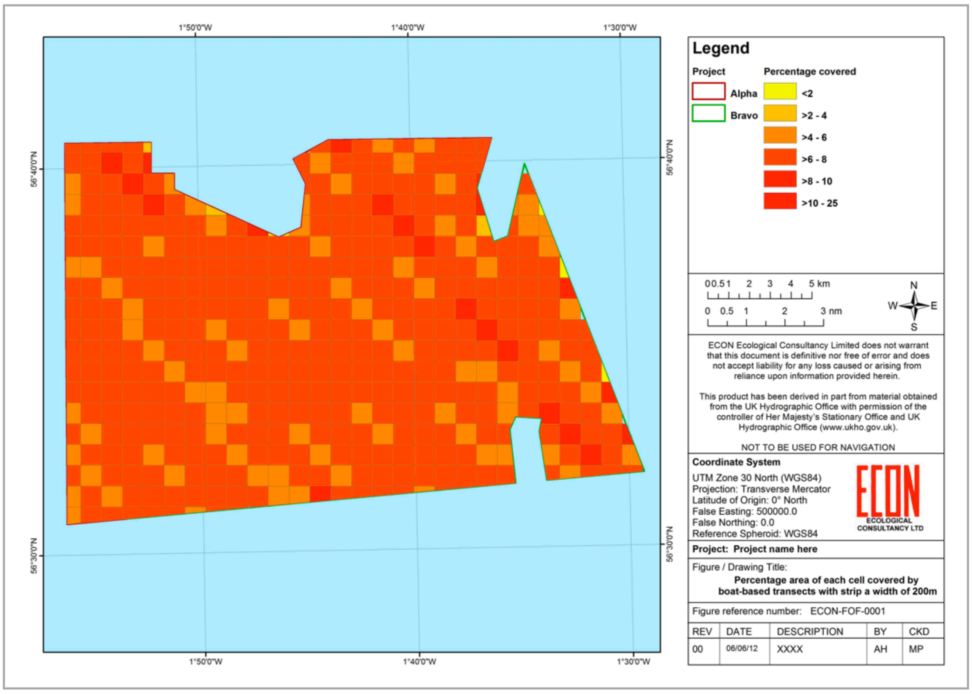
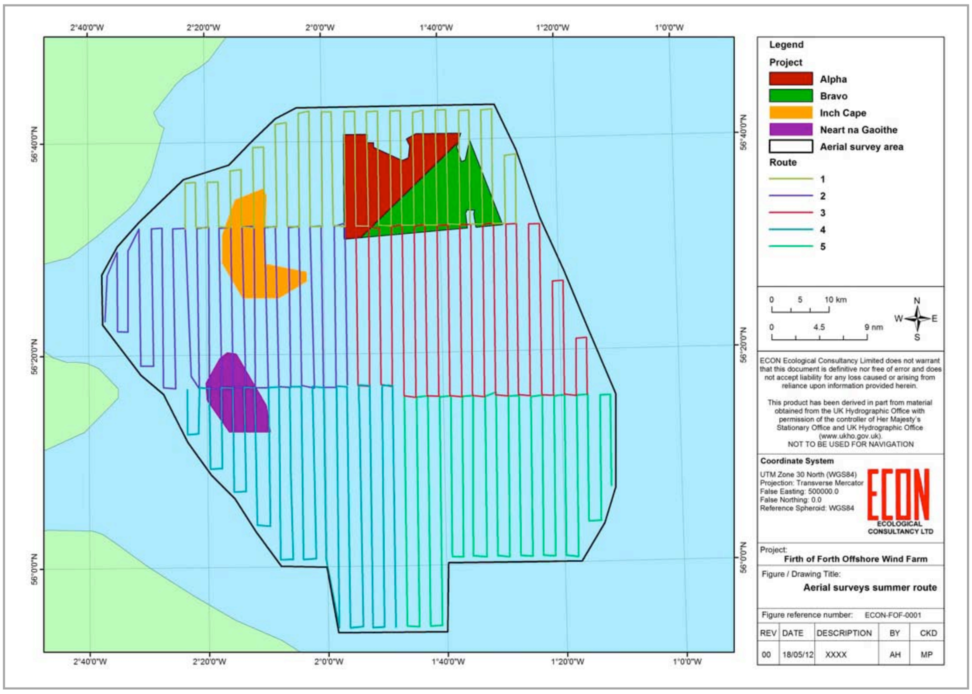


Figure 4.7 Survey effort of each 1 km^2 grid cell across the combined area of Alpha and Bravo for the entire transect of 600 m width adopted for birds in flight (above) and for the reduced transect of 200 m width for birds on the water (below). Coverage is expressed as the percentage of the area that could be covered by multiple surveys (i.e. 1 km^2 x 23 surveys) divided by the area of the cell covered by the combined routes.

Table 4.15 Details of the summer and winter aerial surveys of the wider Firth of Forth in 2009/10.

Season	Survey	Section/ route	Date	Transect length (km)
Summer	1	1	28/05/09	473.2
		2	29/05/09	559.6
		3	29/05/09	555.9
		4	28/05/09	528.4
	2	1	25/06/09	498.7
		2	20/06/09	558.0
		3	21/06/09	559.4
		4	21/06/09	528.7
		5	20/06/09	556.3
	3	1	16/07/09	475.3
		2	06/08/09	561.2
		3	25/07/09	561.1
		4	16/07/09	475.2
		5	06/08/09	554.9
Winter	1	a	04/11/09	440.3

Season	Survey	Section/ route	Date	Transect length (km)
		b	05/11/09	449.9
		c	08/11/09	455.6
		d	04/11/09	455.3
		e	05/11/09	456.2
		f	09/11/09	340.9
	2	a	03/12/09	440.0
		b	11/12/09	271.3
		c	04/12/09	405.4
		d	12/12/09	455.6
		e	11/12/09	438.2
		f	12/12/09	364.2
	3	a	08/01/10	409.6
		b	09/01/10	431.3
		d	09/01/10	455.9
		e	08/02/10	389.5
	4	a	16/02/10	436.9
		b	17/02/10	450.7
		c	14/02/10	455.9
		d	16/02/10	455.8
		e	17/02/10	455.7
		f	14/02/10	450.4



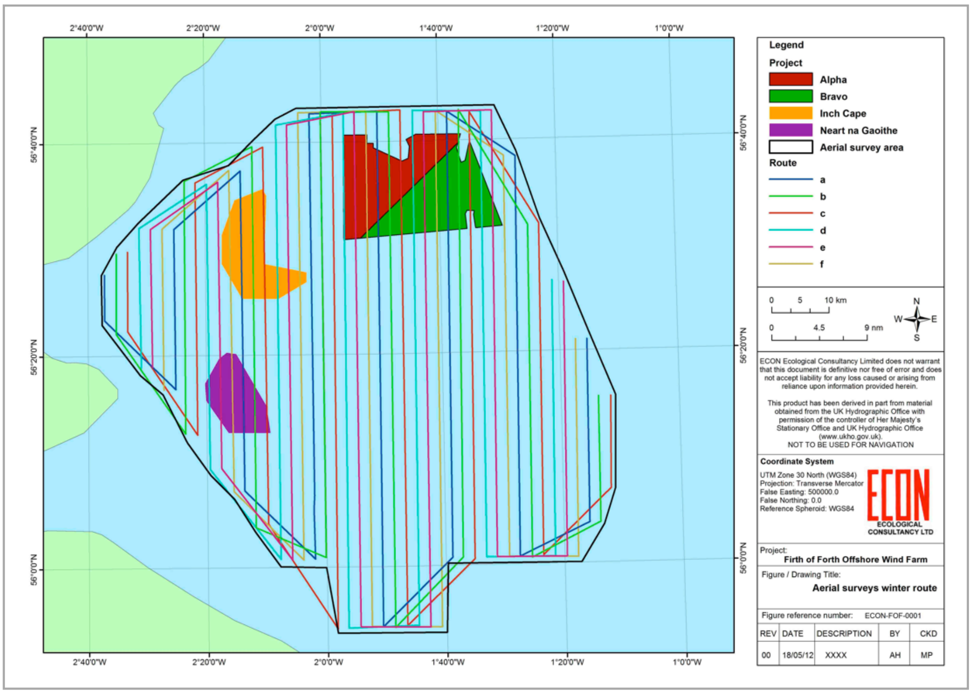


Figure 4.8 Firth of Forth Round 3 Zone aerial survey blocks during summer 2009 (above) and winter 2009/10 (below) relative to the Alpha and Bravo and Scottish Territorial Waters development sites.

Data collection and survey

4.3.4 Aerial surveys used the recommended methodology specified by COWRIE (Camphuysen *et al*. 2004):

- Surveys were conducted from Partenavia PN68 high-winged twin-engined aircraft flying at an altitude of 76 m (250 ft) and a speed of approximately 200 km/h along transects spaced at 2 km intervals oriented along a north south axis to the shore, which helped reduce glare and improved detection of birds;
- Two experienced observers (one on port side and one on starboard side) conducted surveys over four hours flight time centred on midday (GMT) of one day, in selected good weather conditions with wind speeds of <15 knots;
- The location of the aircraft was recorded every five seconds using GPS (Garmin 12XL), allowing the subsequent accurate positioning of any bird(s) to within a few hundred metres;
- For each observation of a bird, their identity, number, general behaviour (e.g. swimming, flying etc), distance from the boat, and time of observation were recorded using a Dictaphone;
- The survey transect width, measuring 956 m, was divided into four distance bands (A: 44-163 m; B: 163-282 m; C: 282-426 m; and D: 426-1000 m). Birds were assigned to these bands using a clinometer when perpendicular to the flight path of the aircraft. At less than 44 m range birds could not be seen beneath the body of the aircraft; and,
- The survey method assumes all birds in Band A are detected and greatest effort was concentrated in this band.

4.3.5 Although birds were identified to species wherever possible, this proved to be limited and the great majority of individuals of the dominant groups including auks and gulls were not identified to species level.

Density and population estimation

4.3.6 In principle, the speed of the survey platform ensures that both birds in flight as well as those on the water are effectively stationary in relation to the survey platform. This means that all records may be pooled for use in DISTANCE analysis, and the objective was therefore to estimate density and population size of species and species groups wherever possible.

4.3.7 However, the violation of the assumptions of DISTANCE (such as too few records, grouping in further distance bands) coupled with the limited species identification in aerial surveys meant that analysis could be performed for only a limited number of species (Gannet and Kittiwake) and species groups (auks and gulls).

Relative importance of population size

4.3.8 The aerial survey dataset covering more or less the entire area of the Firth of Forth in summer and winter was used to elucidate potential regional population size for the limited number of species (Gannet and Kittiwake) and species/groups (auks and gulls) that could be analysed.

4.3.9 Aerial survey data was also used to assess the relative importance of the estimated populations of birds within Alpha or Bravo and also within the STW sites of Neart na Gaoithe Inch Cape, compared to the wider regional area through the use of Jacob's selectivity index (D). The index indicates whether birds prefer one area over another as manifested by a preference or selection for a particular area relative to its size. The proportion of birds using the area of interest relative to a total number for the whole aerial survey area was calculated as follows:

$$D = \frac{(r - p)}{(r + p - 2rp)}$$

Where:
r = the proportion of the total count of a species that is within either Alpha or Bravo
p = the proportion of the total area of the survey that is made up by Alpha or Bravo

4.3.10 Values vary from +1 (exclusive selection for the site) to -1 (total avoidance), values close to 0 indicate no selection. It should be noted that a value of -1 will be generated if a species is not seen at all on the site and given the fact that some species are difficult to identify in aerial surveys values of -1 may not always be informative. For this reason any species with a count of <50 records was excluded. Of most interest were values greater than +/- 0.5, seen to provide clear evidence of selection or avoidance respectively.

4.3.11 Caution needs to be used when interpreting preferences based on aerial data as many species groups may be difficult to identify to the species level during aerial surveys. Nonetheless, even given that an unknown fraction of birds would remain unidentified there was no reason to suspect that there was any bias in the distribution of the identified fraction. Thus, given sufficient data the patterns revealed by D were seen to be broadly reflective of real patterns of preference.

Spatial distribution

4.3.12 Survey effort and survey routes varied in effort (number of surveys) and route (some lines were also missed or only one side of the aircraft was surveyed) both within and between the different survey periods (Table 4.16). It was therefore somewhat difficult to compare the results directly, thereby confounding general analyses of spatial trends. Limited species identification and low numbers meant that only Auk species, Kittiwake, Gannet, Fulmar and Herring Gull had sufficient data to warrant mapping. These are presented within individual sections.

4.3.13 Analysis of variation in the spatial distribution of birds, between summer and winter, based on these data was hindered by the variability in survey effort and for the purposes of showing basic patterns, raw count data for each of these species / groups was plotted using proportional circles, allowing the broad scale patterns of distribution and abundance to be visualised. The centre of each circle represents the centre of each survey cell.

4.4 Tracking of individual seabirds

4.4.1 Individual tracking establishes specific links to particular colonies that cannot be unequivocally established by other means. To build upon previous studies, FTOWDG commissioned CEH to determine the foraging distribution of breeding SPA species thought likely to be important receptors of cumulative impacts (see 4.1.18 above). The basic method was to attach miniaturised Global Positioning System (GPS) data loggers to actively breeding birds. The technology involves the recapture of the tagged individual to retrieve the tag and the stored data within.

4.4.2 The combination of species and colonies was Kittiwake, Guillemot and Razorbill breeding on the Isle of May during 2010 and Kittiwake breeding at Fowlsheugh and St Abb's Head in 2011. Fowlsheugh and St Abb's Head also support important populations of Guillemot and Razorbill**,** but capture of auks at either of these sites was not practical given the size and scale of the cliffs and the relative nesting positions of the birds. However, data on the trip duration and flight direction of Guillemots at both colonies was gathered and compared with data from tracking studies in order to inform possible foraging distribution.

4.4.3 In addition, FTOWDG purchased data gathered by CEH on 10 individual Puffins from the Isle of May in 2010 following a trial of the attachment of dummy tags to three birds. The evidence was that Puffin breeding behaviour, specifically chick provisioning, was disrupted by tag attachment (see 4.4.10 & 4.4.11 below). However, the data was still thought to be of value to help determine general patterns of foraging range and the relative importance of different areas.

4.4.4 Full methods and results of the tracking of Kittiwake, Guillemot and Razorbill in 2010 are provided by Daunt *et al*. (2011a), with equivalent reporting for 2011 on tracked Kittiwakes and the monitoring of trip duration and flight direction of Guillemots in Daunt *et al*. (2011b). Only brief details of the tracking of Puffin in 2010 are supplied in the form of a letter dated 23 January 2012 from Francis Daunt of CEH to Mainstream Renewable Power representing FTOWDG.

Capture and attachment

4.4.5 In 2010, capture and attachment of tags to birds was conducted between 29 May- 27 June for Kittiwake, 8-18 June for Razorbill and 10-18 June for Guillemot coinciding with incubation and chick rearing for Kittiwake and chick-rearing for the auk species. In 2011, tag deployment upon Kittiwake was undertaken in a similar period from 24 May-22 June at Fowlsheugh and in the slightly narrower period of 2-17 June at St Abb's Head.

4.4.6 All loggers were tested prior to deployment. In 2010, sampling interval was set at 1 minute for most deployments, with a small number set at 5 minute. In 2011, only 1 minute sample intervals were used.

4.4.7 For all three species at all colonies, birds were captured at the breeding site with a noose on the end of a long pole and the device attached to the feathers on the back of the bird using Tesa tape. Handling time was typically less than 5 minutes, and not longer than 10 minutes. Birds returned to normal breeding behaviour within a few minutes of release.

4.4.8 Birds carried loggers for short periods of 1-2 days for a maximum of 5 days before they were recaptured at the nest and the logger retrieved. All tape was removed from the feathers and the bird released. As with deployment, birds returned to normal behaviour within a few minutes.

4.4.9 As well as the potential for tag failure either as a result of inherent technical faults or the tag becoming detached from the bird, species-specific issues such as ease of capture and likelihood of breeding failure caused variation in the success of tagging. In 2010, 74 GPS tags were deployed on Kittiwakes, with 36 (49%) successful retrievals of data. Both Guillemot (35 of 46 tags – 76%) and Razorbill (18 of 25 tags – 72%) had higher rates of recovery. In 2011, data retrieval rates were higher on Kittiwake than previously experienced with 65% (35 of 54 tags) at Fowlsheugh and 78% (25 of 32 tags) at St Abb's Head.

4.4.10 For Puffins at the Isle of May, 10 birds from burrows containing chicks were fitted with tags on either 19 or 23 June 2010 with retrieval of 70% of the tags between 21-26 June. Observations conducted at each nest revealed that three of the 10 birds was never seen again after tag attachment, with another not seen again after the tag was removed. Another bird delayed return after tag attachment and the burrow was subsequently dug out either by other Puffins or European Rabbit *Orcytolagus cuniculus.* Yet another tagged individual did not enter the burrow after its tag was removed. These results indicate that birds seem to respond negatively to handling and that these are difficult to separate from the burden of carrying a tag, that also seem likely to occur.

4.4.11 The feeding rate of tagged puffins appeared to be depressed with these making just over one feed per day which was unlikely to match the 4-5 recorded in undisturbed burrows even allowing for the contribution of their partner. During recapture of the seven birds from which tags were retrieved, two (29%) had returned without fish, compared to 2% recorded in n=81 returns to undisturbed burrows. A check on the status of the nest on 2 July showed that 20% of nests had failed in comparison to 9% of unmanipulated burrows, with chicks recorded as thin or very thin at 37.5% of the remainder.

Data processing

4.4.12 The basic amount of data available from each set of tracking is shown in Table 4.16. The total number of positional fixes for Kittiwake was 79,435 from 254 trips reasonably evenly distributed between the different colonies in the different years. The number of trips recorded for Guillemot and Razorbill was just less than half of the total for Kittiwake from just one colony in one year. In contrast, the available dataset for Puffin from the Isle of May was much smaller and potentially of lower quality as a result of the effects of tagging the birds.

Table 4.16 Details of the available data from the deployment of GPS tags on Kittiwake, Guillemot, Razorbill and Puffin at specific colonies in specific years.

Species	Colony	Year	Tags retrieved	Number of trips	Number of GPS fixes
Black-legged Kittiwake	Isle of May	2010	36	91	26,545
	Fowlsheugh	2011	35	93	32,875
	St Abb's Head	2011	25	70	20,015
Guillemot	Isle of May	2010	33	112	32,021
Razorbill	Isle of May	2010	18	111	19,462
Puffin	Isle of May	2010	7	15	8,971

4.4.13 The methods of data processing of retrieved tags are presented in detail by Daunt *et al*. (2011ab). In basic terms, the data required processing in two steps. First, all locations recorded at the colony were removed from the data set. Second, locations recorded during flights were partitioned from locations recorded during non-flight periods comprising foraging or resting. This partitioning was achieved by plotting a histogram of speeds, which was typically bimodal with the different peaks representing flight and non-flight respectively. A boundary value to distinguish the two activities was set on a individual by individual basis using histograms of flight speed, with the speed at any fix being derived from the time-distance relationship from the previous point. For guillemot the boundary range was 3-5 ms^{-1}, with 3-4.5 ms^{-1} for razorbill and 5-6 ms^{-1} boundary range for kittiwake. For Puffin, the threshold between flight and non-flight was set at 49 $km.h^{-1}$ or 13.6 $m.s^{-1}$ (Pennycuick 1987).

4.4.14 The rationale for dividing the data in this way was that the distribution of flight locations was seen to be most relevant to collision risk (Desholm & Kahlert 2005), and the distribution of non-flight locations of most relevance to displacement. Barrier effects (Masden *et al*. 2010) could conceivably occur in both modes of activity. However, as the thresholds were determined pragmatically, there is considerable uncertainty on the actual behaviour of the bird and the division between flight and non-flight must be treated with caution.

4.4.15 Daunt *et al*. (2011ab) conducted a number of analyses on the data for Kittiwake, Guillemot and Razorbill following an initial test to determine whether the sample size available was adequate to estimate the range at sea using a bootstrapping technique. The analysis supported the view that the available data was a robust indicator of population range over the course of deployment of all species at all colonies.

4.4.16 No such analysis could be conducted on the limited dataset available for Puffins. Nevertheless, interpretation of the available data by Daunt in the letter to Mainstream (see 4.4.4 above) suggested that the basic patterns of trips including the potential for overnight stays at considerable distance (tens of kilometres) from the burrow was similar to that reported in other studies, suggesting that the wider range of birds was reasonably well represented. However, short-range trips that provision chicks were not well represented in the dataset. In conclusion, Daunt suggested that the dataset could represent a worst-case scenario of the interaction between Puffins breeding on the Isle of May and the propose wind farms in the Firth of Forth.

4.4.17 Further analyses conducted on the datasets for Kittiwake, Guillemot and Razorbill included simple analysis of horizontal flight lines and more complex kernel distribution to show preferred areas at sea and association with habitat variables derived from remote sensing data. All but the latter was also conducted for the more limited Puffin data. These analyses were all conducted in relation to the distribution of the STW sites and the entire Round 3 zone, which is not of relevance to this technical report.

4.4.18 As a result, specific analysis of all species data in relation to Alpha and Bravo was conducted from the datasets, following correction of some technical issues by CEH. Analysis included replotting the tracklines of each trip by each bird coupled with simple analyses of the number and proportion of: 1) trips entering either Alpha or Bravo as well as the different STW sites, 2) the distance travelled within each wind farm and 3) GPS fixes according to combined and flight and non-flight behaviours (as define in 4.4.14 above). For each species, the parameters were calculated as a total for all birds. As more than one trip could be undertaken by each bird and any individual doing so could bias the results as a result of specific ranging behaviour, all analyses were conducted by each individual to derive a mean value to accounts for variation between individual birds.

5. ORNITHOLOGICAL OVERVIEW

5.1 Boat-based surveys

Species composition and patterns of abundance

Project Alpha

5.1.1 A total of 24,655 individual birds of 40 species and 10 unidentified taxa were recorded during boat-based surveys of area encompassed by Project Alpha in the 24 surveys between December 2009 and November 2011 inclusive (Table 5.1). A range of seabirds such as Gannet, petrels and shearwaters, skuas, gulls, terns and auks and a wide variety of migrant passerines and waterfowl were represented.

Table 5.1. Total count from all surveys and maximum density (individuals' km^{-2}) and maximum population size (individuals) in any single survey, of all species and unidentified taxa recorded in boat-based surveys of Project Alpha and Project Bravo from December 2009 to November 2011 inclusive.

Species	Scientific name	Project Alpha			Project Bravo		
		Total count	Maximum Density	Maximum Population	Total count	Maximum Density	Maximum Population
Mallard	*Anas platyrhynchos*				2	0.12	23
Common Eider	*Somateria mollissima*	3	-	9			
Unidentified duck					1	-	3
Red-throated Diver	*Gavia stellata*	1	-	3	2	0.025	5
Unidentified diver	*Gavia* sp.	1	-	3			
Northern Fulmar	*Fulmarus glacialis*	627	2.519	497	810	2.606	505
Great Shearwater	*Puffinus gravis*	1	-	3			
Sooty Shearwater	*Puffinus griseus*	19	0.398	78	7	0.143	28
Manx Shearwater	*Puffinus puffinus*	14	0.053	10	14	0.079	15
European Storm Petrel	*Hydrobates pelagicus*	22	0.468	92	7	0.078	15
Unidentified petrel	*Oceanodroma sp.*	1	-	3			
Northern Gannet	*Morus bassanus*	3,951	13.776[1]	2,716[1]	3,292	5.890[1]	1,141[1]
Great Cormorant	*Phalacrocorax carbo*	2	-	6			
European Shag	*Phalacrocorax aristotelis*	2	-	6			
Merlin	*Falco columbarius*				1	-	3
Eurasian Oystercatcher	*Haematopus ostralegus*	3	-	9			
European Golden Plover	*Pluvialis apricaria*	8	0.461	91	4	-	12
Northern Lapwing	*Vanellus vanellus*	2	0.050	10	2	0.056	11
Common Snipe	*Gallinago gallinago*				2	0.106	21

Species	Scientific name	Project Alpha			Project Bravo		
		Total count	Maximum Density	Maximum Population	Total count	Maximum Density	Maximum Population
Eurasian Curlew	*Numenius arquata*	13	0.537	106	1	0.056	11
Ruddy Turnstone	*Arenaria interpres*				4	-	12
Grey Phalarope	*Phalaropus fulicarius*	1	-	3	9	0.159	31
Unidentified wader		17	-	50	1	0.053	10
Pomarine Skua	*Stercorarius pomarinus*	1	0.055	11	1	0.053	10
Arctic Skua	*Stercorarius parasiticus*	5	0.056	11	4	-	6
Great Skua	*Stercorarius skua*	13	0.081	16	6	0.058	11
Unidentified skua	*Stercorarius* sp.				1	-	3
Black-legged Kittiwake	*Rissa tricactyla*	5,837	22.875[1]	4,510[1]	4,468	14.527[1]	2,813[1]
Black-headed Gull	*Chroicocephalus ridibundus*	2	0.430	85	2	0.056	11
Little Gull	*Hydrocoloeus minutus*	3	0.051	10	6	0.108	21
Common Gull	*Larus canus*	21	0.231	45	9	0.056	11
Lesser Black-backed Gull	*Larus fuscus*	42	0.498	98	36	0.698	135
European Herring Gull	*Larus argentatus*	181	0.614	121	116	0.841	163
Great Black-backed Gull	*Larus marinus*	185	1.301	257	175	1.266	245
Unidentified large gull	*Larus* spp.	97	0.170	34	61	0.116	23
Unidentified small gull	*Larus* spp.	2	-	3	19	-	53
Sandwich Tern	*Sterna sandvicensis*	1	-	3			
Common Tern	*Sterna hirundo*	31	0.335	66	1	0.056	11
Arctic Tern	*Sterna paradisaea*	186	1.810	357	129	4.132	800
Unidentified tern	*Sterna* spp.	127	-	361			
Common Guillemot	*Uria aalge*	7,307	54.827[1]	10,811[1]	5,453	54.571[1]	10,569[1]

Species	Scientific name	Project Alpha			Project Bravo		
		Total count	Maximum Density	Maximum Population	Total count	Maximum Density	Maximum Population
Razorbill	*Alca torda*	1,796	10.660[1]	2,102[1]	1,423	6.605[1]	1,279[1]
Little Auk	*Alle alle*	295	12.530[1]	2,471[1]	216	5.749[1]	1,113[1]
Atlantic Puffin	*Fratercula arctica*	1,734	14.134[1]	2,787[1]	2,341	28.082[1]	5,439[1]
Unidentified auk		1,911	5.905	1,164	1,271	7.674	1,486
Feral Pigeon	*Columba livia*	1	0.025	5	1	-	3
Common Swift	*Apus apus*	8	-	18			
Goldcrest	*Regulus regulus*				1	0.058	11
Eurasian Skylark	*Alauda arvensis*				1	-	3
Barn Swallow	*Hirundo rustica*	1	-	3	1	-	3
Common Starling	*Sturna vulgaris*	2	0.026	5	3	0.113	22
Common Blackbird	*Turdus merula*				3	-	6
Fieldfare	*Turdus pilaris*				4	0.055	11
Song Thrush	*Turdus philomelos*	1	0.053	10			
Redwing	*Turdus iliacus*	1	0.058	11	16	-	47
Unidentified thrush	*Turdus* sp.	1	-	3	1	0.053	10
Spotted Flycatcher	*Muscicapa striata*				1	0.053	10
Meadow Pipit	*Anthus pratensis*	7	0.056	11	5	0.051	10
Unidentified pipit	*Anthus* sp.	1	0.055	11			
Brambling	*Fringilla montifringilla*	1	0.082	16			
Unidentified passerine		12	0.058	11			

5.1.2 General abundance is broadly indicated by the numbers of individuals recorded, with Guillemot (28.1%), Kittiwake (24.8%), Gannet (16.1%) comprising 69% of all birds recorded. Unidentified auks (7.9%), Razorbill (7.6%) and Puffin (7.5%) were the next most numerous taxa. The general dominance of seabirds is in keeping with the location of the site >27 km from shore.

5.1.3 Auks generally dominated the assemblage throughout the year, with variable numbers of Kittiwake in the small gull category reaching exceptionally high numbers on a single occasion in late autumn, something which was not repeated (Figure 5.1). The numbers of Gannets recorded were generally more consistent through the breeding season and into the autumn passage period.

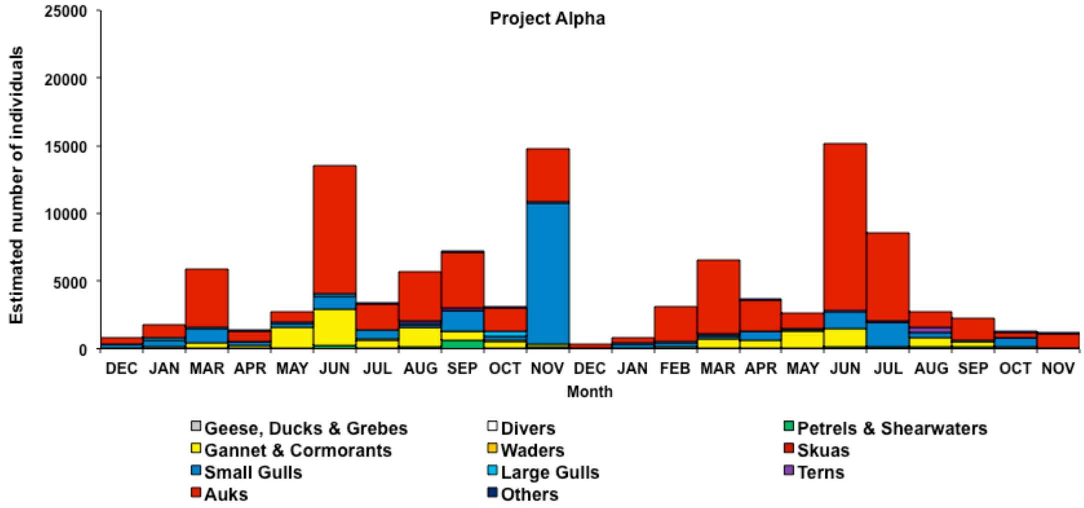
5.1.4 Overall, the numbers of birds were lowest in the winter from December to February (~1,000-3,000 individuals) increasing in March, but with variable numbers during the breeding season (April –July) albeit with peaks in June (around 11,000-14,000 birds) in both 2010 and 2011. In 2010, there was an increase in numbers from a relatively low level in July during the early part of the autumn dispersal period to September. The opposite pattern was recorded in 2011, with numbers declining from a high point in July. These trends may be linked to differential breeding success and the timing of breeding of different species at the different colonies. However, productivity (chicks fledged $pair^{-1}$) on the Isle of May at least was at least similar in 2010 and 2011 for Guillemot (0.80 and 0.71 respectively), the dominant auk species.

Project Bravo

5.1.5 A total of 19,936 individual birds of 40 species and 7 unidentified taxa were recorded during boat-based surveys of area encompassed by Project Bravo in the 24 surveys between December 2009 and November 2011 inclusive (Table 5.1). The representation of different taxonomic groups was similar to that recorded in Alpha, with some minor differences such as the lack or reduced numbers of inshore seabirds such as Cormorant, Shag, Sandwich Tern and Common Tern testament to the slightly more offshore position of Bravo (Table 5.1). This did not seem to affect the number of passerines or waders recorded however.

5.1.6 The general composition of the assemblage as broadly indicated by the numbers of individuals recorded, was similar to Alpha with Guillemot (29.3%), Kittiwake (21.6%), Gannet (16.6%) comprising 67.5% of all birds recorded. Although various categories of auks were also the next most numerous taxa, the order of abundance was weighted more towards Puffin (11.0%) and then Razorbill (6.8%) and unidentified auks (6.2%), which may be related to the increased distance from shore (to 59 km).

5.1.7 As in Project Alpha, auks generally dominated the assemblage throughout the year, again with the more notable exception of very high numbers of Kittiwake (amongst the small gull category) on a single occasion in late autumn 2010 (Figure 5.1). Variation in the numbers of Kittiwakes was again apparent but with not necessarily in the same months as in Alpha (Figure 5.1). As in Alpha, Gannets were consistently recorded through the breeding season and into the autumn passage period.



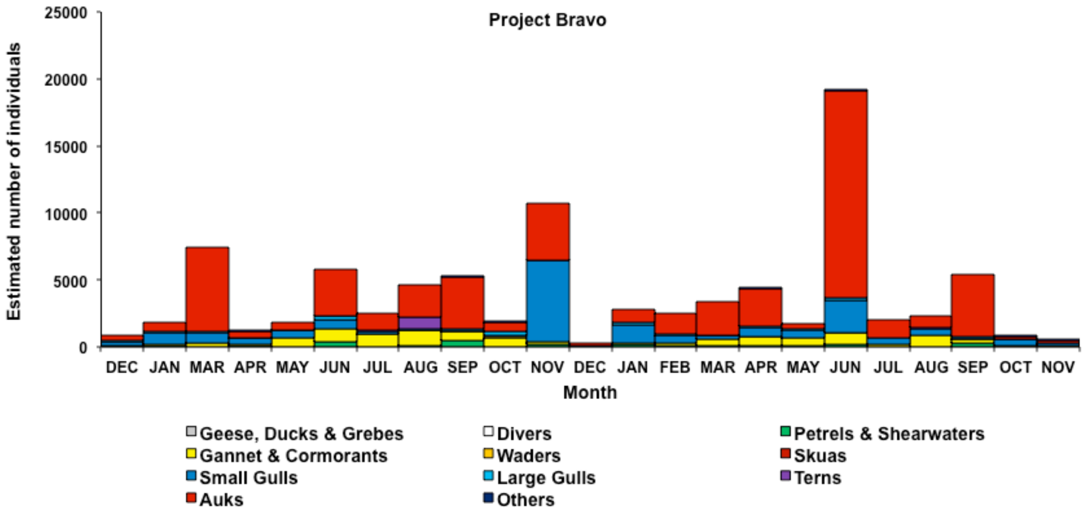


Figure 5.1. Estimated numbers of individuals and relative abundance of different taxonomic groups of birds in each survey month from December 2010 to November 2011 inclusive in boat-based surveys of Project Alpha and Bravo. The number of individuals is estimated from standard methodology of combining the density of birds on the water in line transect, with birds in flight in snapshots.

5.1.8 The seasonal distribution of populations of the different taxonomic groups showed broad similarity to that recorded in Alpha with lowest numbers (<2,000 individuals) in the winter from December to February, with more consistent numbers of around 5,000 individuals during the breeding season and into autumn, punctuated by occasional peaks in abundance to >10,000 individuals (Figure 5.1). Some of these peaks (e.g. November 2010) were consistent with records from Alpha, although the exceptional peak of >23,000 birds in June 2011 was not. There is no ready explanation of this peak of mainly auks at this stage.

Distribution

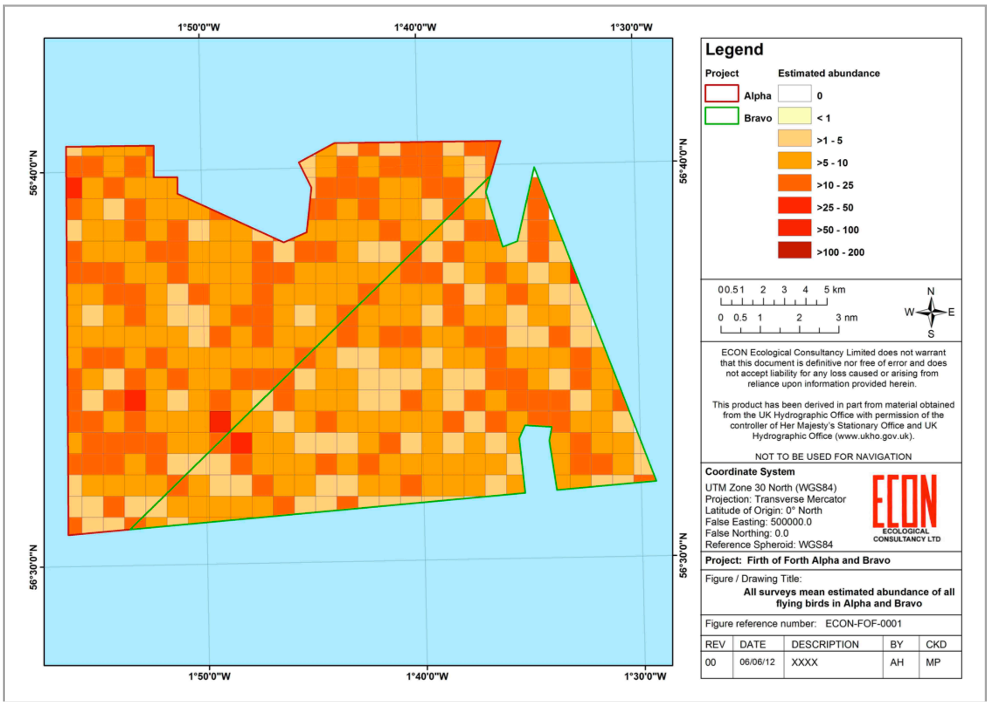
5.1.9 The spatial distribution (relative abundance) of birds in flight in all surveys across all seasons was relatively even with the majority of 1 km^2 grid cells supporting on average between 5-25 flying birds per km^2 surveyed (Figure 5.2). There were however a few 'hotspots' of activity within a few cells, with >50 flying birds per km^2 surveyed on average. The relatively low number of hotspots are thought likely to indicate aggregation in particular surveys most likely as a result of feeding aggregation rather than representing a consistent pattern of selection for one area over another perhaps linked to the presence of a particular habitat feature.

5.1.10 In general terms, the distribution pattern of flying birds would tend to suggest a relatively even risk of collision across the two projects, although this could of course be heavily influenced by the distribution patterns of particular species at risk. Moreover, the patterns between different periods (e.g. breeding season) may vary considerably. Both species-specific and temporal patterns are shown in greater detail in individual species accounts.

5.1.11 In contrast to birds in flight, the distribution of birds on the water over all surveys and seasons showed much greater patchiness (Figure 5.2). In general, there was some suggestion of parts of Alpha including the central portion and areas closer to shore on the western side supporting greater density. In these areas, many cells supported >10 individuals km^{-2} on average, interspersed with hotspots of >50 and even >100 individuals km^{-2}.

5.1.12 Over the eastern part of Alpha and Bravo, density typically averaged 5-25 individuals km^{-2}, but with patches containing 25-100 individuals km^{-2}. The nature of the distribution of these patches over a series of adjacent cells was suggestive of consistent association with a particular habitat feature rather than simple aggregation for whatever reason on one occasion.

5.1.13 The prospect of patchy distribution according to particular features may provide the basis of more sensitive areas in relation to potential displacement from wind turbines. Both patchy distribution and what this may mean for individual species is discussed in greater detail in individual species accounts.



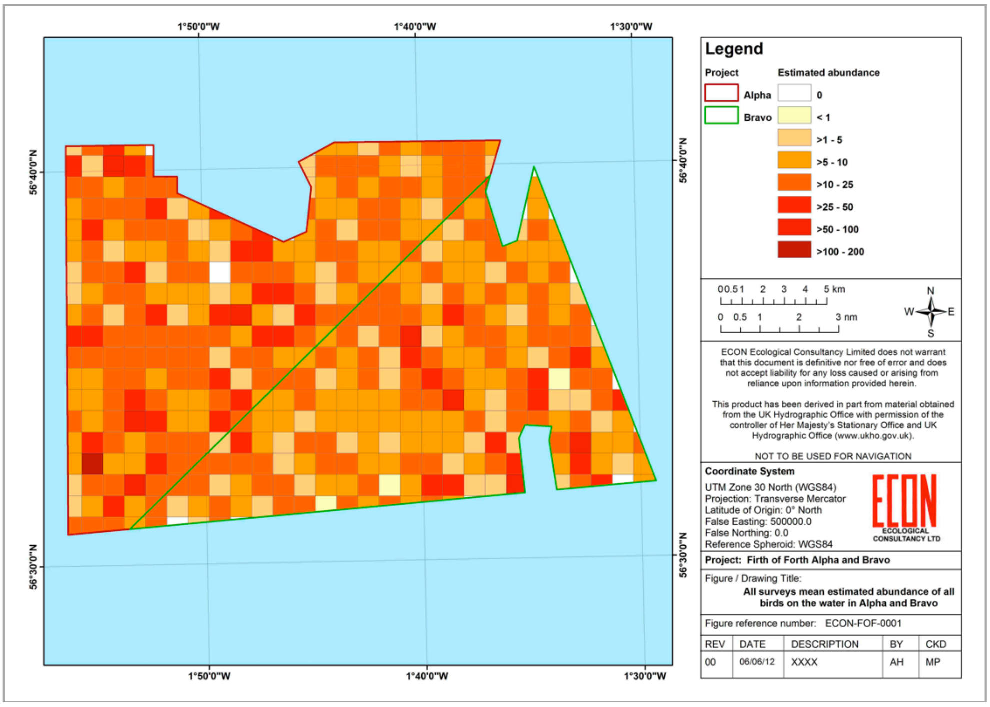


Figure 5.2 Relative abundance (individuals recorded km^{-2}) of birds in flight (above) and density (individuals' km^{-2}) of birds on the water (below) in 1 km^2 grid cells across Alpha and Bravo in all surveys in all seasons.

Identification of sensitive species

5.1.14 Species thought to be sensitive to development are typically those that occur in important numbers, be it in an international, national or regional context, or are important in conservation terms, or are in some way ecologically sensitive. Many seabirds may fit in the latter category as a result of being *k*-selected with low reproductive turnover and high adult survival, or perhaps are part of populations that are in decline (e.g. Kittiwake, Herring Gull and Lesser Black-backed Gull).

5.1.15 In the case of Projects Alpha and Bravo, the intensive boat-based survey programme was the primary source of quantitative information to identify any potentially sensitive species. It was also recognised that more qualitative criteria may be required to capture potentially sensitive species that could occur but were not necessarily recorded. The mixture of quantitative and qualitative criteria used to define sensitive species in Project Alpha and Bravo separately were as follows:

- If the maximum population of a seabird recorded in the project exceeded the respective 1% criterion for regional, national or international populations during breeding, passage or winter periods.
- If there was a prospective link between breeding seabirds within protected colonies (primarily SPA but including SSSI) and the project as determined by consideration of foraging range expressed as radii from colonies.
- There was a prospective interaction between a project and migratory birds such as waders and waterfowl using protected areas, including Ramsar (an international designation for important wetlands), SPA and SSSI.

5.1.16 From records in boat-based surveys in either Alpha or Bravo only species – Razorbill – was classified as occurring in nationally important numbers in the breeding season as derived from DISTANCE in combination with more standard means of calculating density (Table 5.2). Puffin occurred in at least nationally important (i.e. in the context of the North Sea) numbers in winter. A further eleven species were classed as occurring in regionally important numbers in different periods suggesting thirteen sensitive species overall.

5.1.17 In addition, a further three species – Fulmar, Herring Gull and Lesser Black-backed Gull – from specific SPA colonies were deemed to have the potential to reach and be affected by project Alpha (Table 5.3) as outlined in the response to the HRA screening report issued by Seagreen (2011c) by JNCC to Marine Scotland correspondence dated 31 January 2012. Fulmar was linked to Buchan Ness and Collieston Coast SPA, Forth Islands SPA and Fowlsheugh SPA, with Herring Gull to all these and St Abb's Head to Fast Castle SPA, with Lesser Black-backed Gull to Forth Islands SPA only (Table 5.3).

Table 5.2. Peak density and population estimates (with the month specified) of each seabird species recorded during the breeding, passage and winter seasons in Alpha and Bravo. Species sensitive to development of either site are identified by colours relating to the conservation importance of the peak population estimate in terms of regional (orange), national (red) or 'super-national' (i.e. the entire North Sea - purple) importance, or as breeding species requiring consideration under the HRA process (yellow).

Species	Season	Alpha			Bravo		
		Month	Maximum density	Maximum population	Month	Maximum density	Maximum population
Red-throated Diver	Breeding	-	-	-	May	0.025	5
Northern Fulmar	Breeding	September	2.519	497	September	2.606	505
	Passage	October	0.082	16	October	0.184	36
	Winter	November	0.457	90	January	0.880	170
Sooty Shearwater	Passage	November	0.398	78	September	0.143	28
Manx Shearwater	Breeding	August	0.053	10	June	0.130	25
European Storm Petrel	Breeding	September	0.468	92	October	0.078	15
	Winter	-	-	-	December	0.026	5
Northern Gannet	Breeding	June	13.776	2,716	August	5.890	1,141
	Passage	October	2.413	476	October	3.430	664
	Winter	March	3.557	701	March	2.469	478
Pomarine Skua	Passage	October	0.055	11	-	-	-
Arctic Skua	Breeding	July	0.056	11	-	-	-
	Passage	September	0.056	11	-	-	-
Great Skua	Breeding	August	0.058	11	August	0.025	5
	Passage	October	0.081	16	September	0.058	11
Black-legged Kittiwake	Breeding	June	9.765[1]	1,925[1]	June	14.527[1]	2,813[1]
Black-legged Kittiwake	Passage	September	7.603[1]	1,499[1]	October	2.381[1]	461[1]
	Winter	November	22.875[1]	4,510[1]	November	13.189[1]	2,554[1]

Species	Season	Alpha			Bravo		
		Month	Maximum density	Maximum population	Month	Maximum density	Maximum population
Black-headed Gull	Breeding	July	0.430	85	July	0.056	11
Little Gull	Passage	September	0.051	10	May	0.108	21
Common Gull	Breeding	-	-	-	April	0.055	11
	Passage	October	0.231	45	August	0.056	11
	Winter	March	0.163	32	March	0.056	11
Lesser Black-backed Gull	Breeding	June	0.498	98	June	0.698	135
	Passage	October	0.255	50	September	0.051	10
	Winter	January	0.025	5	November	0.052	10
European Herring Gull	Breeding	June	0.614	121	June	0.841	163
	Passage	October	0.173	34	September	0.058	11
	Winter	March	0.466	92	December	0.495	96
Great Black-backed Gull	Breeding	June	0.078	15	June	0.215	42
	Passage	October	1.301	257	October	1.266	245
	Winter	January	0.416	82	January	0.698	135
Common Tern	Breeding	July	0.281	55	August	0.056	11
	Passage	September	0.335	66	-	-	-
Arctic Tern	Passage	August	1.810	357	August	4.132	800
Common Guillemot	Breeding	July	34.938[1]	6,889[1]	June	54.571[1]	10,569[1]
	Passage	September	5.301[1]	1,045[1]	August	2.585[1]	501[1]
Common Guillemot	Winter	March	26.335[1]	5,193[1]	March	33.775[1]	6,541[1]
Razorbill	Breeding	July	10.660[1]	2,091[1]	July	3.013[1]	583[1]
	Passage	August	7.783[2]	1,535[1]	September	6.605	1,279[1]

Species	Season	Alpha			Bravo		
		Month	Maximum density	Maximum population	Month	Maximum density	Maximum population
	Winter	November	4.562[2]	899[1]	February	2.900[1]	562[1]
Little Auk	Winter	November	12.530[1]	2,471[1]	November	5.749[1]	1,113[1]
Atlantic Puffin	Breeding	June	14.134[1]	2,666[1]	June	28.802[1]	5,439[1]
	Passage	September	7.470[1]	1,481[1]	September	27.764[1]	5,537[1]
	Winter	November	8.003[1]	1,578[1]	November	9.646[1]	1,868[1]

Note: [1] Overall density derived from DISTANCE corrected for birds on the water combined with flying birds from standard snapshot methodology.

5.1.18 Thus, Fulmar, Lesser Black-backed Gull and Herring Gull were included as being important in the breeding season although the numbers of any species were not close to being of regional importance. For example, the maximum number of Fulmars recorded in Alpha and Bravo at 497 and 505 individuals respectively was far smaller than the 1% threshold of 9,586 birds (Table 4.8). Although less extreme, the maximum numbers of Lesser Black-backed Gull at 98 and 135 in Alpha and Bravo respectively was some way below the threshold of 396 individuals (Table 4.8). The situation for Herring Gull was similar with 121 and 193 individuals compared to the 1% threshold of 472 individuals.

5.1.19 The numbers of Fulmar in the winter months were judged to be regional importance even though the 1% criterion was relatively low at 60 individuals (Table 4.14). However, there is little information to further qualify this number in Forrester *et al*. (2007) especially since it is derived from records at sea.

5.1.20 The apparent regional importance of both Lesser Black-backed Gull and Herring Gull in both the passage and winter periods was brought into question using records in Forrester *et al.* (2007). For example, in the passage period, one site alone at Strathclyde Country Park supports up to 5,200 Lesser Black-backed Gulls in August setting a 1% threshold of 52 birds. Even though there is no specific mention of birds in the Forth and around Edinburgh, it was considered that this is due to a lack of coverage rather than a specific indication of small numbers of birds. The maximum count of 10 birds in Bravo in a period of the likely occurrence of thousands in the wider region was thus not considered to be important. However, the occurrence of 50 birds in Alpha may indeed be of regional importance. Similarly, the occurrence of a few birds (10 or less) in winter on either site was also not seen to be important when roosts contain 500 birds in some areas (Forrester *et al*. 2007).

5.1.21 For Herring Gull, the situation is similar with the passage period seeing a mixture of breeding birds and the influx of large numbers of *argentatus* race into Scotland from Scandinavia (Forrester *et al*. 2007) The threshold for regional importance is thus likely to be at least the size of that represented by the breeding population, and for this reason, the low maximum counts of 34 and 11 birds in Alpha and Bravo respectively in the passage period are deemed to not be of regional importance. In winter, counts in Lothian in 1993 suggested 7,626 Herring Gulls in coastal locations and 1,312 inland (Forrester *et al*. 2007). A 1% threshold derived from this suggests 89 individuals. Although such a number may be viewed to be unlikely to represent the entire region, the maximum counts of 92 and 96 birds in winter in Alpha and Bravo respectively are indicative of some importance in a regional context and were classed as such.

5.1.22 A few species that apparently occurred in regionally important numbers in the breeding season including Storm Petrel, Black-headed Gull, Common Gull, Great Black-backed Gull and Common Tern as a result of the low thresholds (<3 individuals) for these species (Table 4.8). These were also subject to 'sense-check' using Forrester *et al*. (2007) and further investigation of the data.

5.1.23 In the case of Storm Petrel there are no active colonies within range, although the estimate of range from Thaxter *et al*. (2012) based on little data may prove to be an underestimate. With the major colonies of Storm Petrel located in the Shetlands and the west coast of Scotland, the September estimate for Storm Petrel may not actually represent breeding birds but adults or fledged birds from these colonies or alternatively, non-breeding wandering birds, which are known to make rapid, long distance movements (Forrester *et al*., 2007). As such, the estimate recorded in the Alpha development site has not been considered a regionally important breeding population.

5.1.24 Whilst a 1% threshold for breeding Black-headed Gull of <1 was derived using the foraging radius technique, Forrester *et al*. (2007) shows that no coastal breeding colonies have been recorded in the region (Fife, Upper Forth and Lothian) in national surveys since Operation Seafarer, 1969-1970. Therefore the peak populations in Alpha and Bravo, both recorded in July are likely to be dispersal from inland colonies, where fledged birds return to the coasts from late June as described by Forrester *et al*. (2007).

5.1.25 As with Black-headed Gull, no breeding colonies of Common Gull are present in the region (Forrester *et al*., 2007) and thus the population of 11 Common Gull in Bravo during the breeding season can be discounted as regionally important. Equally, the importance of the Musselburgh-Portobello winter colony on the coast of the Firth of Forth (33,500 ind. in 1993 – see Forrester *et al*., 2007) discounts the passage and winter populations of 45 and 32 Common Gull within Alpha and 11 birds in Bravo as being of regional importance.

5.1.26 The estimated population size of Great Black-backed Gulls in Alpha and Bravo in the breeding season were 15 and 42 individuals respectively, suggesting regional importance. However, these estimates were derived from just two and six individuals respectively. All records of birds that were aged were adults and so unless these birds were non-breeding it does seem that some adults from the scattered, small breeding colonies around the region do indeed reach Alpha and Bravo. However, given the small numbers of birds recorded there is no reason to suggest that similar numbers could not be recorded anywhere within the wider region and no particular importance should be given to the Project areas. For this reason, the sites were considered not to hold regionally important numbers in the breeding season, although the much higher numbers in the passage and winter periods were considered to be of regional importance and thus Great Black-backed Gull was still classed as sensitive in relation to Projects Alpha and Bravo.

5.1.27 Regionally important numbers of Common Tern were recorded in Alpha during both the breeding and passage seasons based on a threshold of just 1 individual. In fact, Lothian remains a key area for Common Terns, with Leith Docks supporting 818 pairs (SMP database) alone suggesting a 1% threshold of at least 16 birds. Whilst this is still exceeded by the estimate, the latter is derived from the record of just five birds, which would not be of regional importance.

Table 5.3. Identification of species potentially sensitive to the development of either Alpha or Bravo according to criteria based on peak estimated population size and potential links to designated sites (SPA) established through discussion with the statutory advisors. Details of the scale and timing of any important populations and the designated sites are provided.

Species	Project Alpha			Project Bravo		
	Population size	Seabird linked to designated site (SPA)	Migratory species linked to designated site (SPA)	Population size	Seabird linked to designated site	Migratory species linked to designated site
(Svalbard) Barnacle Goose			Upper Solway Flats and Marshes			Upper Solway Flats and Marshes
(Taiga) Bean Goose			Slamannan Plateau			Slamannan Plateau
Pink-footed Goose			Firth of Forth, Firth of Tay and Eden Estuary, Montrose Basin, Ythan Estuary			Firth of Forth, Firth of Tay and Eden Estuary, Montrose Basin, Ythan Estuary
Northern Fulmar	Regional winter	Buchan Ness to Collieston Coast, Fowlsheugh, Forth Islands,		Regional winter	Buchan Ness to Collieston Coast, Forth Islands	
Sooty Shearwater	Regional passage					
Northern Gannet	Regional breeding, passage and winter	Forth Islands		Regional passage and winter	Forth Islands	
Eurasian Oystercatcher			Montrose Basin, Firth of Forth			Montrose Basin, Firth of Forth
Common Ringed Plover			Firth of Forth			Firth of Forth
European Golden Plover			Firth of Forth			Firth of Forth
Grey Plover			Firth of Forth			Firth of Forth
Northern Lapwing			Firth of Forth			Firth of Forth
Red Knot			Montrose Basin, Firth of Forth			Montrose Basin, Firth of Forth

Species	Project Alpha			Project Bravo		
	Population size	Seabird linked to designated site (SPA)	Migratory species linked to designated site (SPA)	Population size	Seabird linked to designated site	Migratory species linked to designated site
Sanderling			Firth of Tay and Eden Estuary			Firth of Tay and Eden Estuary
Dunlin			Firth of Forth			Firth of Forth
Black-tailed Godwit			Firth of Tay and Eden Estuary			Firth of Tay and Eden Estuary
Bar-tailed Godwit			Firth of Tay and Eden Estuary, Firth of Forth			Firth of Tay and Eden Estuary, Firth of Forth
Eurasian Curlew			Firth of Forth			Firth of Forth
Common Redshank			Montrose Basin Firth of Tay and Eden Estuary, Firth of Forth			Montrose Basin Firth of Tay and Eden Estuary, Firth of Forth
Ruddy Turnstone			Firth of Forth			Firth of Forth
Black-legged Kittiwake	Regional breeding, passage and winter	Buchan Ness to Collieston Coast Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle		Regional breeding, passage and winter	Buchan Ness to Collieston Coast Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle	
Lesser Black-backed Gull	Regional passage	Forth Islands			Forth Islands	
European Herring Gull	Regional winter	Buchan Ness to Collieston Coast, Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle		Regional winter	Buchan Ness to Collieston Coast, Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle	
Great Black-backed Gull	Regional passage and winter			Regional passage and winter		

Species	Project Alpha			Project Bravo		
	Population size	Seabird linked to designated site (SPA)	Migratory species linked to designated site (SPA)	Population size	Seabird linked to designated site	Migratory species linked to designated site
Common Tern	Regional passage					
Arctic Tern	Regional passage			Regional passage		
Common Guillemot	Regional breeding, passage and winter	Buchan Ness to Collieston Coast, Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle		Regional breeding, passage and winter	Buchan Ness to Collieston Coast, Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle	
Razorbill	National breeding and regional passage and winter	Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle		Regional breeding, passage and winter	Forth Islands, Fowlsheugh, St Abb's Head to Fast Castle	
Little Auk	Regional winter			Regional winter		
Puffin	Regional breeding and passage and national[1] winter	Forth Islands		Regional breeding and passage and national[1] winter	Forth Islands	

[1] in the context of the entire North Sea suggesting at least national importance

5.1.28 Moreover, the Common Terns present were recorded in July and could thus represent non-breeding bird or failed birds that are not associated with a breeding colony. During the passage season, Forrester *et al*. (2007) states that flocks linger in the food-rich Firth of Forth for a few weeks prior to migrating south. Skov *et al*. (1995) also regards Arbroath as a key area. With estimates more clearly within the passage season (September) in Alpha that also seem to be of importance, Common Tern was considered to a sensitive species, but in relation to the passage and not breeding season.

5.1.29 Similarly, the large numbers of Arctic Tern recorded within the range of the breeding season in August were almost certainly birds on passage conceivably including failed and non-breeders as well as post-breeding birds rather than actual breeding birds. The closest colonies at Montrose and from Montrose to Lunan Bay are outside prospective foraging range and are anyway rather small (58 birds combined) compared to the numbers seen at Alpha and Bravo. When on passage, Forrester *et al*. (2007) suggest the Firth of Forth is an important area for Arctic Tern, which may remain in the area for 1-2 weeks before migrating. During passage, gatherings of >1,000 birds have been known from a number of locations. The maximum estimates of 357 and 800 individuals in Alpha and Bravo respectively, are thus not exceptional but do suggest regional importance and Arctic Tern was considered to be sensitive on this basis.

5.1.30 A number of other species were recorded in apparently important numbers in the passage period as a result of low threshold values. For example, although the 1% passage threshold for Arctic Skua (2 ind.) was exceeded with a population estimate of 11 birds in Alpha, day counts from Hound Point in the Firth of Forth range can range from 20 to 50 birds (Forrester *et al*. 2007) suggesting the few records of Arctic Skua in Alpha or Bravo should not be considered to be regionally important. Similarly, day counts of 10 to 40 Great Skuas are also often observed at Hound Point during the autumn passage period (Forrester *et al*. 2007), and therefore the peak population estimate of 16 birds within Alpha should also not be considered to be regional importance.

5.1.31 The regional threshold for Little Gull was also low at just 11 birds (Table 4.14). Forrester *et al*. (2007) describe the autumn passage of Little Gull in two or more waves, with the first comprised of non-breeding adults, failed breeders first-year birds from June to September, with post-breeding adults from late July through to August and then juveniles after the first week of August. Up to around 1,000 birds are typically present at roost near Arbroath. Numbers of birds on passage may be much higher, with up to 3,000 thought to be present in some years. The estimated peaks of 10 and 21 birds in Alpha and Bravo (both derived from two birds seen) are unimportant in this context.

5.1.32 The peak population estimates for Sooty Shearwater during the passage season of 78 and 28 for Alpha and Bravo respectively, were considered as regionally important. Whilst the 1% threshold of only 3 individuals, derived from Stone *et al*. (1995), is questionably low and that 1,312 Sooty Shearwaters were observed from the Isle of May on 22nd and 23rd September 2002, the number of passage Sooty Shearwater considered to be in Scottish waters is up 7,500+ (see Forrester *et al*., 2007). As such, the peak population estimate for Sooty Shearwater during the passage season of 78 exceeds the 1% threshold for Scottish waters and thus can be considered as regionally important. Whereas the number of Sooty Shearwater present in Bravo (28 ind.) represents 2% of the number flying through the area in two consecutive days.

5.1.33 Whilst the regional 1% threshold for wintering Little Auk derived from Stone *et al*. (1995) is relatively low (62 – Table 4.10), estimates for Alpha and Bravo exceed 2,000 and 1,000 birds respectively. As the wintering population in Scotland ranges widely in different years but up to 35,000 recorded in some years (Forrester *et al*., 2007), the number present in either Alpha or Bravo would seem to equate to a minimum of 3% of the Scottish population. However, Forrester *et al*. (2007) do state that the true nature of the population is unknown and if 35,000 birds were seen along the coast the true size of the population at peak is likely to be much larger. Overall, the estimated peak populations of Little Auk recorded in both sites were thought to be more likely to be of regional rather than national importance.

Project Alpha

5.1.34 In summary, 29 species were viewed as being sensitive in relation to Project Alpha in one way or another with only five of these, all seabirds, not linked to a particular SPA (Table 5.3). The majority of the sensitive species were not seabirds, but 16 species of migratory waterfowl designated within six different SPAs (Upper Solway Flats and Marshes, Slammannan Plateau, Montrose Basin, Firth of Forth, Firth of Tay and Eden Estuary and Ythan Estuary). Eight of the 13 seabird species were associated with four SPAs (Buchan Ness to Collieston Coast, Fowlsheugh, Forth Islands and St Abb's Head to Fast Castle). Project Alpha thus had the potential to affect ten SPAs overall (Table 5.3).

5.1.35 In terms of the distribution of important populations, only two species of seabirds were thought to occur in nationally important numbers, with one (Razorbill) in the breeding season and the other (Puffin) in the winter (Table 5.3). Overall, more regionally important populations occurred in the passage and winter periods, each with nine species represented, compared to the breeding season when only four species (Gannet, Kittiwake, Guillemot and Puffin) were present in such numbers.

Project Bravo

5.1.36 Slightly fewer species (27) were linked to Project Bravo, with the same 24 species linked to the same SPAs as at Alpha (Table 5.3). The same species of migratory waterfowl represented the same SPAs as in Alpha. The same eight species of seabirds were also associated the same four SPAs. As with Alpha, Project Bravo had the potential to affect ten SPAs overall (Table 5.3).

5.1.37 The distribution of important populations of seabirds was broadly the same as in Alpha albeit with slightly fewer species and no species of national importance in the breeding season. Only Puffin occurred in nationally important numbers in the winter (Table 5.3). More regionally important populations occurred in winter (eight species) compared to passage (seven species) and during the breeding season (three species). In the latter group, it was Gannet that did not occur in regionally important numbers in Bravo in the breeding season.

5.2 Aerial surveys

Species composition and patterns of abundance

5.2.1 A total of 91,737 birds from 26 identified species and 15 unidentified taxa were observed in the aerial surveys of the Firth of Forth (Table 5.4, Appendix F1 Annex 5). With the exception of waders, all records were true seabirds including Gannet, skuas, petrels, shearwaters, gulls, terns and auks.

Table 5.4. Total number observed, maximum count and encounter rate (individuals' km^{-1}) of all bird species and unidentified taxa in the aerial surveys of the Firth of Forth.

Species	Total count	Maximum count	Maximum encounter rate
Common Eider	16	16	0.006
Long-tailed Duck	1	1	0.001
Common Scoter	1	1	0.001
Unidentified duck	3	2	0.001
Red-throated Diver	2	2	0.001
Unidentified diver	4	2	0.001
Northern Fulmar	1,094	368	0.146
Fulmar or unidentified gull	22	22	0.013
Manx Shearwater	404	329	0.122
European Storm Petrel	11	8	0.001
Unidentified petrel	3	3	0.001
Northern Gannet	19,026	8746	3.328
Great Cormorant	1	1	0.001
European Shag	11	7	0.003
Cormorant / shag	1	1	0.001
Unidentified medium sized wader	3	3	0.001
Great Skua	2	2	0.001
Unidentified skua	1	1	0.001
Little Gull	8	4	0.002
Black-headed Gull	7	4	0.002
Common Gull	136	53	0.014

Species	Total count	Maximum count	Maximum encounter rate
Lesser Black-backed Gull	65	39	0.015
European Herring Gull	478	203	0.075
Great Black-backed Gull	57	18	0.009
Black-legged Kittiwake	14,429	5224	1.988
Unidentified black backed gull	83	25	0.012
Unidentified grey gull	126	45	0.017
Unidentified gull	3,335	1410	0.649
Unidentified large gull	227	103	0.040
Unidentified small gull	496	143	0.055
Little Tern	9	9	0.003
Sandwich Tern	6	5	0.002
Arctic Tern	9	9	0.003
'Commic' tern	1,023	988	0.035
Unidentified tern	69	65	0.025
Common Guillemot	26	8	0.005
Razorbill	6	6	0.002
Black Guillemot	2	1	0.001
Little Auk	10	9	0.004
Atlantic Puffin	3	3	0.001
Unidentified auk	50,275	24,519	9.330

5.2.2 Auks were the dominant group, with 50,322 records, representing 59% of the total observations (Table 6.2). Of these, 50,275 individuals or 99.9% were unidentified, with only very small numbers of Guillemot (26 ind.), Little Auk (10 ind.), Razorbill (6 ind.), Puffin (3 ind.) and Black Guillemot (2 ind.) identified to species level.

5.2.3 A further group, gulls represented 21.2% (19,447 ind.) of the total birds, with 74% of these identified as Kittiwake (14,429 ind.). Otherwise, Gannet was the most frequently identified species of bird, with 19,026 records contributing 20.7% of the total birds observed. In total, 1,150 Fulmars and shearwaters were identified, representing 1.9% of the total bird count. Terns, predominantly unidentified undistinguished Common/ Arctic ('commic') terns comprised 1.2% of the total bird count.

5.2.4 The proportions of true seabirds recorded in aerial surveys were broadly comparable with the total counts for boat-based surveys. For example, auks contributed 49.9% of records in boat-based surveys, followed by gulls and Gannet (22.4% and 19.4% respectively). Even the proportion of terns, which mostly occur on migration and may thus be subject to considerable variation between surveys, was directly comparable at 1.3% and 1.2% for aerial and boat-based surveys respectively.

Density and population size

5.2.5 DISTANCE correction of the dominant group, auks, showed considerable variation between the summer and winter and between surveys within these periods (Table 5.5). For example, density was far higher in July (mean of 26.0 individuals km^{2}) compared to May (mean of 9.6 individuals km^{-2}) or June (mean of 4.1 individuals km^{-2}). This may be partly explained by the slightly different coverage in May, but not June compared to July. The resulting population estimates were therefore very different with nearly 150,000 auks present in July compared to June (~24,000), a factor of >6-fold. Apart from some systematic problem in recording, this would suggest that the auks on the colonies distributed around the region were simply concentrated closer to the colonies during May and June in the inshore waters not sampled by the survey.

Table 5.5 DISTANCE corrected estimates of density and population (Pop) size of auks from aerial surveys (5,755 km^{2} covered). Upper (UCI) and lower (LCI) confidence limits of both estimates and the coefficient of variation (%CV) of the density is also shown.

Survey	Month	*n*	Coverage	Density	%CV	LCI	UCI	Pop	LCI	UCI
S1	May	3227	1-4	9.562	7.9	8.183	11.173	55,025	7,935	9,271
S2	June	2191	All	4.138	8.0	3.533	4.846	23,812	3,481	4,074
S3	July	5162	All	25.980	8.1	22.119	30.516	149,502	22,218	26,102
W1	Nov	1758	All	3.736	13.7	2.814	4.959	21,499	5,306	7,038
W2	Dec	1268	All	3.303	10.5	2.677	4.075	19,007	3,602	4,442
W3	Jan	581	a,b,d,e	2.958	20.0	1.945	4.499	17,022	5,829	8,868
W4	Feb	4350	All	16.458	9.6	13.516	20.535	94,708	16,930	23,461

5.2.6 In the winter, there was again considerable variation, with low densities of 2-3 individuals km^{-2} in late winter, with this increasing in February to >16 individuals km^{-2} and a resulting population estimate of >94,000 individuals. Such a pattern could be explained by the wholesale return of potential breeding birds to the vicinity of the colony before this time (Cramp *et al*. 1974, Forrester *et al*. 2007).

5.2.7 For gulls excluding Kittiwake, density and population estimates showed a similar pattern in the summer months by increasing from May to July, but with less extreme variation (<4-fold) in resultant population sizes (Table 5.6). Whilst this could again be caused by a change in the distribution of resource from inshore (and thus not sampled) to offshore, the question of a more systematic issue with the surveys cannot be entirely ruled out. Nonetheless, the difference in pattern in the winter months compared to auks, with a much larger density (>1 individual km^{-2}) in December compared to the other months increases confidence in the surveys.

5.2.8 Density and population size estimates of any species identified to specific level with sufficient records to conduct DISTANCE correction are presented in individual species accounts (see 6. below).

Table 5.6 DISTANCE corrected estimates of density and population (Pop) size of gulls from aerial surveys (5,755 km^2 covered). Upper (UCI) and lower (LCI) confidence limits of both estimates and the coefficient of variation (%CV) of the density is also shown.

Survey	Month	*n*	Coverage	Density	%CV	LCI	UCI	Pop	LCI	UCI
S1	May	167	1-4	0.188	19.7	0.128	0.277	1,082	345	512
S2	June	429	All	0.323	15.3	0.240	0.437	1,859	478	656
S3	July	451	All	0.732	13.0	0.567	0.945	4,212	949	1,226
W1	Nov	403	All	0.744	23.5	0.471	1.176	4,281	1,571	2,486
W2	Dec	214	All	1.161	41.5	0.528	2.553	6,681	3,643	8,010
W3	Jan	68	a,b,d,e	0.112	21.8	0.072	0.172	645	230	345
W4	Feb	239	All	0.375	13.5	0.287	0.489	2,158	506	656

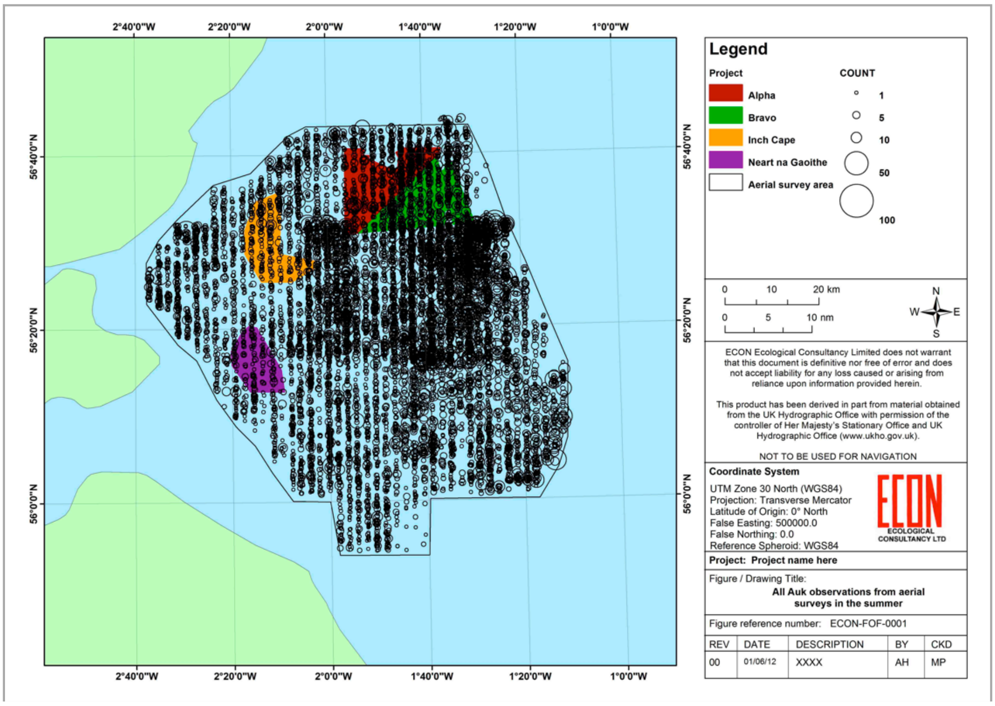
Distribution

5.2.9 Pooling records has the potential to illustrate areas that may be repeatedly selected by birds perhaps as a result of particular habitat features and the foraging opportunities these offer on patchily distributed prey resources. Whilst auks were distributed throughout the survey, there was indeed evidence of some preference for areas immediately to the south of Alpha and Bravo in both the east and west in the summer months (Figure 5.3).

5.2.10 This pattern was mirrored, albeit less obviously, during the winter months (Figure 5.4). The preferred areas broadly correspond to the Marr Bank (east) and Wee Bankie (west) complexes known to attract seabirds (Camphuysen 2005, Kober *et al*. 2009).

5.2.11 Jacob’s selectivity index was calculated for Alpha and Bravo and the STW sites areas in both summer and winter. With the apparent preference for areas outside of wind farms, there was no overall selection, either positive or negative for Alpha (D = +0.07) or Bravo (D = +0.10) or either of the STW sites (Inch Cape D = -0.33, Neart na Gaoithe D = -0.35).

5.2.12 The lack of selection was repeated in the winter for Alpha (D = +0.22), Bravo (D = +0.27) and the STW sites (Inch Cape D = -0.16, Neart na Gaoithe D = -0.04). In the summer however, although again there was no selection of Alpha (D = -0.04), Bravo (D = -0.04) or Inch Cape (D = -0.45), there was avoidance of Neart na Gaoithe (D = -0.59).



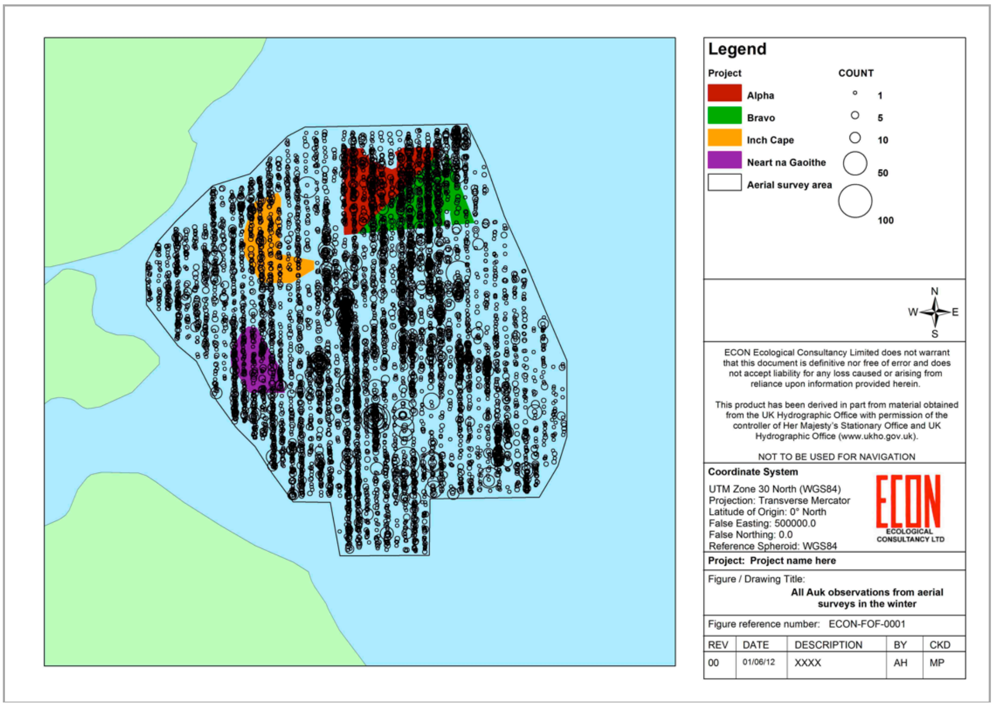


Figure 5.3 Relative distribution of auks within the Firth of Forth aerial survey area from pooled records of all birds from all surveys in the summer (above) and winter months (below) where $n = 3$ and $n = 4$ respectively.

6. DETAILS OF SENSITIVE SPECIES

6.1.1 The aim of this section is to outline the species that are potentially sensitive to the development of the Alpha and/or Bravo Projects. A total of 29 species require some consideration as a result of one criterion or another in relation to either Project (Tables 5.2 & 5.3). It is stressed that this list encapsulates all species that may be considered under both EIA and HRA processes.

6.1.2 Indeed, the three species of migratory waterfowl and 13 species of migratory waders (see Table 5.3 above) were considered to be a focus for HRA and were unlikely to be considered in EIA. Moreover, the exercise outlined below effectively operates as a screening process to determine if any of these species merit detailed consideration in HRA through an assessment of collision risk, which is the key impact from the Projects. For ease of reference and brevity, the different species of geese and waders are considered in a separate section on 'migratory waterfowl' following the presentation of information on seabirds.

6.1.3 A total of 13 and 11 species of seabird were identified as being potentially sensitive to the development of Alpha and Bravo respectively, 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 either site as derived from boat-based surveys. In taxonomic order the species were Fulmar, Sooty Shearwater (Alpha only), Gannet, Kittiwake, Lesser Black-backed Gull, Herring Gull, Great Black-backed Gull, Common Tern (Alpha only), Arctic Tern, Guillemot, Razorbill, Little Auk and Puffin. A number of species, namely Fulmar, Gannet, Kittiwake, Lesser Black-backed Gull, Herring Gull, Guillemot, Razorbill and Puffin were automatically included as being sensitive in the breeding season on the basis of their occurrence in nearby SPA breeding colonies.

6.1.4 Within this section for ease of reference, seabirds were partitioned as 'breeding species' and 'passage/wintering' species according to their main or most important period of occurrence. Any species named as a breeding species within an SPA was however automatically included as a breeding season even if it was less numerous at this time (e.g. Lesser Black-backed and Herring Gulls). Within each of the sub-sections, the species are listed in taxonomic order.

6.1.5 For each of the breeding and passage/wintering seabirds, detailed information is provided under the following themes:

- Population ecology
- Density distribution and population size
- Foraging range and potential origin
- Summary of risks

6.1.6 The theme of population ecology introduces the conservation status of the species and outlines any population change and any underlying agents of any change. Specific reference is made to any studies in the Firth of Forth. The information provided aims to set the context of any potential effect by the developments.

6.1.7 Density distribution and population size describes the patterns of occurrence on both Projects separately, outlining any seasonal and inter-annual variation according to known patterns. Comparative reference to other studies is made to help frame the importance of the populations recorded within the site boundaries.

6.1.8 The potential origin of the birds recorded in the sites is set within the context of the populations of different colonies within foraging range for breeding species. Particular attention is given to designated, especially SPA colonies where the species in question is a qualifying feature or is part of the seabird assemblage. For birds recorded on passage likely migration routes or flightlines are discussed in order to indicate the potential origin of birds, although specific evidence (e.g. from tagged birds) this may be difficult to establish. This is especially true for wintering birds unless there is specific evidence.

6.1.9 Distillation of information in the summary of risks effectively determines whether a species is at risk of ecologically significant impact according to the principles established by the IEEM (2010) from either or both Projects. In terms of EIA, particular effects on particular species form the basis of impact assessment within the ES.

6.1.10 The discussion of risks also provides an early recognition of those species linked to European sites that may ultimately be at risk of likely significant effect (LSE), determination of which lies at the heart of the HRA process. However, any assessment of likely risks upon such protected species undertaken in this report merely provides background context to HRA assessment and should not be seen to influence or trigger what is a separate process.

6.2 Breeding seabirds

Northern Fulmar

Population ecology

6.2.1 Fulmar has an extremely large global range and a global population estimate of 15-30 million individuals (BirdLife International 2012a). The European population of Fulmar is very large (2.8-4.4 million pairs) and classified as 'Secure' (BirdLife International 2004). In the UK, during Seabird 2000 the breeding population centred mostly in Scotland stood at 501,609 pairs, representing 7 – 9% of the world total (Mitchell *et al.* 2004).

6.2.2 Between Seabird 2000 and 2010 it is estimated that the UK population increased by 1% (JNCC 2011). However, Fulmar is of conservation concern in the UK with 'Amber' status due to a moderate (>25% but <50%) decline in the breeding population over the past 25 years and on account of >50% of the breeding population occurring in ten or fewer sites (Eaton *et al.* 2009). This belies the previous spectacular expansion and colonisation starting in the mid 19th century from Iceland and St Kilda in the North Atlantic that ultimately included virtually the whole of Britain as well as France, Denmark and Germany (Mitchell *et al*. 2004).

6.2.3 Fulmars feed on a wide variety of prey items gathered on the sea surface including small to large invertebrates such as squid and carrion of fish, other birds and large mammals (Cramp *et al.* 1974). They only tend to aggregate at particularly rich sources, such as offal and discards from fishing boats. The initial increase and more recent decline in Fulmars since the 1970s is linked to environmental change and the distribution and abundance of natural prey such as sandeels (*Ammodytes spp*.) in the North Sea and of certain species of zooplankton in the North Atlantic, as well as the expansion and subsequent collapse of human fisheries (Mitchell *et al*. 2004). The decline in the North Sea whitefish industry and the amount of offal and bycatch discharged from fishing vessels is thought to have resulted in a decline in productivity of Fulmars in recent times. Large numbers of Fulmars are also caught and killed accidentally by the longlining fleet in the Norwegian Sea and also probably in the North Atlantic (Mitchell *et al.* 2004).

6.2.4 In the UK, Fulmar colonies are located along all coasts, although the largest colonies consisting of more than 10,000 nesting pairs are situated on islands off north and west Scotland. The majority of Fulmar breeding colonies occur on cliffs and steep grassy slopes abutting the sea (Lloyd *et al.* 1991). According to Mitchell *et al*. (2004) Scottish districts around the Firth of Forth with reasonable numbers of breeding pairs included Banff and Buchan (5,146 pairs), Kincardine and Deeside (3,135 pairs) and Angus (1,185 pairs). Colonies in which Fulmar is designated in the vicinity of Alpha and Bravo (<100 km) such as Buchan Ness and Collieston Coast SPA, Forth Islands SPA and St Abb's Head to Fast Castle SSSI currently support in the order of 6,344 individuals between them. These are dwarfed by much larger designated sites at greater distance (>250 km or more) such as Fair Isle SPA, Foula SPA and Hoy SPA that all support >40,000 individuals.

6.2.5 Fulmars begin to attend their nesting sites from November onwards, earlier than any other UK seabird (Cramp *et al.* 1974). Nesting does not however begin until April after a 'honeymoon' period in which adult birds attempt to accumulate resources for breeding. Laying of the single egg commences in early May, with the egg not being replaced should it be lost (Cramp *et al.* 1974). During the egg laying period, adult Fulmars are known to leave their breeding colonies for long (four to five days) foraging trips (Brown & Nettleship 1981) with potential to range vast distances away from their breeding colony.

6.2.6 The majority of chicks hatch throughout June, and during the chick feeding stage adults tend to undertake shorter foraging trips (Ojowski *et al.* 2001), although a Norwegian study found that some birds travel around 500 km in the later stages of chick development (Weimerskirch *et al.* 2001). The chicks fledge in August and September (Forrester *et al.* 2007) and then spend the next ten years or so wandering UK and North Atlantic waters before returning to land to breed. As a result of the presence of >1 million individuals, comprised of large number of non-breeding and sub-adult birds Fulmars are therefore widespread and numerous in British waters throughout the entire year (Forrester *et al.* 2007).

Density distribution and population size

Project Alpha

6.2.7 Fulmar were observed within the Alpha site boundary in all surveys over the two year study period. Whilst estimated population size was higher during the breeding season, the 1% threshold was not exceeded (Figure 6.1) as a consequence of the large foraging range encompassing an extremely large regional population (see Table 4.8 above). During the breeding season, population size was broadly consistent with a cycle of increase up to the nesting and egg laying period, followed by the decrease during chick rearing when adults make shorter foraging trips (Ojowski *et al*. 2001) followed by an increase at the end of the season as chicks fledge and dispersal of both fledglings and adults begins (Figure 6.1).

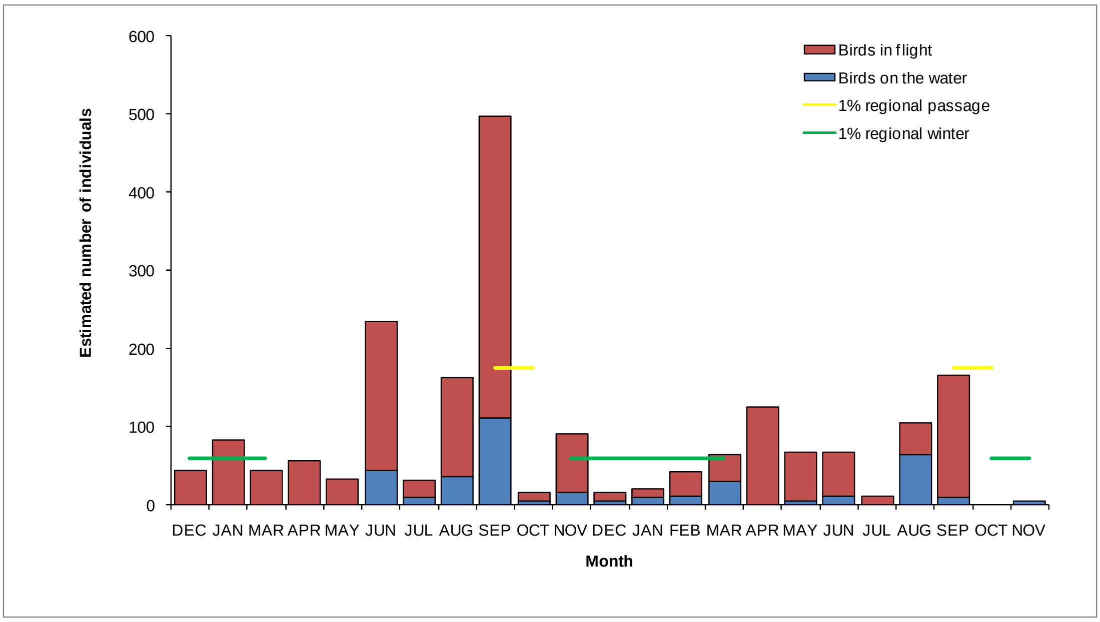
6.2.8 Peak populations were thus achieved in September in both 2010 and 2011 exceeding 1% regional passage population estimates, although in truth, at this time birds may originate from virtually anywhere in the North Atlantic (see below) suggesting a huge ‘pool’ of available birds. The much lower 1% regional threshold (60 birds) for wintering Fulmar was exceeded in January 2010, November 2010 and March 2011 with 83, 90 and 63 individuals respectively (Figure 6.1).

6.2.9 The majority of Fulmars were encountered in flight and no good model could be derived from DISTANCE analysis for birds on the water. Densities were therefore derived from a combination of line transect and snapshot data. Densities were typically less than 0.8 individuals’ km^{-2} (Table 6.1) with the mean peak in September reaching nearly 2 individuals km^{-2}.

Table 6.1. Monthly mean (± 1SD) density of Fulmar in Projects Alpha and Bravo as 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
Alpha	0.3 ± 0.2	0.2	0.3 ± 0.1	0.5 ±0.2	0.3 ± 0.1	0.8 ± 0.6	0.1 ± 0.1	0.7 ± 0.2	1.7 ± 1.2	<0.1 ± 0.1	0.2 ± 0.3	0.2 ± 0.1
Bravo	0.7 ± 0.3	0.4	0.2 ± 0.2	0.4 ± 0.1	0.4 ± 0.5	1.7 ± 0.6	0.2 ± 0.1	0.4 ± 0.3	2.2 ± 0.6	0.1 ± 0.1	0.5 ± 0.5	0.3 ± 0.1

Project Alpha



Project Bravo

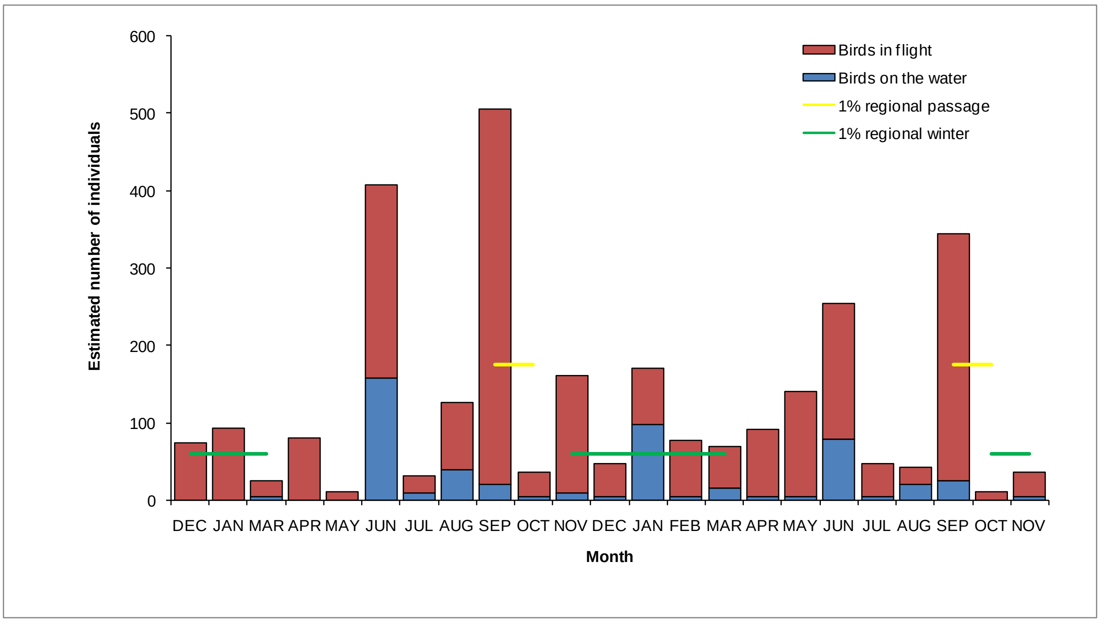


Figure 6.1. Fulmar population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from density derived from snapshots of birds in flight combined with DISTANCE-corrected density of birds on the water for Alpha and the non-corrected density in Bravo. Criteria for regional importance in the passage and winter periods are shown. Note that the scale is too small to show the 1% criterion for the breeding population.

6.2.10 Distribution patterns over the study period and during both breeding seasons and both winter periods were relatively uniform with low abundance across the site (Figure 6.2 shows the breeding period only). This suggests that Alpha is not a key foraging area (see Summary of risks below), nor indeed suggests there was a consistent flight path to and from a particular colony. This in part is a consequence of the extremely large foraging range of the species and thus Fulmar observed within the Alpha boundary could originate from a large number of colonies stretching from the Shetlands to the north and Kent in the south.

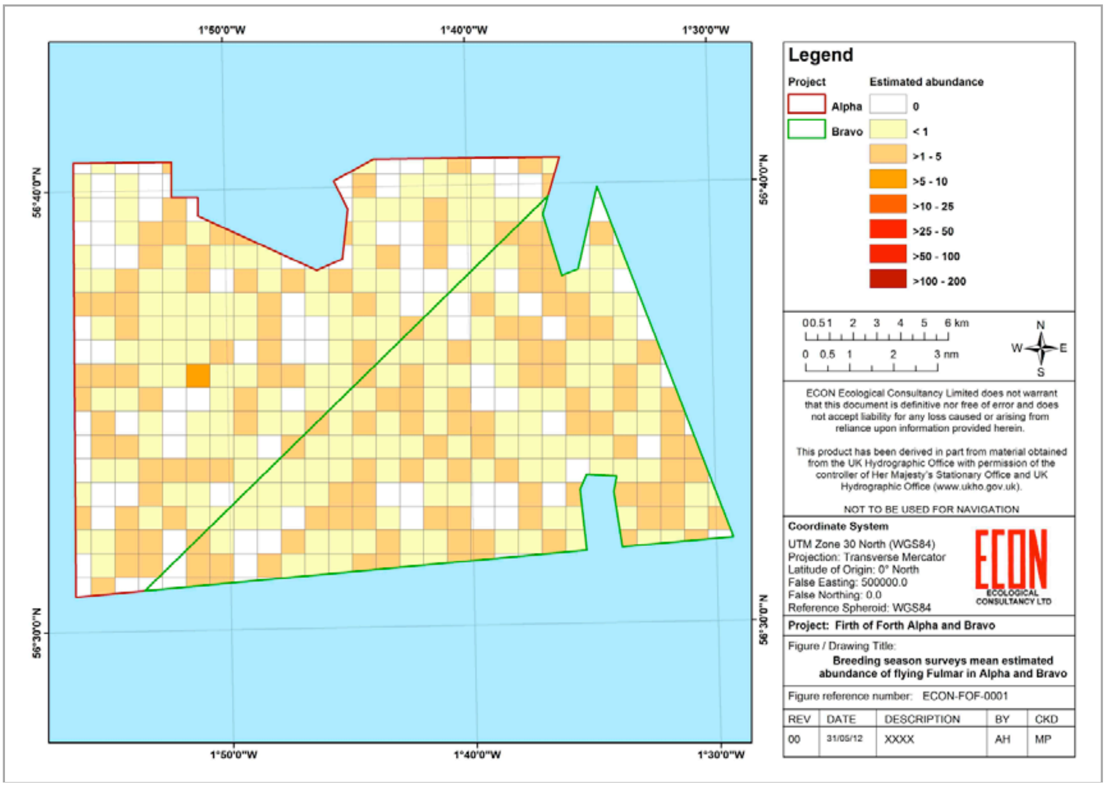
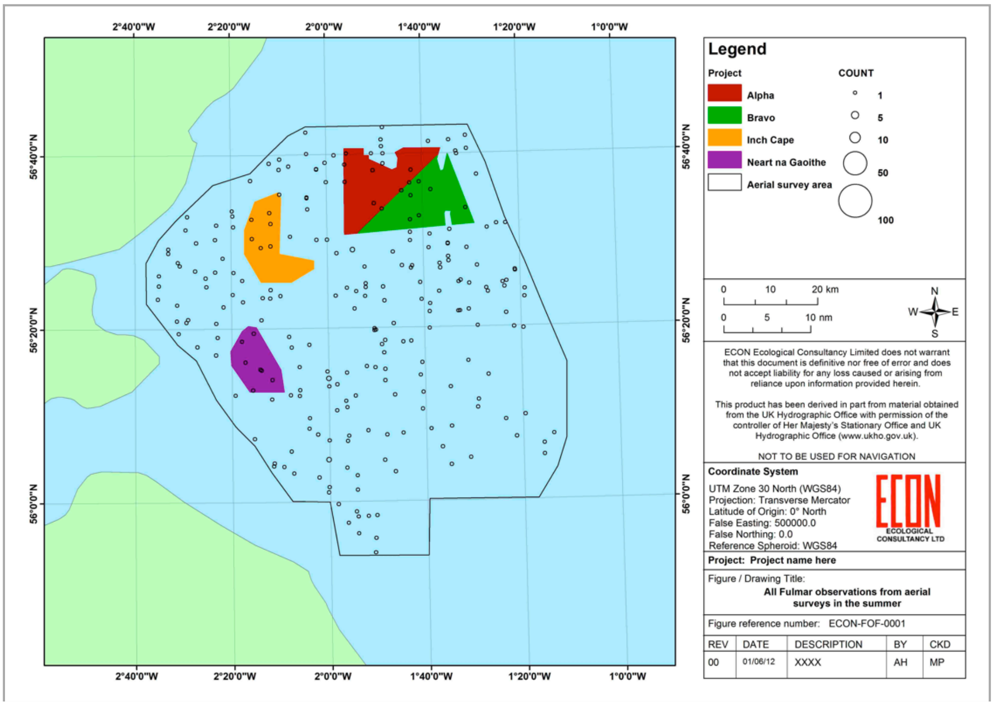


Figure 6.2. Relative abundance of Fulmar expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to September inclusive.

6.2.11 Distribution patterns derived from aerial surveys revealed that no particular area of the region was selected by Fulmar in either the summer or winter period (Figure 6.3). This was further reinforced through Jacob's selectivity index, which indicated that Fulmar did not select Project Alpha site nor that of the STW sites of Inch Cape nor Neart na Gaoithe in either summer (D = -0.04, -0.11 and +0.15 respectively), winter (D = -0.01, +0.19 and -0.03 respectively) or overall (D = -0.02, +0.11 and 0.00 respectively).



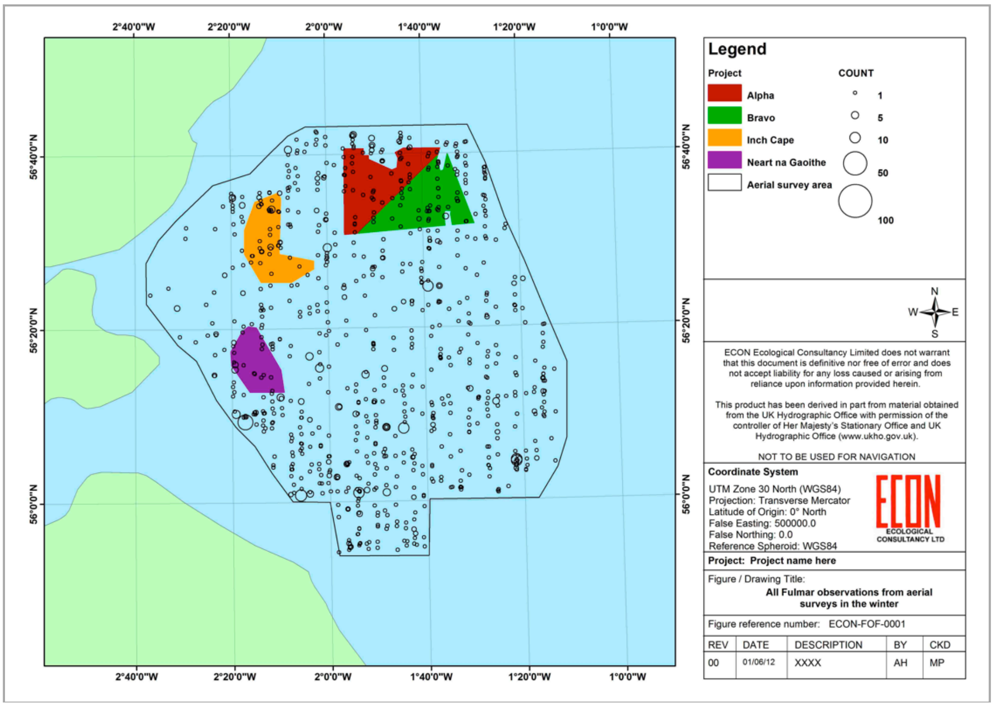


Figure 6.3. Relative distribution of Fulmar within the Firth of Forth aerial survey area from pooled records of all birds from all surveys in the summer (above) and winter months (below) where $n = 3$ and $n = 4$ respectively.

Project Bravo

6.2.12 As with the data derived for Alpha, Fulmar were ever present in the surveys of Bravo over the study period. In general, the densities derived from each survey followed a similar pattern (Table 6.1) and were generally low in context with other parts of the species' range. The resultant population sizes were slightly greater in Bravo compared to Alpha (Figure 6.1). Peak populations in June and September equated to population sizes of 407 and 505 individuals respectively. As in Alpha, September recorded peak populations in any one year. Nevertheless, regionally important numbers were not recorded during the breeding season. Populations during the winter of 2010/2011 were higher than in Alpha, with only December failing to reach regionally important numbers (Figure 6.1).

6.2.13 As with Alpha, distribution mapping derived from the aerial surveys conducted in the summer of 2009 and winter 2009/2010 (Figure 6.3), with Jacob's selectivity index revealing that there was no selection of Project Bravo by Fulmer (D values ranging being -0.04 in the summer, +0.27 in the winter and +0.10 overall). The distribution of birds within the site showed no selection of any particular area (Figure 6.2).

Foraging range and potential origin

6.2.14 Fulmar has a mean maximum foraging range of 400 km and a mean maximum foraging range + 1 SD of 645.8 km (Figure 6.4), which means that 558,874 and 958,786 individuals respectively breed within each range (Table 6.2). These birds are distributed amongst 1,075 colonies in mean maximum foraging range and 1,694 colonies within the range incorporating 1SD (Appendix F1 Annex 6) extending from Hasting Cliffs, East Sussex in the south anti-clockwise around the coast to the island of Jura, Argyll and Bute, with the highest concentrations in Shetland and Orkney (Figure 6.4).

6.2.15 Within mean maximum foraging range Fulmar is designated/notified within 18 SPAs and 11 separate SSSIs (i.e. not within SSSIs contained within SPAs). This increases to 24 SPAs and 21 SSSIs within range incorporating 1SD. Some 225 and 276 actual colonies (as multiple colonies may be present within an SPA or SSSI) are designated within mean maximum and mean maximum + 1SD respectively. Of these, 162 (11.9%) colonies are contained within SPAs in mean maximum range with 202 (15.1%) within the entire mean maximum + 1SD range. The low proportion of colonies within SPAs initially suggests that Fulmar is not routinely collected within SPAs.

6.2.16 However, the number of birds contained within SPAs is proportionally higher than in non-designated colonies and thus, of the 558,874 individuals within mean maximum foraging range, 290,020 (51.9%) are from SPAs. In mean maximum + 1SD range, of the 958,786 individuals, 54.4% (52,1002) originate from SPAs. In other words, assuming equal mixing of all Fulmars from all colonies in the breeding season, then approximately 50% occurring in Alpha and Bravo would originate from SPAs. There is however, likely to be a bias towards colonies that are physically closer even in this wide ranging species.

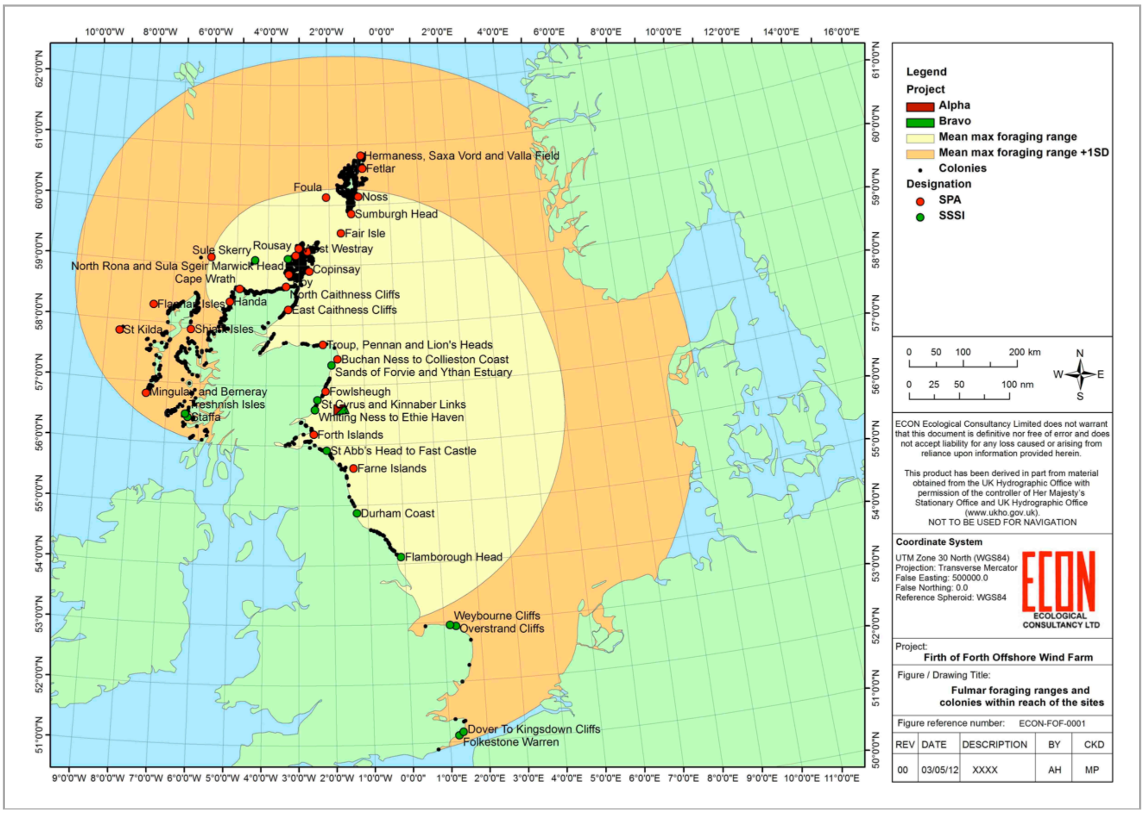


Figure 6.4. Distribution of Fulmar breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.2.17 The distance at the closest point from either Alpha or Bravo of all designated colonies and larger (>5,000 individuals) non-designated colonies within mean maximum and mean maximum +1SD ranges is shown in Table 6.2. This also shows the numbers of birds in each colony and how this has changed in the recent past, represented by a series of counts including the latest available.

Table 6.2 Details of Fulmar breeding colonies at increasing distance from Projects Alpha or Bravo and within mean maximum and mean maximum ± 1SD foraging ranges (400.0 and 654.8 km respectively). Sites include all SPAs and SSSIs in range and non-designated 'master' sites with *n*>5,000 individuals. Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count in the year specified from the SMP database are shown.

Foraging range	Site and designation	Distance (km)	Natura 2000	Seabird 2000	Latest count	
					Number	Year
Mean Max	St Cyrus and Kinnaber Links SSSI	30.08		170	102	2008

Foraging range	Site and designation	Distance (km)	Natura 2000	Seabird 2000	Latest count	
					Number	Year
	Fowlsheugh SPA	30.41	2,340	1,186	920	2009[1]
	Whiting Ness to Ethie Haven SSSI	35.12		1,902	1,902	2001
	St Abb's Head to Fast Castle SSSI	67.90		1,430	1,292	2011[6]
	Forth Islands SPA	71.68	1,596	1,632	2,274	2011
	Sands of Forvie and Ythan Estuary SSSI	74.05		594	378	2011
	Buchan Ness to Collieston Coast SPA	81.85	3,530	3,952	2,778	2007
	Farne Islands SSSI	98.98		508	552	2011
	Troup, Pennan and Lion's Head SPA	112.92	8800	5,800	3,590	2007
	Gamrie and Pennan Coast	114.40		528	528	2001
	Durham Coast SSSI	172.19		276	230	2010
	East Caithness Cliffs SPA	195.65	30,000	28,750	28,750	1999
	North Caithness Cliffs SPA	235.43	29,400	30,340	30,310	2002[3]
	South Ronaldsay	244.18		6,870	6,870	2002[3]
	Copinsay SPA	251.70	3,230	4,522	3,558	2008
	Smoo to Melvich	252.97		15,054	15,054	2000
	Sumburgh Head SPA	354.95	5,084	2,974	466	2009
	Deerness	256.09		6,974	6,974	2002[7]
	Hoy SPA	257.87	70,000	67,296	67,418	2005[2]
	Staffa SSSI	271.20		160	296	2010
	Handa SPA	272.35	7,000	7,100	3,830	2008
	Treshnish Isles SSSI	275.93		894	610	2009
	Cape Wrath SPA	279.27	4,600	4,456	4,456	2000
	Flamborough Head	280.11		2,346	3,134	2008
	Rousay SSSI	283.45		1,286	1,286	2000
	Marwick Head SSSI	283.48		1,430	692	2006
	Costa Head	284.26		5,498	5,498	2002[3]
	Eday	285.02		10,762	10,762	2002[3]
	Rousay SPA	285.80	2,480	1,948	1,948	2002[4]
	Sanday	289.40		7,386	7,386	2002
	Calf of Eday SPA	289.50	3,910	1,880	3,684	2002
	West Westray SPA	299.34	2800	9,006	7,904	2004[5]
	Shiant Islands SPA	299.69	13,640	8,774	8,774	1999
	Sule Skerry SSSI	305.39		940	800	2007
	Fair Isle SPA	316.89	70,420	40,848	59,298	2011
	Butt of Lewis to Gress - Lewis	319.70		17,386	17,386	1999

Foraging range	Site and designation	Distance (km)	Natura 2000	Seabird 2000	Latest count	
					Number	Year
	Tolsta Chaolais to Bragair - Lewis	341.23		5,216	5,216	1999
	Mingulay and Berneray SPA	348.95	20,900	20,040	16,302	2011
	Brenish to Valtos - Lewis	350.97		6,964	6,964	1999
	North Rona and Sula Sgeir SPA	356.61	23,000	7,040	5,232	2005
	Sumburgh to Peerie Voe of Spiggie	360.99		54,814	54,814	1999
	No Ness to Levenwick and Boddam to Virkie	367.59		11,040	11,040	1999
	Maywick to Scalloway	375.93		8,228	8,228	2000
	Flannan Isles SPA	383.96	9,460	15,472	15,472	1998
	Foula SPA	385.31	93,600	42,212	42,212	2000
	Noss SPA	387.80	12,700	9,998	10,496	2011
	Bressay	388.08		9,238	9,238	2000
Mean Max + 1 SD	Muckle Roe	411.58		6,022	6,022	1998
	Hunstanton Cliffs SSSI	418.92		130	230	2011
	St Kilda SPA	419.14	125,600	148,782	143,364	2003[9]
	Heylor to Stenness	427.78		10,204	10,204	2000
	Ronas Voe to the Ness	432.34		7,298	7,298	1999
	Weybourne Cliffs SSSI	433.40		6	6	1999
	Fetlar SPA	438.58	19,000	18,406	18,406	2002[8]
	Ulsta to Whalefirth (Yell)	438.84		7,316	7,316	1999
	Unst - south west	455.13		5,076	5,076	1999
	Hermaness, Saxa Vord and Valla Field SPA	463.23	39,078	42,158	27,688	2011[6]
	Saxavord, Skaw, Haroldswick and Baltasound	464.58		8,286	8,286	1999
	Dover To Kingsdown Cliffs SSSI	628.99		42	42	2001[10]
	Folkestone Warren SSSI	631.33		22	22	1999

[1]2000 & 2009; [2]1999 & 2005; [3]2000 & 2002; [4]1999, 2000 & 2002; [5]1999, 2000 & 2004; [6]2000 & 2011; [7]1999 & 2002; [8]1999, 2000, 2001 & 2002; [9]1999 & 2003; [10]2000 & 2001

Project Alpha

6.2.18 There are eight main sites within 100 km of Project Alpha that all are relatively small, ranging between 102 and 2,778 individuals, with the largest of these being Buchan Ness and Collieston Coast SPA. The Forth Islands SPA is of similar size at similar distance. In combination, the eight colonies contain just over 10,000 individuals. The nearest substantial colony (28,750 individuals) is over 190 km away at East Caithness Cliffs SPA. Although no tracking studies have been performed on this species in the region (Daunt *et al.* 2011), it would seem logical to suggest that the majority of Fulmars seen within Alpha during the breeding season are from the closest colonies within 100 km.

6.2.19 The prominent flight direction recorded was northwest, with more than a third of flying Fulmars heading in the direction of the Fife coast (Table 6.3) The closest colony at Fowlsheugh SPA at only 30 km lies in this direction tentatively suggesting the return of birds to this colony or perhaps a less direct route to Buchan Ness and Collieston Coast. However, there was no obvious reciprocal southeast flight path of birds flying from Fowlsheugh The fact that Fulmar is a wide-ranging species using shearing flight in the wind to travel, with lengthy foraging trips likely to incorporate much wandering movement means that this is perhaps not unexpected.

Table 6.3 Number and proportion (%) of flight directions recorded for Fulmar during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	45	53	34	58	26	36	50	186	57
	%	8.26	9.72	6.24	10.64	4.77	6.61	9.17	34.13	10.46
Breeding season	Count	37	45	17	28	10	26	38	141	45
	%	9.56	11.63	4.39	7.24	2.58	6.72	9.82	36.43	11.63

6.2.20 Outside the breeding season it is believed that most adult birds stay within relative proximity of the breeding colonies during the winter months (Forrester *et al.* 2007). However, ringing has shown that young birds fledging from Scottish colonies will, in their first four or five years, range all around the British Isles, as well as further afield, (e.g. there have been recoveries from east Canada, west Greenland and the Barents Sea). In return there have been recoveries in Scotland of birds ringed at colonies in Canada, Iceland, the Faeroe Islands and Norway (Forrester *et al.* 2007). These younger, pre-breeding birds, are indistinguishable from adults, and therefore will constitute an unknown proportion of the wintering population. Furthermore, the winter population may be supplemented by birds from more northerly breeding populations.

6.2.21 Overall, it is probably safe to assume that Fulmars in the passage and wintering period could effectively originate from many of the colonies falling mean maximum + I SD foraging range. This would suggest ~50% would have some origin within SPA colonies (see above) and although this could be partitioned between different colonies according to their size, there is no firm basis for this approach.

Project Bravo

6.2.22 The origin of birds in Bravo seems likely to match that in Alpha with birds most likely to originate from the eight colonies within 100 km in the breeding season. The three sites likely to make the greatest contribution of birds would seem to the two largest within the Buchan Ness to Collieston Coast SPA and Forth Islands SPA and the closest at Fowlsheugh SPA. As in Alpha, the predominant flight direction of northwest may suggest return of birds to Fowlsheugh SPA and perhaps Buchan Ness to Collieston Coast SPA.

Table 6.4 Number and proportion (%) of flight directions recorded for Fulmar during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	79	76	50	76	32	37	60	206	84
	%	11.29	10.86	7.14	10.86	4.57	5.29	8.57	29.43	12.00
Breeding season	Count	56	50	37	53	21	31	41	138	68
	%	11.31	10.10	7.47	10.71	4.24	6.26	8.28	27.88	13.74

Summary of risks

6.2.23 Of the 26 seabirds Garthe & Hüppop (2004) considered, Fulmar was ranked as the least vulnerable to any effects of offshore wind farms. Furness & Wade (2012) however, divided the risks between displacement and collision risk and classified Fulmar as 12th from 37 seabird species in the context of collision risk and 36th in the context of displacement.

6.2.24 The data gathered for Project Alpha suggests the proportion of flying birds is high, with 87% of all birds recorded in flight (545 from 630 individuals). However, the proportion of these that were recorded flying above 20 m was very low at 0.2% with only one individual recorded >20 m. The proportion recorded within Alpha was considerably lower than proportion of 4.8% presented by Cook *et al*. (2011), derived from 24 studies of 20 offshore wind farm sites. Nevertheless, both proportions are within the category score of 1 (median flight height below 5 m) by both Garthe & Hüppop (2004) and Furness & Wade (2012). A similar proportion of flying birds were observed in Project Bravo, with 80% of birds in flight and 0.3% of birds (two individuals) flying at > 20 m.

6.2.25 In terms of vulnerability to displacement, Fulmar was ranked 37th from 38 seabirds by Furness & Wade (2012). This stems from the wide-ranging behaviour of a species exploiting a wide variety of prey items that are patchily distributed over large areas of sea.

6.2.26 Significant displacement could occur if birds were actively selecting an area to feed. However in the case of Fulmar only twelve birds were recorded displaying direct feeding behaviour (<1% for both Alpha and Bravo). Moreover, only 10% and 12% of all flying birds in Alpha and Bravo respectively were recorded as having no specific flight direction (Tables 6.3 & 6.4). In some species, this may indicate foraging behaviour in some species but in Fulmar may also indicate an association with the survey vessel.

6.2.27 Overall, there is no suggestion that the site is an important foraging ground for Fulmar which means that displacement from resources as a result of the presence of the wind farm is extremely unlikely to be important. Moreover, if the areas are of no importance as foraging areas then there is no basis for any concern over indirect effects affecting the distribution or abundance of food resources, unless this is positive.

6.2.28 In terms of barrier effects, the lack of specific flight directions and links to particular colonies save the possibility of birds returning to Fowlsheugh SPA or Buchan Ness to Collieston Coast SPA, coupled with the wide-ranging nature of Fulmar means that barrier effects are also very unlikely to affect the energetic balance of birds.

6.2.29 Finally, the simple fact that the 1% threshold for the regional population during the breeding season was not exceeded for either Alpha or Bravo during the two year survey period, despite the great number of colonies within foraging range (Table 6.2, Appendix F1 Annex 6), suggests that both the Alpha and Bravo development sites are not of significant importance to the species.

Project Alpha

6.2.30 In conclusion, the prospect of a significant ecological impact at a population scale according to (IEEM 2010) appears to be extremely low in relation to Project Alpha and for this reason Fulmar is not included for further assessment within the ES ornithology chapter (Chapter 10: Ornithology of ES Volume I). However, this is not to say that the links between Fulmar and SPAs in the Firth of Forth region and perhaps even further afield will not require further consideration in HRA

Project Bravo

6.2.31 The same conclusions were reached for Project Bravo as for Project Alpha in that Fulmar was not to be considered as a sensitive receptor within the Project Bravo section of the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I). Again, this does not eliminate the need for further consideration within HRA, with this perhaps depending on further discussion with the statutory advisors.

Northern Gannet

Population ecology

6.2.32 The global breeding population of Gannet has shown a long-term increase and range expansion, and recent estimates suggest 418,000 pairs (Wanless *et al.* 2005). Europe supports 75% of this population that is currently classified as 'Secure' (BirdLife International 2004).

6.2.33 The UK supports 53.9% of the world population (Wanless *et al.* 2005) with the majority of Gannets breeding at a few major colonies on remote islands and sea cliffs (Cramp *et al.* 1974). During Seabird 2000, 16 Gannet colonies in the UK were surveyed which gave a breeding population estimate of 226,553 breeding pairs (Mitchell *et al.* 2004). Of most relevance to the Firth of Forth is the colony at Bass Rock, which is the second largest colony in the east Atlantic supporting 55,482 breeding pairs when last surveyed in 2009, having increased by 14.3% since the previous survey in 2004 (Murray 2011).

6.2.34 Gannet has one of the best documented changes in population of any seabird as a result of a long history of monitoring (Mitchell *et al.* 2004). During the last decade, UK Gannet numbers have continued to increase, with JNCC (2010) reporting a 22% increase in the UK population from 1999 to 2009. Nonetheless, 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.* 2009).

6.2.35 Likely reasons for the continued success of Gannet include an increase in their prey fish, probably as a result of the overfishing of competitive predatory fish and possibly by scavenging discards from fishing vessels in some areas (Camphuysen 2011). Gannet also has an ability to adopt a number of strategies to take a wide variety of prey items. Gannet feeds on large shoaling fish such as Mackerel *Scomber scombrus*, gadoids and clupeids by plunge diving at heights of 10-40 metres (Lloyd *et al.* 1991) to depths that are beyond the scope of other aerially foraging seabirds. 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). Further offshore, Gannet also routinely associates with dolphins, which may also drive prey to the surface (Camphuysen 2011).

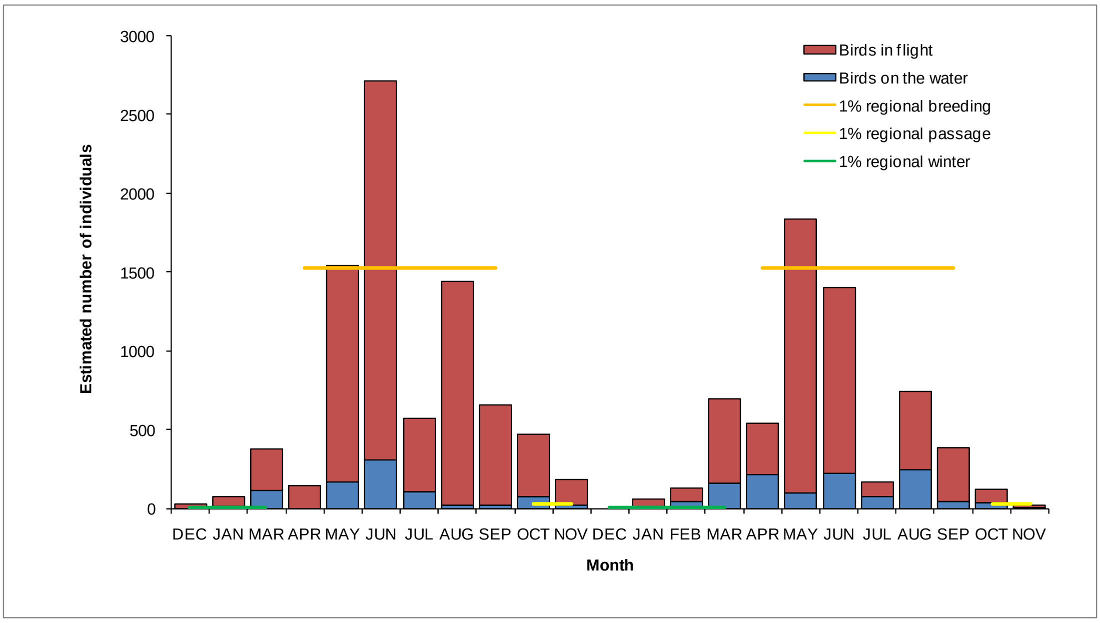
6.2.36 Gannets do not commence breeding until 5-6 years old after they have undergone complex patterns of movement potentially covering enormous sea areas (Skov *et al.* 1995, Wernham *et al.* 2002). Once breeding they pair for life and are faithful to their nest site, returning to the same nest every year (Cramp *et al.* 1974). The first birds return to their colonies in January, with the first eggs being laid in April. Both sexes incubate the egg for equal durations and most chicks hatch in June and early July (Cramp *et al.* 1974) with fledging mostly in September (Forrester *et al.* 2007).

Density distribution and population size

Project Alpha

6.2.37 Gannet were present within the Alpha site boundary in all surveys with peak populations achieved during the breeding season (Figure 6.5). The peak population estimate was recorded in June 2010 at 2,716 individuals exceeding the 1% regional threshold of 1,530. The peak value in 2011 was in May (1,841 individuals), comparable to that recorded in 2010 (1,543 individuals). The 1% regional threshold during the breeding season was exceeded on only three occasions over the two year study period (Figure 6.5). It is especially noteworthy that nationally important populations were never achieved despite the relative proximity of the extremely large colony at Bass Rock.

Project Alpha



Project Bravo

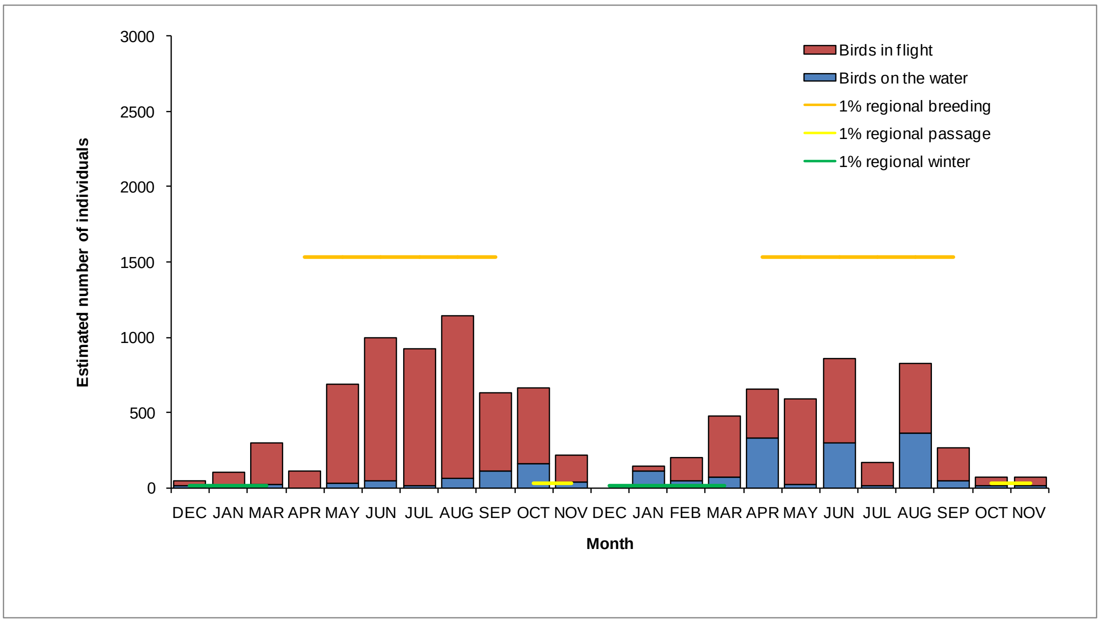


Figure 6.5 Gannet population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from density from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect. Criteria for regional importance in the breeding, passage and winter periods are shown.

Gannets were generally rather more abundant in 2010 compared to 2011 albeit with a similar pattern of abundance during the breeding season save the lower numbers in June 2011 (or higher numbers in 2010). In general, there was some evidence of higher populations at the start of the breeding season in May/June with this declining by July with an increase in August at the beginning of dispersal of failed birds and the first chicks. Population estimates for the passage and winter periods of the year were much lower, although regionally important numbers were achieved for both periods (Figure 6.5), potentially as result of the birds from Bass Rock remaining in the Forth of Forth area.

6.2.38 Densities reached 6-9 individuals km^{-2} at peak in the breeding season (Table 6.5), which accords closely with the range to >10 individuals km^{-2} presented by Camphuysen (2011) in the Firth of Forth. 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 unsurprising given the proximity of Bass Rock colony.

Table 6.5 Monthly mean (± 1SD) density of Gannet in Projects Alpha and Bravo as 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
Alpha	0.4 ± 0.1	0.7	2.8 ± 1.2	1.8 ±1.5	8.6 ± 1.1	8.7 ± 7.2	1.9 ± 1.4	5.6 ± 2.4	2.7 ± 1.0	1.5 ± 1.3	0.5 ± 0.6	<0.1 ± 0.1
Bravo	0.6 ± 0.1	1.0	2.0 ± 0.7	1.9 ± 1.9	3.3 ± 0.4	6.4 ± 1.7	2.8 ± 2.8	4.9 ± 1.3	2.3 ± 1.3	1.9 ± 2.2	0.7 ± 0.5	0.1 ± 0.2

6.2.39 In more detail, the average density in June and July coinciding with the surveys of Camphuysen (2011) would be around 4-5 individuals km^{-2}, which mirrors the value of 2-4.99 in what appears to be the equivalent rectangle surveyed by Camphuysen (2011). There does however appear to be considerable variation, with some rectangles further offshore supporting higher density, suggestive of concentration of birds at important resources. Skov *et al.* (2008) did however suggest that most foraging occurred within distinct hydrographic frontal areas, in particular the tidal shelf front.

6.2.40 The density within Alpha during the winter months after passage of up to 0.6 individuals km^{-2} 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}).

6.2.41 In total, 88.6% of all Gannets were aged in Alpha and Bravo combined. Where a single bird was observed the proportion aged was very high at 92.6%. The proportion of observations aged dropped to 88.6% when two birds were observed together, which consistently reduced to 25% of all records when flocks of 21 to 30 individuals were recorded (4 flocks from 12 were aged). In Alpha alone, the proportion of Gannets aged as adults in the breeding season of April to September was 96.7% from the aged sample of *n* = 2,299 (Table 6.6).

Table 6.6 Number and proportion of adult Gannets relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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

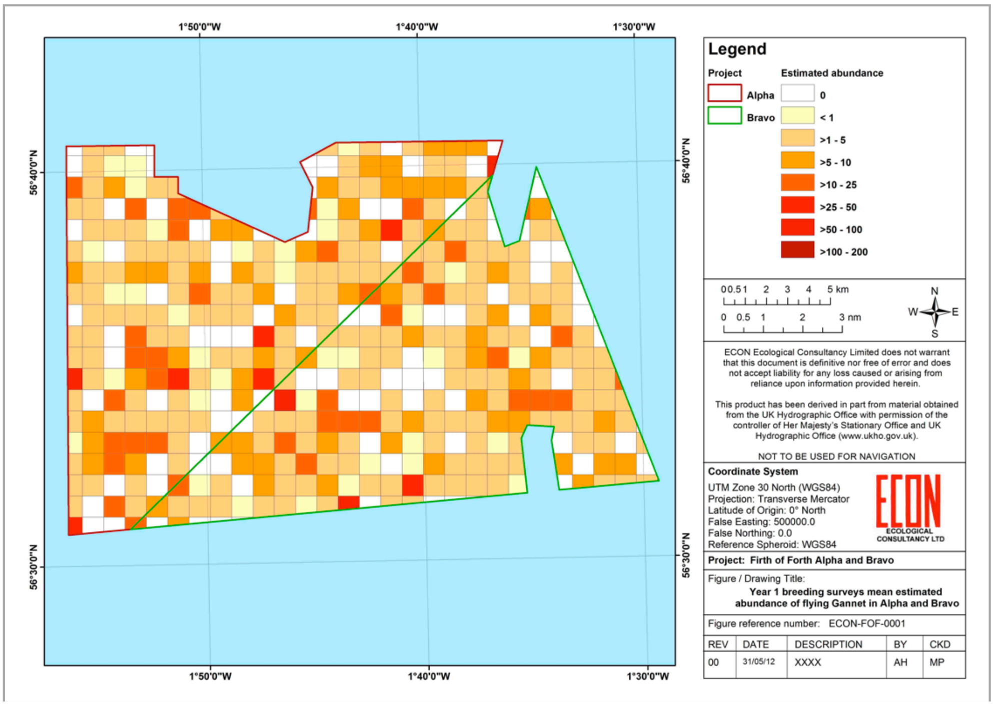
6.2.42 Plots derived from the abundance of Gannets in flight suggested some subtle differences in distribution patterns in the two breeding seasons. In 2010, when estimates were greater, Gannet were distributed more in the south-eastern part of the site, whereas in 2011 the area to the north of this section was more prominent (Figure 6.6). Otherwise, distribution was relatively patchy with a moderately high number of cells either not recording any birds at all or only a relatively low abundance (mean of 1-5 flying birds km^{-2}).

6.2.43 Distribution maps derived from aerial surveys conducted in 2009 suggested a concentration of observations along the north western edge of the aerial study area through Neart na Gaoithe and over a section through the central area broadly corresponding to Wee Bankie and the Marr Bank complex, all broadly on a northeast/southwest flight path from Bass Rock (Figure 6.7).

6.2.44 However, Jacob's selectivity index did not reveal any significant selection of Neart na Gaoithe in summer (D = +0.28) compared to Inch Cape (D = 0.08) and although there was some avoidance of Alpha this was not quite significant (D = -0.42). In winter, there were no trends for Alpha, Neart na Gaoithe nor Inch Cape (D = +0.16, +0.20 and +0.22 respectively) or overall (D = -0.34, +0.30 and +0.13 respectively).

Project Bravo

6.2.45 Gannet were ever present in the boat-based surveys of Bravo and whilst peak numbers were recorded during the breeding season, the general pattern of abundance differed somewhat from Alpha (Figure 6.2). For example, a substantially lower number of birds was recorded in Bravo in 2010 compared to Alpha. Population size also essentially increased each month in 2010, reaching a peak in August compared to June in Alpha. In 2011, the peak population was recorded in June, a month later than in Alpha. Similar patterns during the passage and winter periods were observed in both Alpha and Bravo.



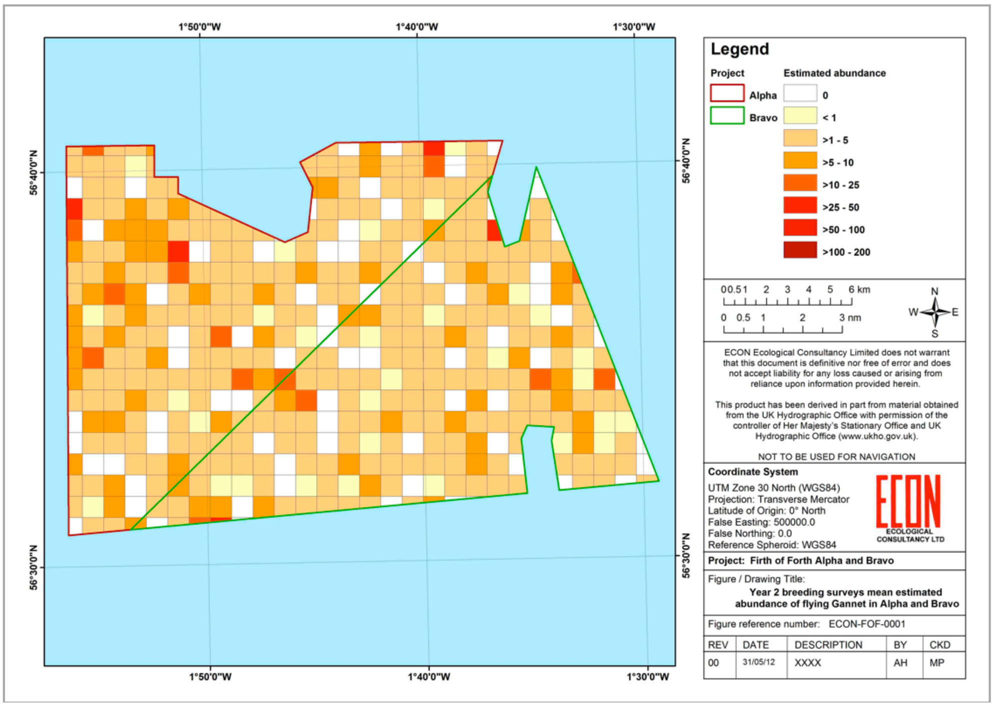


Figure 6.6 Relative abundance of Gannet expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to September inclusive in 2010 (above) and 2011 (below).

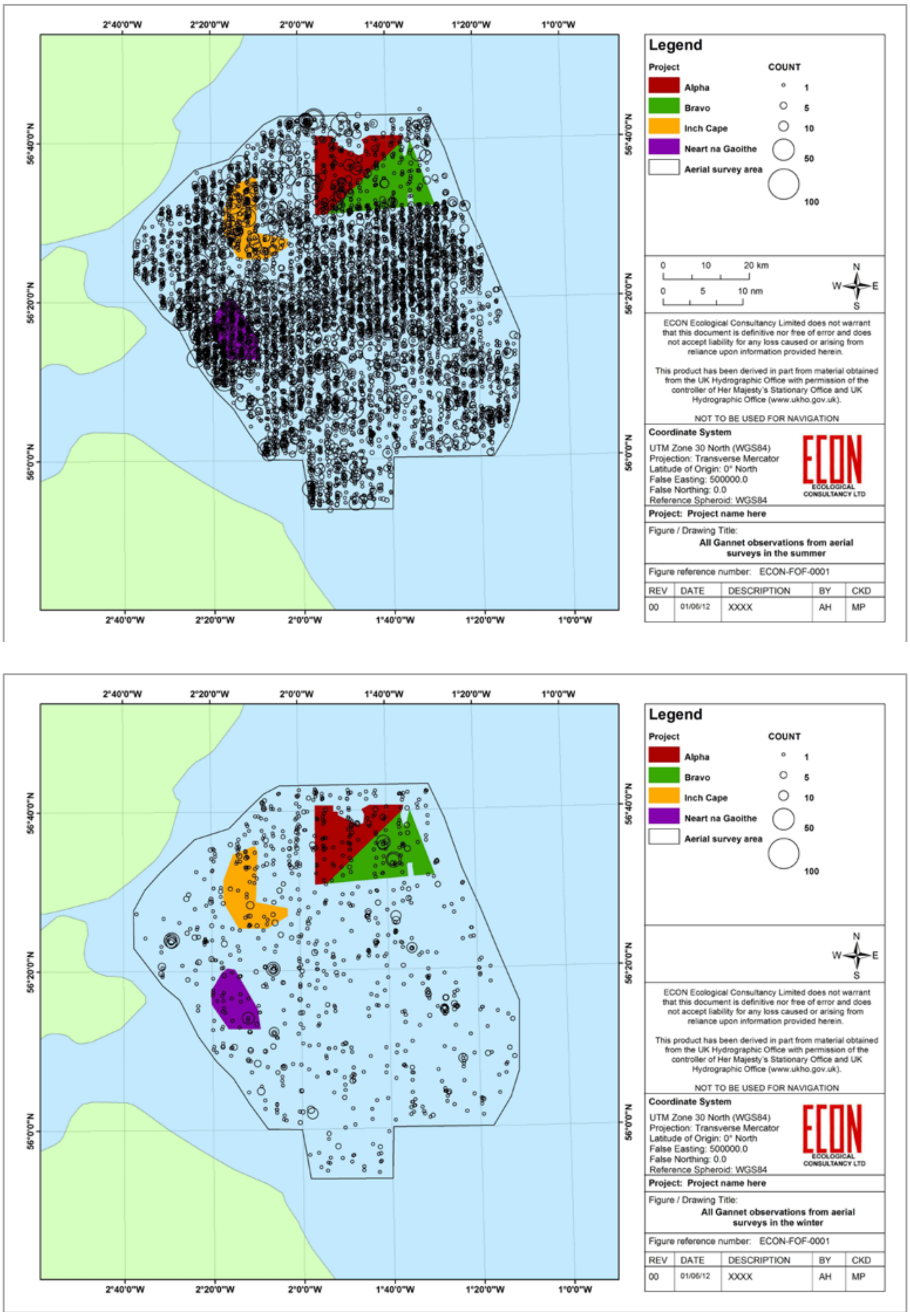


Figure 6.7. Relative distribution of Gannet within the Firth of Forth aerial survey area from pooled records of all birds from all surveys in the summer (above) and winter months (below) where n = 3 and n = 4 respectively.

6.2.46 Despite the proximity of Bass Rock, the 1% regional threshold for the breeding season was not exceeded in either year within Bravo. The peak population estimate in 2010, derived in August was 1,141 birds (approximately 400 birds short of the threshold), with 854 birds estimated to present within Bravo in June 2011 (approximately 700 ind. below the 1% threshold). Peak population estimates during the passage months was recorded in October both years (664 individuals was derived in 2010) and in March during the winter period (478 individuals estimated in 2011) (Figure 6.2).

6.2.47 In comparison with Alpha, a similarly high proportion (97.8%) of Gannets were aged as adults in the breeding season of April to September in an aged sample of *n* = 1,895 recorded in Project Bravo (Table 6.7).

Table 6.7 Number and proportion of adult Gannets relative to the total number of birds aged in each month during boat-based surveys of Project Bravo.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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

6.2.48 As with Alpha, distribution maps derived from all boat-based surveys did not reveal any particular patterns of selection across the Bravo site (Figure 6.6), with a patchy distribution could be considered patchy regardless of year and/or season. However, a lower number of birds in flight in 2011 compared to 2010 with more birds on the water in the former, was reflected in the distribution map of flying birds (Figure 6.6). An area in the south-west supporting higher abundance in 2010 was not used in 2011 and most cells contained a low abundance of flying birds.

6.2.49 In summer aerial surveys there were few observations of Gannet with these concentrated along the southern boundary (Figure 6.7). This was reflected in the significant avoidance of the site suggested by Jacob's selectivity index (D = -0.58). The pattern was almost opposite in the winter months with near selection (D = +0.48) as a result of some large aggregations within Bravo (Figure 6.7), although these were also present in the wider study area. Moreover, the far greater number of birds in the summer months meant that overall selection was still negative, but not significant (D = -0.39).

Foraging range and potential origin

6.2.50 Gannet has a mean maximum foraging range of 229.4 km and a mean maximum foraging range + 1SD of 353.7 km (Figure 6.8), which means that 116,538 and 153,022 individuals respectively breed within each range (Table 6.7). These birds are distributed amongst two colonies within mean maximum foraging range and seven colonies within the range incorporating 1SD, extending from Flamborough Head and Bempton Cliffs SPA in the south to Fair Isle SPA in the north (Figure 6.8).

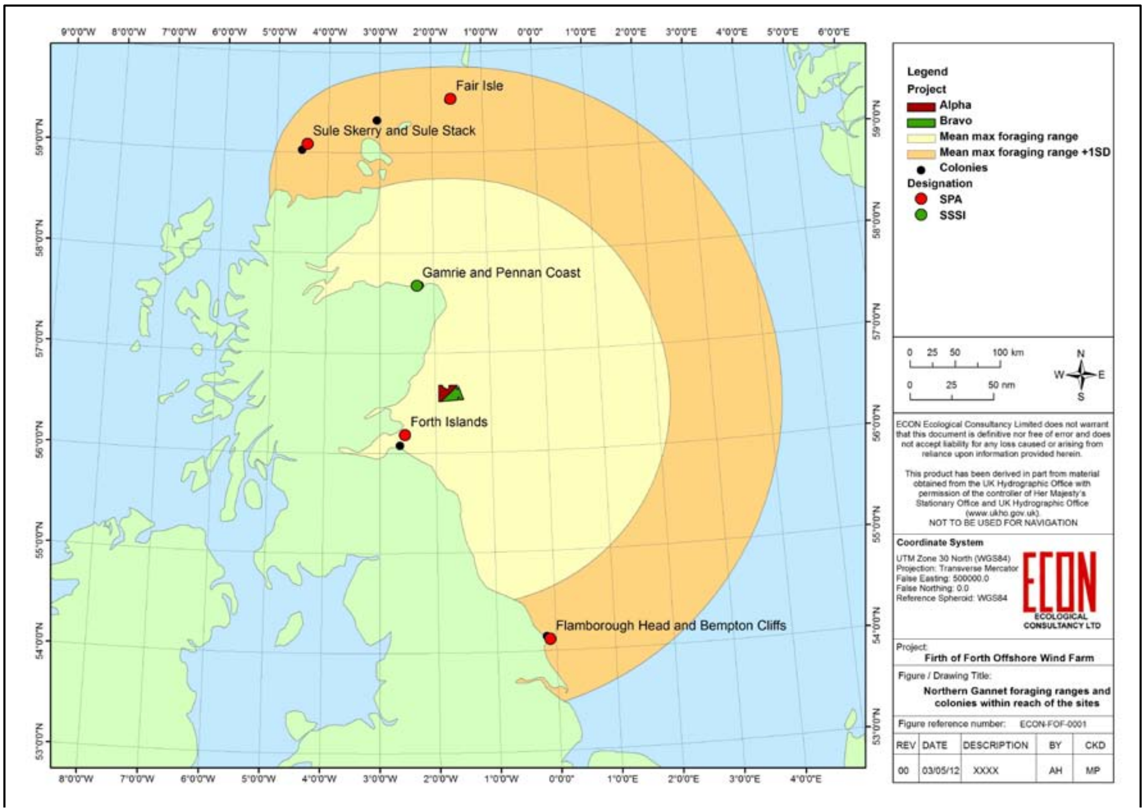


Figure 6.8 Distribution of Gannet breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

Table 6.8 Details of all Gannet breeding colonies at increasing distance from Projects Alpha or Bravo and within mean maximum and mean maximum ± 1SD foraging ranges (229.4 and 353.7 km respectively). Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count in the year specified are shown.

Foraging range	Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
					Number	Year
Mean Max	Forth Islands SPA	65.15	43,200	88,220	110,964	2009
	Gamrie and Pennan Coast SSSI	112.92		2,170	5,574	2010
	Flamborough Head and Bempton Cliffs SPA	278.72	0[1]	5,104	15,718	2009
Mean Max +1 SD	Westray - West Cliffs	302.08		0	1,200	2011
	Sule Skerry and Sule Stack	303.91	11,800	10,274	11,436	2011[2]
	Fair Isle SPA	316.89	2,332	2,246	8,130	2011

[1]In the Assemblage; [2]2004 & 2011

6.2.51 Of the two colonies are within mean maximum foraging range, Bass Rock is designated within the Forth Islands SPA whilst and Troup Head is incorporated within the Gamrie & Pennan Coast SSSI. The number of designated colonies increases to five with a further four SPAs as well as one non-designated colony within range incorporating 1SD. Hence overall, a high proportion of colonies (71.4%) are designated within SPAs.

6.2.52 If, instead of the number of colonies, the number of individual birds in the region is considered, of the 116,538 individuals within mean maximum foraging range, 110,964 (95.2%) are contained within SPAs. In mean maximum +1SD range, of the 153,022 individuals, 146,248 (95.6%) originate from SPAs.

Project Alpha

6.2.53 By far the largest colony in the region, at the Bass Rock in the Firth of Forth containing 95.2% of all birds within mean maximum foraging range (and 72.5% of all birds within range +1SD) lies within 70 km of Project Alpha. Data from satellite-telemetry studies of chick-rearing adults in 1998, 2002 and 2003 showed that at least the greater part of Alpha is within the core foraging area of all Gannets in all years studied, although in 2002, a small area in the north-west corner of Alpha was less heavily used (Hamer *et al.* 2011). Modelling of habitat suitability for Gannet supports this view (Skov *et al*. 2008).

6.2.54 The next closest colonies to Alpha, at Bempton Cliffs to the south and Troup Head to the north, are both relatively small and Hamer *et al.* (2011) argued that chick-rearing adults from these two colonies are unlikely to forage extensively within Alpha. This is supported by satellite tracking of 27 chick-rearing adults breeding at Bempton Cliffs in 2010 and 2011, none of which reached as far north as Alpha (Langston & Boggio 2011). It thus seems that all the adult gannets encountered in the breeding season within Project Alpha are best viewed as originating from Bass Rock within the Forth Island SPA.

6.2.55 The presumption of origin from Bass Rock of Gannets in Project Alpha is supported by the prominent flight path along a southwest to northeast axis linked to flights to and from Bass Rock (Table 6.9). Data presented by Camphuysen (2011) shows a concentration of birds in the area of Buchan Deep and Halibut Bank in the north-east on the edge of the tidal front area suggested to be the core foraging habitat by Skov *et al*. (2008). 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.

6.2.56 However, the number of return flights to Bass Rock (41%) were almost double the flights from the colony suggesting a slightly different outbound, compared to inbound route. Birds may forage on the outward journey incorporating potential patches of suitable habitat but tend to return much more directly from the last point of foraging. The main outbound route from Bass Rock may thus not cross Alpha and may vary according to the distribution of feeding patches, which could also account for the subtly different distribution pattern between years (Figure 6.6). In fact, aerial surveys would tend to suggest the route incorporates Neart na Gaoithe and thence the Wee Bankie and Marr Bank complex (Figure 6.7).

Table 6.9 Number and proportion (%) of flight directions recorded for Gannet during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	181	691	104	173	299	1,345	143	178	188
	%	5.48	20.93	3.15	5.24	9.06	40.73	4.33	5.39	5.69
Breeding season	Count	102	493	50	72	154	1,031	81	102	98
	%	4.67	22.58	2.29	3.30	7.05	47.23	3.71	4.67	4.49

6.2.57 More than 80% of birds tracked from the Bass Rock overwintered mainly off West Africa and in the Mediterranean Sea (Kubetzki *et al*. 2009). As Gannets typically migrate southwards during the non-breeding season, it seems logical to conclude that birds from more northerly colonies, including those on Shetland and even along the west coast of Norway, could potentially pass through Bravo (and Alpha) (Wernham *et al.* 2002). A precautionary stance would be to assume equal mixing of all populations within range within the breeding season could then occur in Alpha in the passage and winter. Such an approach would suggest 75% of all birds present in the passage period and perhaps especially in the winter would originate from Bass Rock. Whilst this may not be unreasonable, there is in fact no direct evidence for this assumption.

Project Bravo

6.2.58 Of specific relevance to Project Bravo, the potential development area Bravo was wholly within the core foraging area of all Gannets in all years studied by Hamer *et al.* (2011). It is therefore assumed that the same principle established for Alpha in that all birds in the breeding season are likely to originate from Bass Rock.

6.2.59 Flight directions of birds recorded in Bravo closely mirrored the patterns shown for Alpha with a predominant northeast- southwest flight axis in the breeding season with a bias towards return flights (Table 6.10). The same interpretation of this pattern of flight direction is offered.

6.2.60 For birds outside the breeding season, post-breeding tracking of a small sample of birds from Bempton Cliffs in 2011 showed one adult flew north along the east, north and west coasts of Scotland, passing just east of Bravo, before continuing its journey southwards along the west coast of Ireland and on to south-west France (Langston and Boggio 2011). This highlights the fact that during the non-breeding season adult birds from any of the colonies within foraging range + 1 SD, together with those from wider afield, could enter Bravo or Alpha as indicated above.

Table 6.10 Number and proportion (%) of flight directions recorded for Gannet during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	172	554	142	193	179	1,054	126	158	235
	%	6.11	19.69	5.05	6.86	6.36	37.47	4.48	5.62	8.35
Breeding season	Count	123	475	88	117	94	902	83	102	148
	%	5.77	22.28	4.13	5.49	4.41	42.31	3.89	4.78	6.94

Summary of risks

6.2.61 Due to factors such as high adult survival rate, the concentration of the biogeographical population within Europe and relatively high flight altitude, Garthe & Hüppop (2004) ranked Gannet 12th from 26 seabirds in terms of vulnerability to offshore wind farms. Separating the main risks, Furness & Wade (2012) ranked Gannet as 4th (of 37 seabirds) in terms of vulnerability to collision with turbines but considered Gannet at low risk to displacement, ranking the species 28th. The flexible habitat use of the species stemming from wide-ranging capability coupled with the ability to sample a wide variety of prey resources is at the root of the lack of concern of displacement.

6.2.62 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. Cook *et al*. (2011) used studies from 26 wind farm sites and found that 16.8% of flights by Gannet were at risk height, the highest value apart from large gulls. The data for the Alpha development from the boat-based surveys did not produce such a high proportion of flights at risk height. From a total of 3,303 records, 9.4% were flights above 20 m. In contrast, the proportion of Gannets at risk height within the Bravo development site, exceeded that derived by Cook *et al*. (2011) at 16.3% (458 individuals from 2,813 birds in flight). The differences 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 below) although densities were generally lower.

6.2.63 Evidence from Egmond aan Zee, an offshore wind farm off the Dutch coast, revealed high rates of avoidance (99.1%) by Gannet outside of the breeding season (Krijgsveld *et al*. 2011). However, avoidance rate could conceivably be reduced by individual reproductive state, with provisioning adults being less likely to demonstrate avoidance. Nonetheless, avoidance is still anticipated to be well above the precautionary rate of 98% suggested for use in assessment by the SNCBs.

6.2.64 In relation to potential displacement and indirect effects, there is little evidence that Gannet use the Alpha development site as a key foraging ground, with only 152 birds observed in direct feeding activity (3.9%) and only 5.7% of flying birds recorded as having no specific direction, with <5% during the breeding season (Table 6.8). A similar proportion of birds were observed in direct feeding activity in Bravo (3.7%) from boat-based surveys, although a greater proportion were recorded with no specific flight direction (8.4% overall and 6.9% during the breeding season - Table 6.9).

6.2.65 The distribution of feeding records was scattered across both development areas with isolated individuals and small feeding aggregations (<25 birds) engaged in active feeding especially during the breeding season (Figure 6.9). As such, the effect of direct displacement from either of the Alpha or Bravo developments in terms of a potential loss of foraging habitat should birds not enter the wind farms was not thought to have the potential for significant ecological impact even though the areas were within core foraging range of birds from Bass Rock.

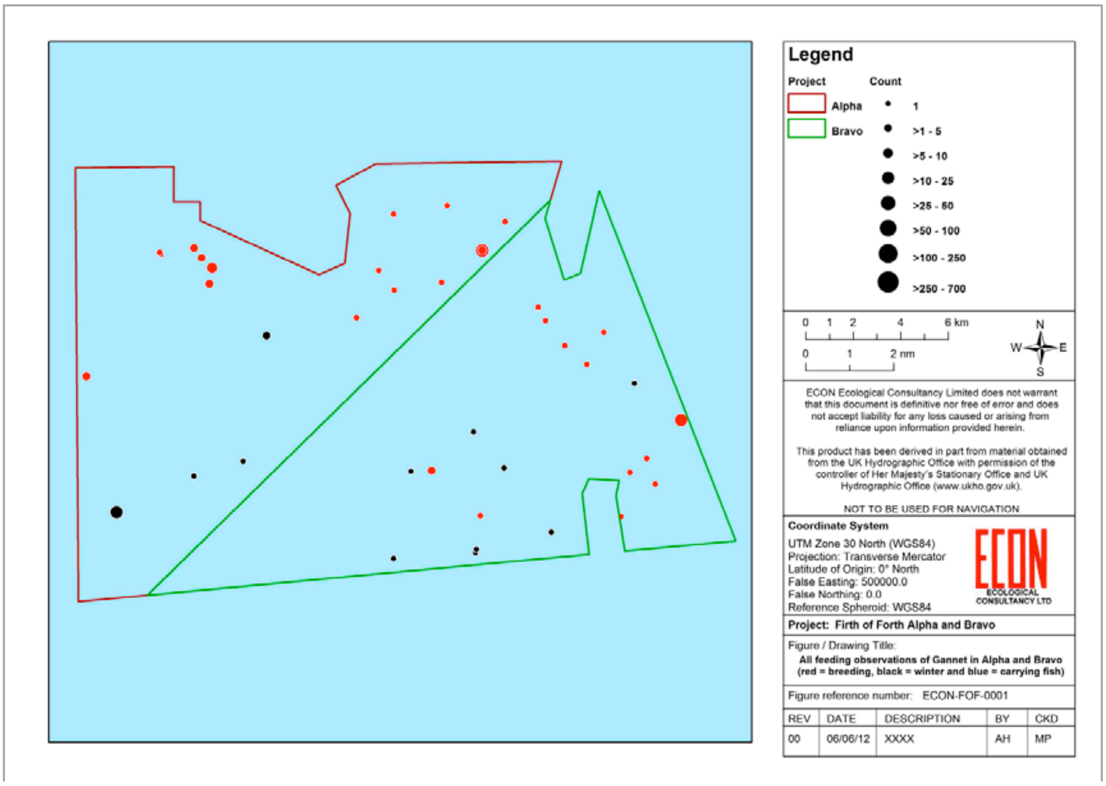


Figure 6.9 Distribution and group size of feeding Gannets recorded in all surveys of Alpha and Bravo in both the breeding season (red) and passage/winter period (black).

6.2.66 On the other hand, indirect effects stemming from the impact of construction noise on fish stocks could extend far beyond the wind farm footprint within the core foraging area. The area affected will depend on the technologies used, thereby generating a particular level, duration and timing of noise impacts upon a range of fish species that have different sensitivities. As hearing specialists, shoaling clupeids are known to be extremely sensitive (Thomsen *et al.* 2006), although sandeels appear to be far less so as they lack a swimbladder.

6.2.67 Moreover, the high proportion of birds recorded in flight at 85% and 83% for Alpha and Bravo respectively, with breeding individuals commuting to and from Bass Rock across both Project areas introduces the prospect of a potentially significant ecological impact through the energetic consequences of barrier effects should birds avoid the wind farm (Masden *et al*. 2010, McDonald *et al*. 2012).

Project Alpha

6.2.68 Overall, the potential for significant ecological impact of collision with turbines, displacement of breeding birds through barrier effects and the indirect effects of construction on prey abundance and distribution within the core foraging range of one of the largest colonies in the World necessitates that Gannet is carried forward as sensitive receptor for Project Alpha in the Impact Assessment of the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

Project Bravo

6.2.69 The densities of Gannet within Project Bravo were lower than those within Alpha and thus any impact generated by Bravo may be less than within Alpha. Nevertheless, the fact that individuals from Bass Rock within the Forth Island SPA would be affected there is still potential for significant ecological impact of collision with turbines, displacement of breeding birds through barrier effects and the indirect effects of construction on prey abundance and distribution. Gannet is therefore carried forward as a sensitive receptor for Project Bravo in the Impact Assessment of the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

Black-legged Kittiwake

Population ecology

6.2.70 Kittiwake is the most numerous gull in the World, with a global population of around 2.7 million breeding pairs (Coulson 2011). Although widespread, Kittiwake is a patchily distributed breeder in Western Europe that accounts for <50% of its global breeding range. In the past, the European population has fluctuated greatly in different periods and within different countries, but has been provisionally evaluated as Secure (BirdLife International 2004). In the UK however, population decline over the past 25 years, coupled with the fact that at least 50% of UK breeding population occur in ten or fewer colonies, has led to the Kittiwake being listed as ‘Amber’ conservation status (Eaton *et al.* 2009).

6.2.71 In the UK, Kittiwake nests along all coasts, with the largest colonies situated in north and east Scotland. The breeding population of the UK was 378,847 pairs in Seabird 2000 having declined by 25% since 1988 (JNCC 2011). The current population trend for Kittiwake is of continued significant decline of 30% between 2000 and 2010 (JNCC 2011). Different colonies in UK and Ireland have shown different rates of decline with the more northerly colonies in Scotland suffering the largest declines. Fowlsheugh for example has declined by almost 40% in the last decade or so (see below). Different rates of decline illustrate the potential for varying factors to influence breeding success, although the prevailing casual factor is thought to be a change in the availability of prey, in turn linked to climate change and anthropogenic fishing activity (Frederiksen *et al.* 2004, Scott *et al.* 2006). Closure of the sandeel fishery in the Forth of Firth in 2000 initially seemed to improve breeding performance following the recruitment of 0-group sandeels but this declined subsequently, illustrating a more complex situation that initially thought (Frederiksen *et al.* 2004).

6.2.72 Kittiwakes feed 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). Kittiwakes are a surface-feeding species and are incapable of submerging much more than one body length. Therefore, Kittiwakes are dependent on prey reaching the surface typically as a result of upwelling water movement associated with frontal systems or particular bed features, or the driving activities of deeper diving species especially auks (Camphuysen 2005).

6.2.73 Kittiwakes are highly pelagic outside of the breeding season, with recent information showing birds from the Isle of May amongst other colonies spending the winter in the West Atlantic between Newfoundland and the Mid-Atlantic Ridge some 3,000 km distant although some stayed in the North Sea (Frederiksen *et al.* 2011). Moreover, winter distribution was partly determined by breeding performance with failed birds much more likely to reach the West rather than East Atlantic (some 1,000 km away) after leaving breeding colonies earlier (Bogdanova *et al*. 2011).

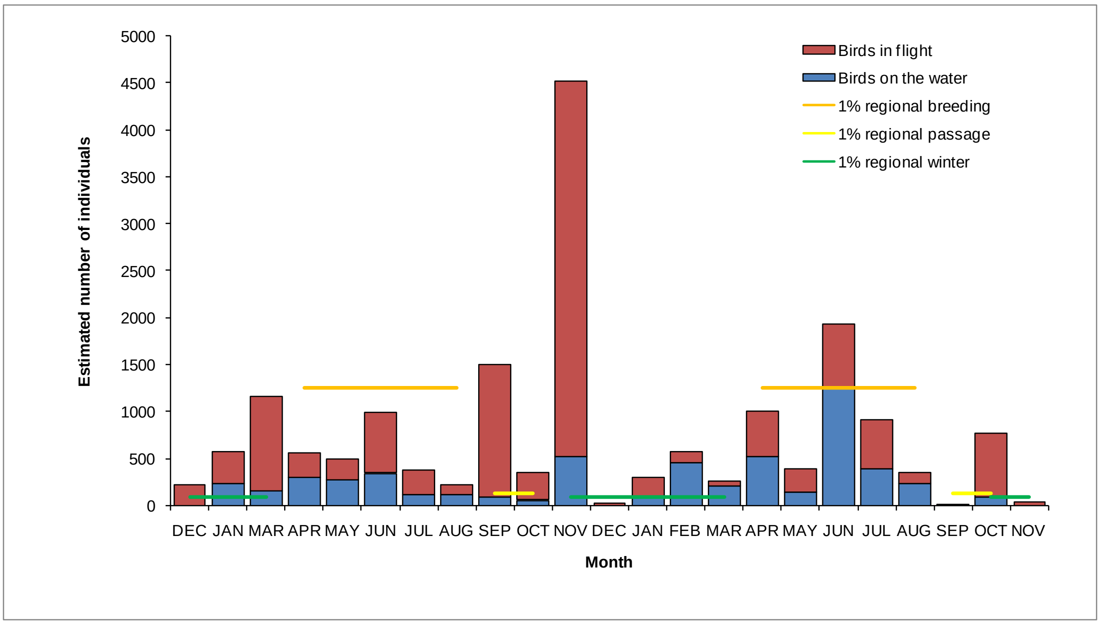
6.2.74 Birds return from the open sea to their nesting colonies on vertical rocky cliffs on the mainland and on islands, as well as artificial structures (Lloyd *et al.* 1991), in March or April, although this can be as early as January (Cramp *et al.* 1974). Kittiwakes usually lay a clutch of two eggs, which are laid during the months of May and June with later laying date at more northerly colonies (Coulson 2011). The chicks hatch throughout June and July and take six weeks to fledge. Whilst most dispersal follows fledging (i.e. in July / August), adult Kittiwakes have been known to remain at their nest site after their chicks have fledged, some staying until November (Cramp *et al.* 1974).

Density distribution and population size

Project Alpha

6.2.75 Kittiwake were present in all boat-based surveys of Alpha, although estimated population size fluctuated between surveys, seasons and years. In 2010, the population estimates decreased over the breeding period and the two peak values were recorded in the passage period (September) and during the winter (2010). In contrast, densities were generally higher during the breeding season of 2011 although numbers fluctuated between April and August, and the lowest estimates were recorded in September and November (Figure 6.10).

Project Alpha



Project Bravo

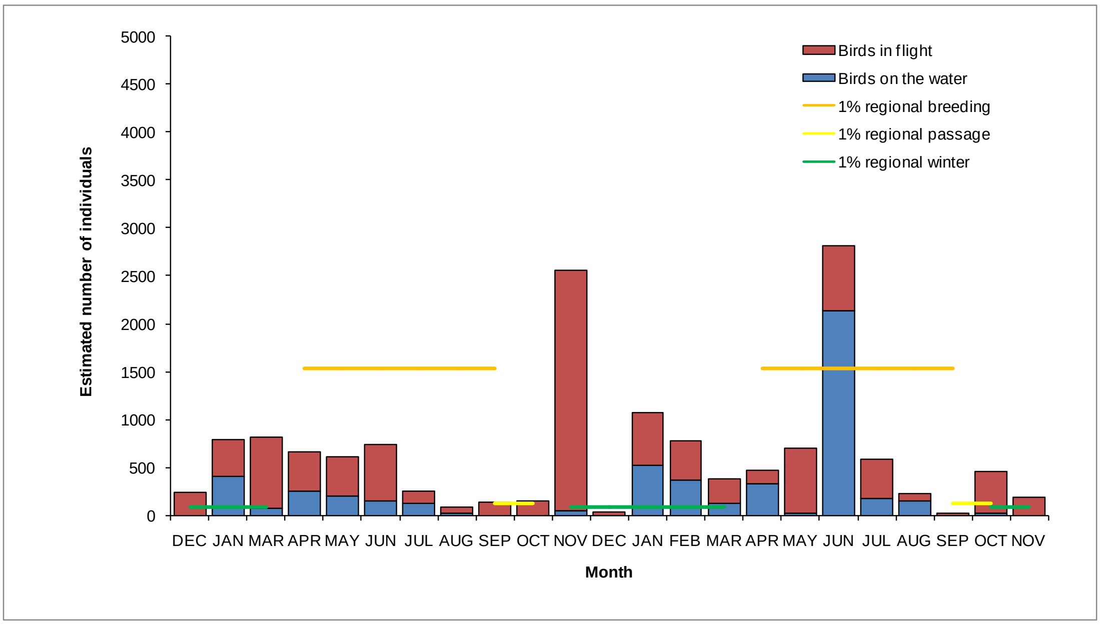


Figure 6.10 Kittiwake population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from density derived from snapshots of birds in flight combined with DISTANCE-corrected density of birds on the water. Criteria for regional importance in the breeding, passage and winter periods are shown.

6.2.76 Despite the presence of the two major colonies of Fowlsheugh to the northeast and the Forth Islands to the west, the regional 1% threshold during the breeding season was only exceeded on one occasion in June 2011 (1,925 individuals) (Figure 6.10). The output derived from DISTANCE for birds on the water made a large contribution to the population estimate on this occasion, providing a mean density of 6.3 ind. km^{-2} with large associated confidence limits (LCI of 3.6 and UCI of 11.1 individuals' km^{-2}), in comparison with the estimate of 2.8 individuals km^{-2} generated using the standard technique (Figure 6.11).

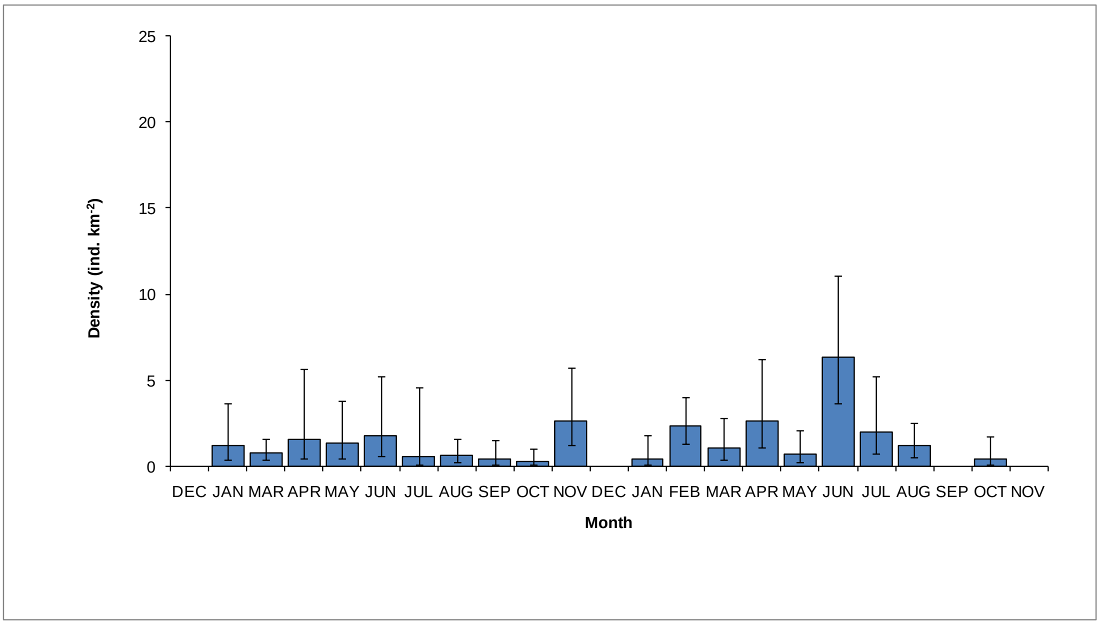


Figure 6.11 Monthly mean (± 95% confidence intervals) density of Kittiwake in Project Alpha as derived from DISTANCE correction of birds on the water.

6.2.77 The regional 1% threshold of Kittiwake for the passage period was exceeded in both September and October of 2010 (1,409 and 296 ind. respectively), whereas the winter threshold was exceeded on eight winter surveys (89%) between 2009 and 2011. Indeed, the peak estimate of the study period was recorded in November 2010 when 1,745 Kittiwakes were observed in feeding aggregations. A population estimate of 4,510 individuals was derived using DISTANCE for birds on the water, but due to the use of a global model, the density for birds on the water was considerably lower than that derived from the standard methodology.

6.2.78 During the breeding season, densities typically ranged from 2-4 individuals km^{-2} within Alpha, but peaked at >7 individuals km^{-2} in June (Table 6.11). These values are 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. Elsewhere, density estimates for the western North Sea at only slightly lower at 0.41-4.54 individuals' km^{-2} in the breeding season (Stone *et al.* 1995).

6.2.79 Outside the breeding season, during the late autumn and winter period, Skov *et al*. (1995) report densities varying in a range of 0.5 individuals km^{-2} in the central North Sea up to 10.9 individuals km^{-2} at Fladen Ground, which again corresponds to the range of winter densities within Alpha to 11.5 individuals km^{-2} (Table 6.11).

Table 6.11 Monthly mean (± 1SD) density of Kittiwake in Projects Alpha and Bravo as 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
Alpha	2.2 ± 1.0	2.8	3.6 ± 3.2	4.0 ±1.6	2.2 ± 0.3	7.4 ± 3.3	3.2 ± 1.9	1.4 ± 0.4	3.8 ± 5.3	2.8 ± 1.5	11.5 ± 16.	0.6 ± 0.7
Bravo	4.9 ± 1.0	4.1	3.1 ± 1.6	2.9 ± 0.7	3.0 ± 0.2	9.2 ± 7.6	2.2 ± 1.2	0.8 ± 0.5	0.4 ± 0.4	1.6 ± 1.1	7.1 ± 8.6	0.7 ± 0.8

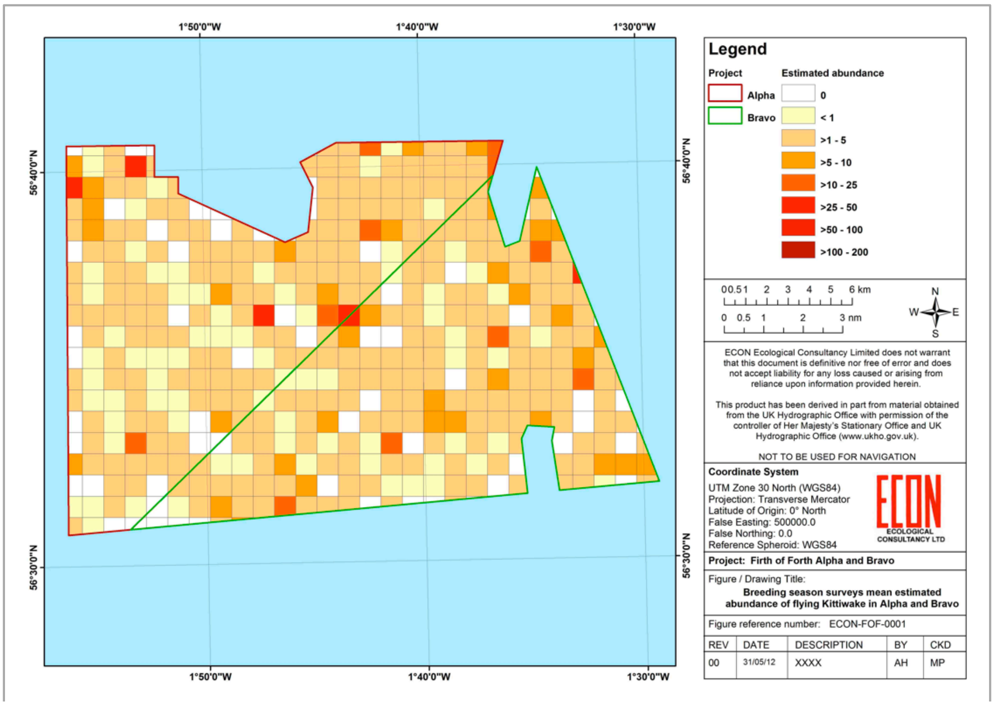
6.2.80 In total, 78.5% of all Kittiwakes in Alpha and Bravo combined were aged. Where a single bird was observed the proportion aged was very high at 92.6%. A very high proportion of single birds were aged (91.6%), with this declining for two birds recorded together (84%). In groups sizes of >5, the proportion of records aged dropped considerably to 31.3%. In Alpha, the proportion of Kittiwakes aged as adults in the breeding season of April to August was 94.2% from the aged sample of *n* = 1,122 (Table 6.12).

Table 6.12 Number and proportion of adult Kittiwakes relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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

6.2.81 Distribution maps derived from flying birds in all boat-based surveys 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 6.12). There was a hint of greater abundance in the north of the site especially when compared to the winter, when more birds were present in the southwest.

6.2.82 The patches of higher density are partly linked to the location of feeding records (Figure 6.13). In the summer, most of the larger foraging aggregations are within Alpha with some trend towards clustering in the northeast and northwest and in the southwest. The latter are is distinctly preferred in the winter months and may represent an extension of what is thought to be good foraging habitat at Scalp Bank (Seagreen Wind Energy 2011a). The small cluster of records in the northeast over Montrose Bank 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).



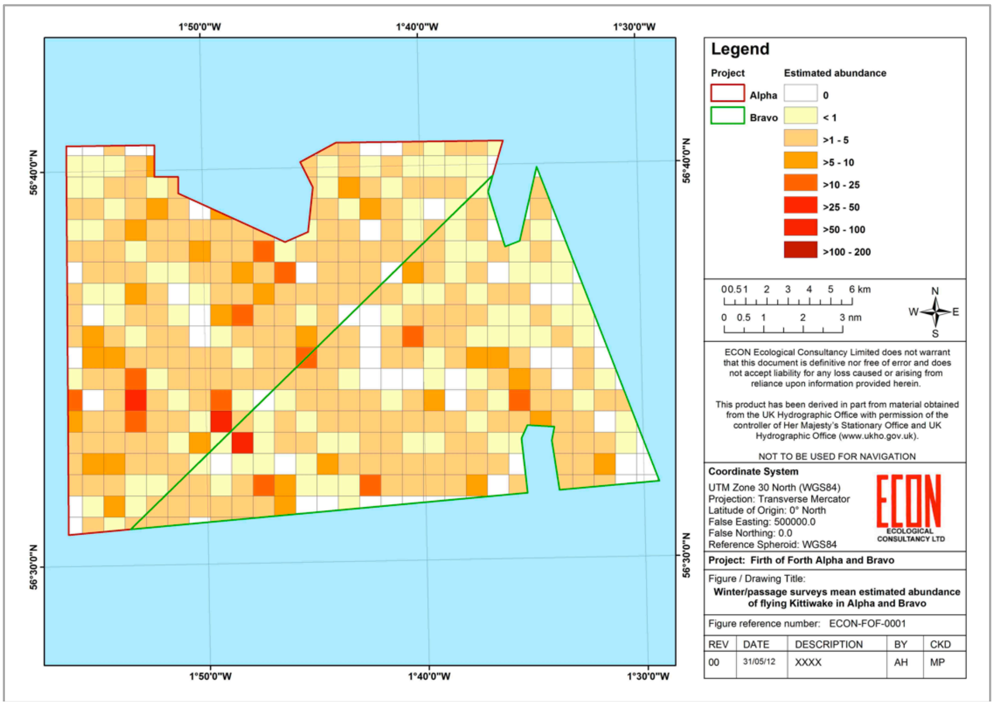


Figure 6.12. Relative abundance of Kittiwake expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August (above) compared to the passage/winter period (below).

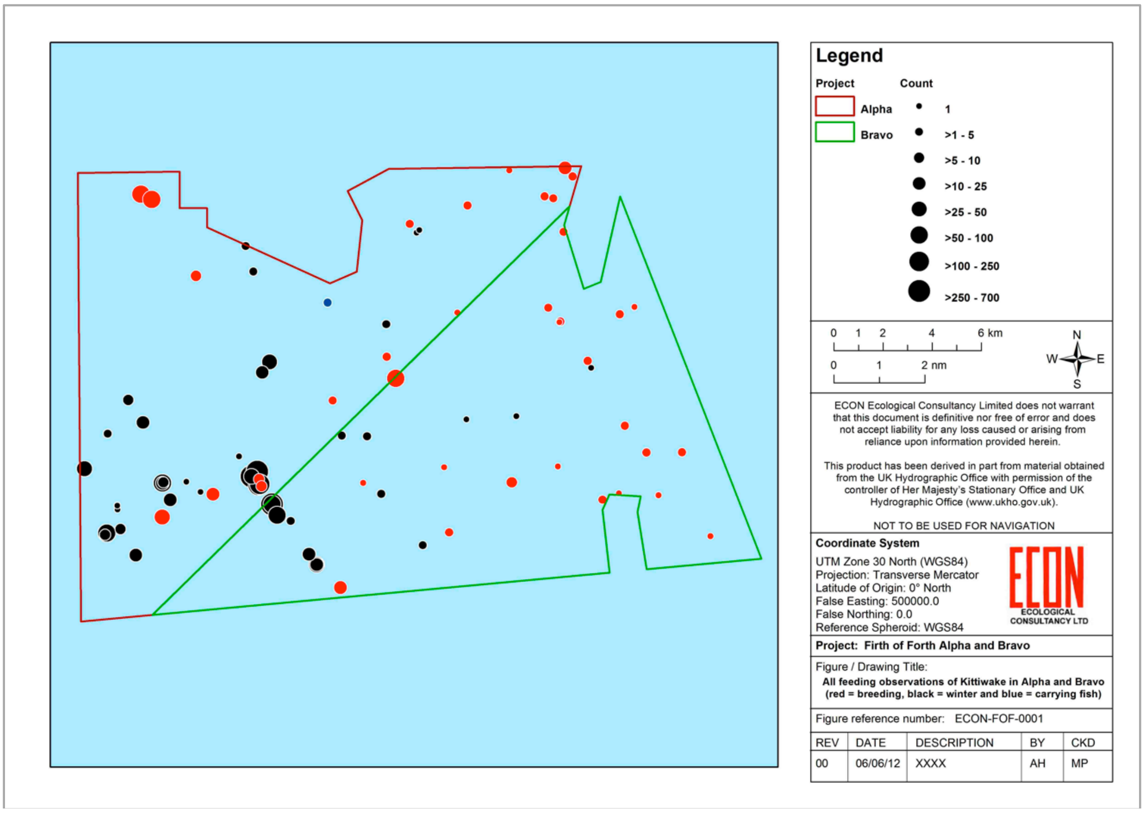
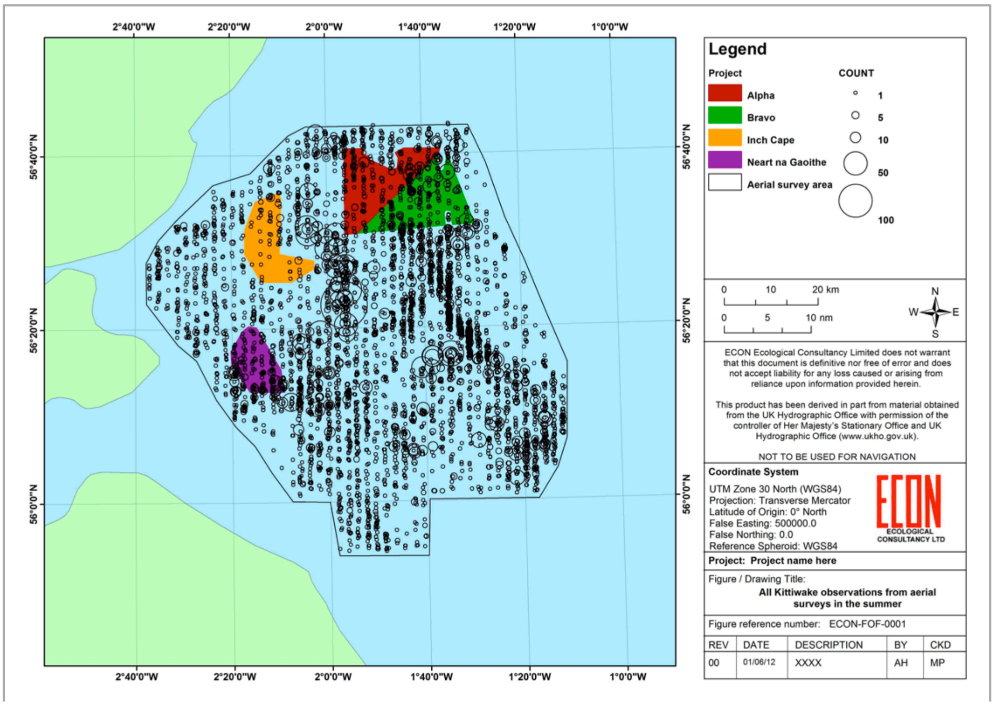


Figure 6.13 Distribution and group size of feeding Kittiwakes recorded in all surveys of Alpha and Bravo in both the breeding season (red) and passage/winter period (black).

6.2.83 The aerial surveys conducted in the summer of 2009 showed that Kittiwake were present throughout Alpha, with an increased number of observations to the north of the site and beyond the boundary (Figure 6.14). In general, birds were concentrated across the Wee Bankie and especially Marr Bank areas to the south of Alpha (and Bravo) and to the east of the STW sites (Figure 6.14). This pattern was reinforced in winter, with large aggregations across Marr Bank in particular

6.2.84 Whilst the Jacob's selectivity index undertaken on the aerial data indicated that Alpha was not selected by Kittiwake in the summer (D = -0.13), winter (D = +0.05) or overall (D = -0.05) it is noteworthy that avoidance of Inch Cape was registered in the summer (D = -0.59), with a similar trend overall (D = -0.45), but with no preference in the winter (D = -0.27). At Neart na Gaoithe the opposite pattern was noted with near selection in the winter (D = +0.47), but with no selection in the summer (D = +0.06) or overall (D = +0.27).



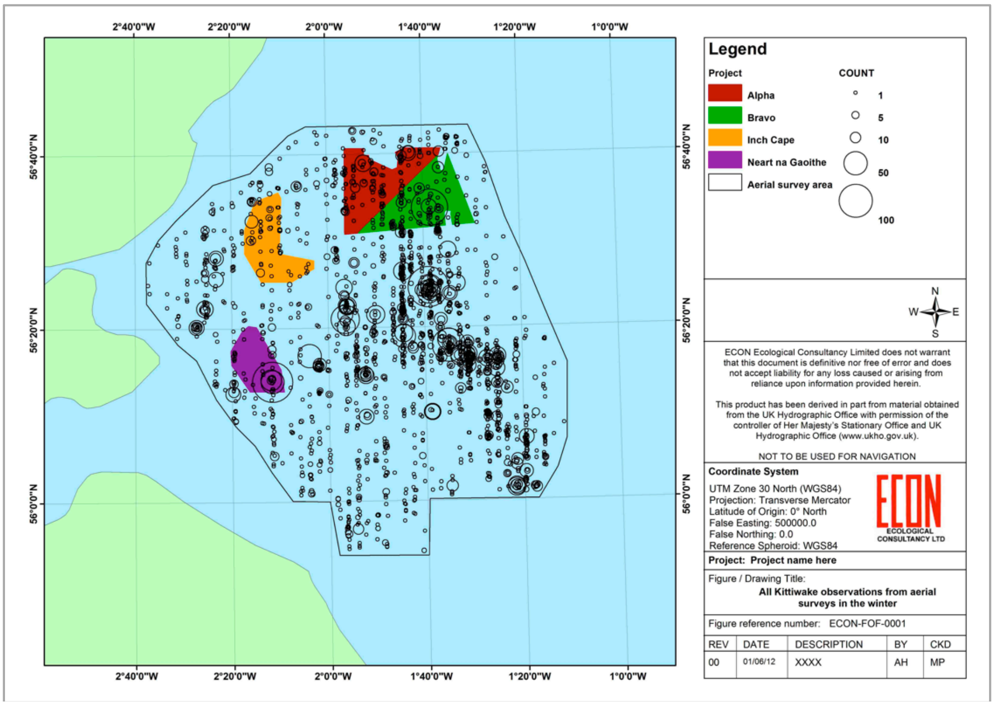


Figure 6.14 Relative distribution of Kittiwake within the Firth of Forth aerial survey area from pooled records of all birds from all surveys in the summer (above) and winter months (below) where n = 3 and n = 4 respectively.

Project Bravo

6.2.85 The seasonal pattern of abundance of Kittiwakes in Bravo was similar to that of Alpha (Figure 6.10), although in 2010, there was a decrease in populations across the breeding season until November when the highest population estimate was recorded. In 2011, January and February recorded relatively high population estimates, with a decline in abundance in the early part of the breeding season until the peak population estimate of the two year period at 2,813 individuals, was recorded in June (Figure 6.10). This corresponds with the peak within Project Alpha (see above).

6.2.86 As for Alpha, the peak population estimate was dependent on the contribution of density derived from DISTANCE for birds on the water at 11.0 ind. km^{-2} with an UCI of 20.2 ind. km^{-2} (Figure 6.15). It was comparable to the 8.8 ind. km^{-2} derived from the standard methodology however. Excluding this peak population estimate, the 1% threshold for the regional population during the breeding season would not have been achieved in either breeding season.

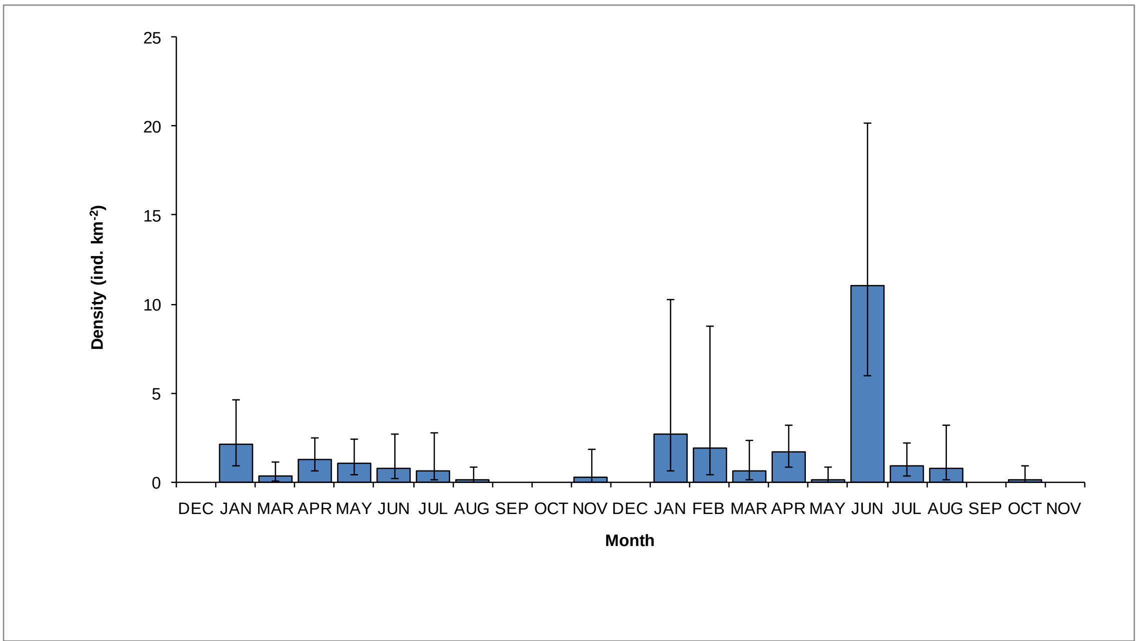


Figure 6.15 Monthly mean (± 95% confidence intervals) density of Kittiwake in Project Bravo as derived from DISTANCE correction of birds on the water.

6.2.87 Densities recorded within Bravo during the summer were similar to those in Alpha (Table 6.9) apart from the peak of 9.2 individuals km^{-2}. Such values are however not without exception in the general area as Skov *et al.* (1995) reported a peak of 12.1 individuals km^{-2} at Aberdeen Bank just to the north of the Firth of Forth.

6.2.88 In Project Bravo, as in Alpha, the proportion of Kittiwakes aged as adults in the from the aged sample of *n* = 1,118 in the breeding season of April to August was very high at 95.8% (Table 6.13).

Table 6.13 Number and proportion of adult Kittiwakes relative to the total number of birds aged in each month during boat-based surveys of Project Bravo.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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

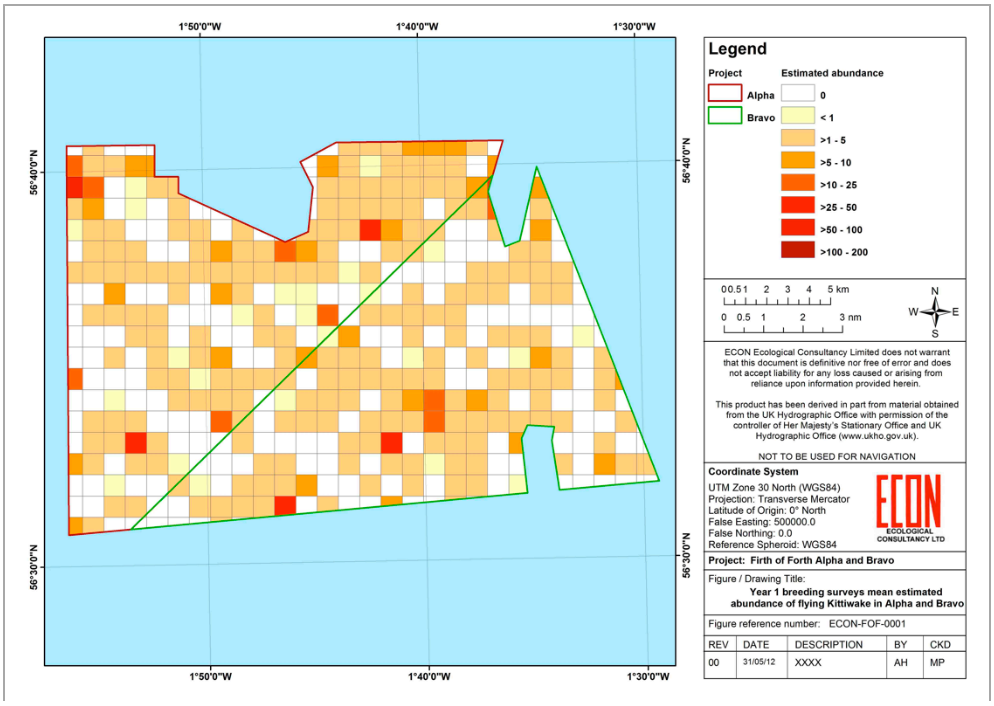
6.2.89 As in Project Alpha, the 1% threshold for the regional winter population was exceeded in every survey with the exception of December 2010. The peak winter population estimate of 2,556 Kittiwake was recorded in November, derived from a density of 7.1 individuals km^{-2}, which is not particularly unusual in the context of records from elsewhere (see 6.2.88 above).

6.2.90 Of more interest was the relative abundance of birds recorded in feeding aggregations (937 individuals) in the winter, including a single aggregation of 790 individuals (Figure 6.13). A large group was also recorded within Bravo in the winter aerial surveys (Figure 6.14). Most feeding records in boat-based surveys were in the west of Project Bravo. In contrast, feeding records from the summer were scattered across the site and generally involved small groups and single birds (Figure 6.13).

6.2.91 Comparison between the two breeding seasons indicated some inter-annual variation in the general abundance of Kittiwakes, with the eastern edge of Bravo only populated in 2011, suggesting birds were ranging further from breeding colonies in 2011 compared to 2010 (Figure 6.16).

6.2.92 The scope for inter-annual variation in foraging movements has been previously documented by Daunt *et al*. (2011c) using 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.

6.2.93 According to aerial survey data, there was no selection of Bravo in any season as derived from Jacob's selectivity index (D = +0.01 and D = +0.21 D = +0.10 in summer winter and overall respectively).



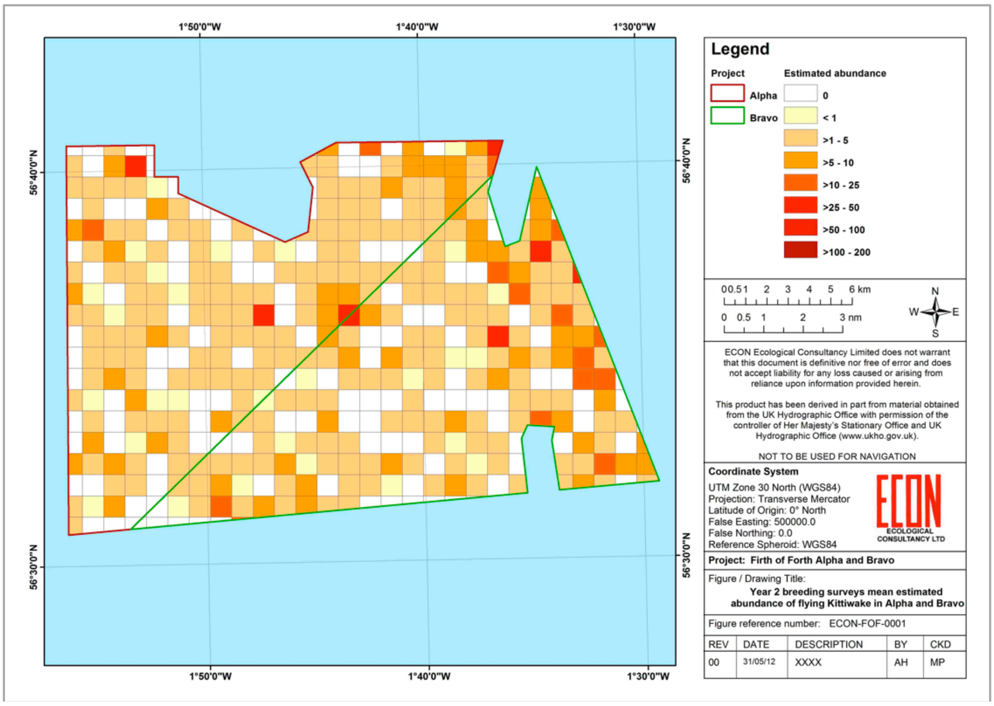


Figure 6.16 Relative abundance of Kittiwake expressed as birds in flight (individuals recorded km^{-2}) in 1 km^{2} grid cells across Alpha and Bravo in the breeding season of April to August in 2010 (above) compared to 2011 (below).

Foraging range and potential origin

6.2.94 Kittiwake has a mean maximum foraging range of 60 km and a mean maximum foraging range + 1SD of 83.3 km (Figure 6.17), which means that 64,922 and 124,684 individuals respectively breed within each range (Table 6.14). Birds are distributed amongst 31 colonies within mean maximum foraging range and 51 colonies within range incorporating 1SD. extending from Northumberland in the south to Aberdeenshire in the north.

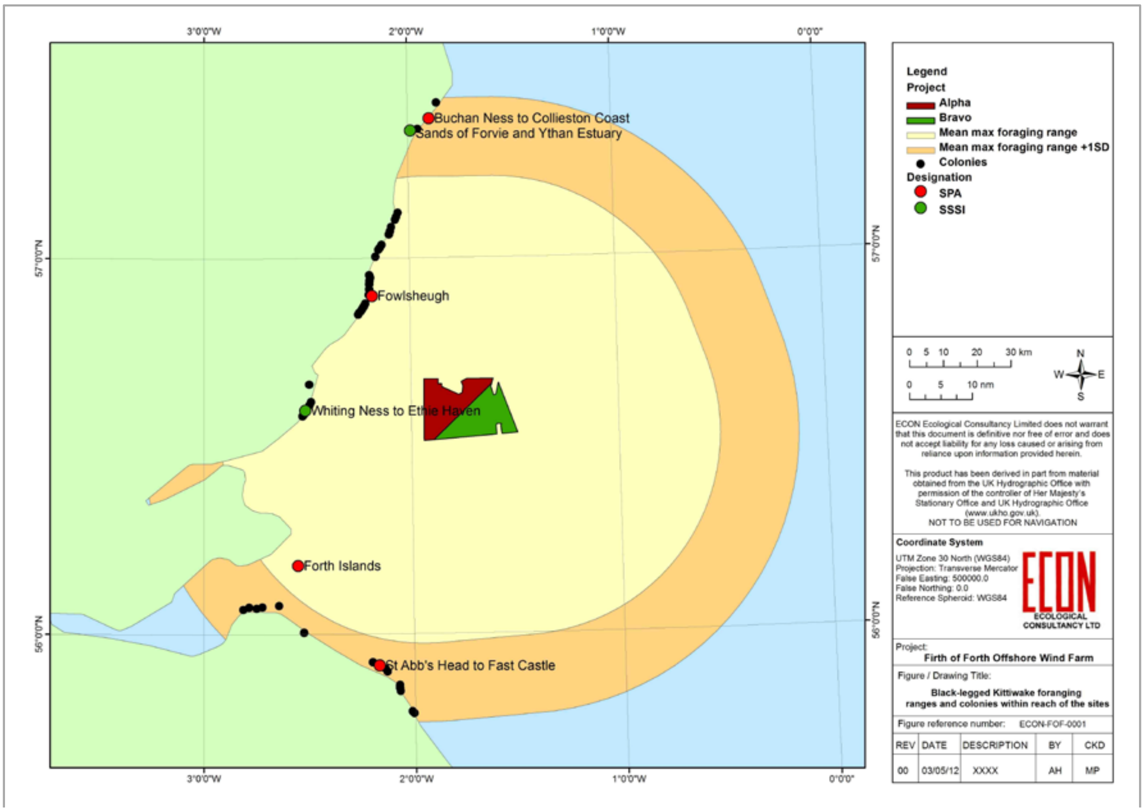


Figure 6.17 Distribution of Kittiwake breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.2.95 Within mean maximum foraging range, Kittiwake is designated within two SPAs (Fowlsheugh and Forth Islands) and one separate SSSI (i.e. not within SSSIs contained within SPAs). This increases to five SPAs and two SSSIs within range incorporating 1SD. Considering the colonies themselves, only eight and 17 overall are designated/notified within mean maximum and mean maximum + 1SD respectively. A total of three (9.7%) colonies fall within SPAs in mean maximum range with 11 (21.6%) within the entire mean maximum + 1SD range.

Table 6.14 Details of all Kittiwake breeding colonies at increasing distance from Projects Alpha or Bravo and within mean maximum and mean maximum ± 1SD foraging ranges (60.0 and 83.3 km respectively). Numbers of individuals recorded in Natura 2000 for SPAs, Seabird 2000 and the latest count in the year specified are shown.

Foraging range	Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
					Number	Year
	Catterline to Inverbervie	27.64		6,136	6,136	1999
Mean Max	Fowlsheugh SPA	30.41	73,300	47,078	28,386	2009[1]
	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	5,370	2011
	Dunbar Coast	67.12		5,032	5,032	2000
	St Abb's Head to Fast Castle SPA	67.90	42,340	30,860	18,136	2011[2]
Mean Max + 1 SD	St Abb's to Eyemouth	69.23		2,382	2,310	2007
	Forth Islands SPA (Bass Rock, Craigleith, Fidra, The Lamb)	69.88		4,316	2,182	2011
	Eyemouth to Burnmouth	73.35		2	2	2000
	Sands of Forvie and Ythan Estuary SSSI	74.05		840	780	2011
	Berwick to Scottish Border	80.45		3,054	3,054	2000
	Buchan Ness to Collieston Coast SPA	81.85	60,904	28,182	28,266	2007

[1]1999 & 2009; [2]2000 & 2011

6.2.96 If, the number of individual birds within colonies is considered, then of the 64,922 individuals within mean maximum foraging range, 33,756 (52.0%) are contained from SPAs. Within mean maximum +1SD range the proportion increases to 66.0%, with 82,340 of the 124,684 individuals originating from SPAs.

Project Alpha

6.2.97 Tracklines of breeding Kittiwakes from the Isle of May in 2010 (Daunt *et al.* 2011a) and Fowlsheugh and St Abb's Head in 2011 showed that birds from different colonies showed some isolation of core foraging range but with overlap of more wide-ranging individuals or trips (Figure 6.18).

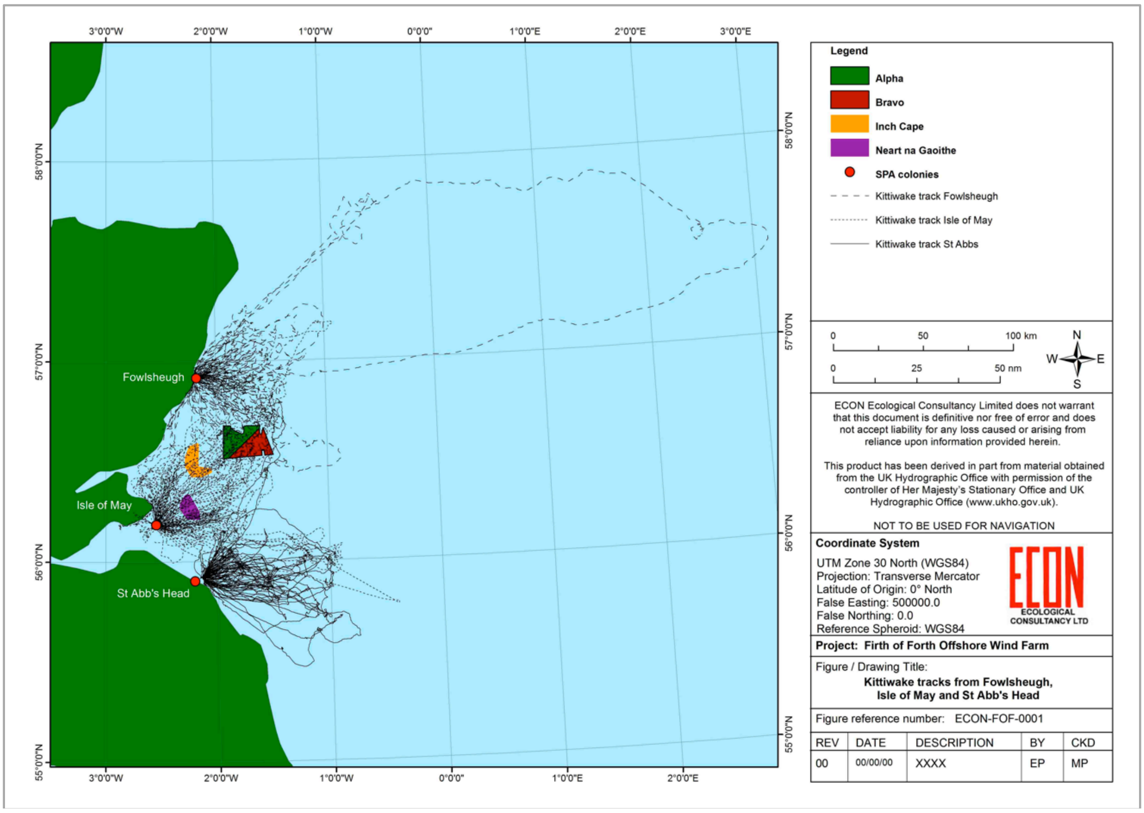


Figure 6.18 Tracklines of breeding Kittiwakes fitted with GPS tags from Isle of May (*n* = 36) in 2010 and Fowlsheugh (*n* = 35) and St Abb's Head (*n* = 25) in 2011.

6.2.98 The different distances of the different colonies relative to Projects Alpha and Bravo (see below) and the STW sites, produced differences in the amount of overlap as indicated by different measures. A higher proportion of overall trips or expressed by bird of Kittiwakes from the Isle of May crossed Alpha (~15%) compared to Fowlsheugh (~10%) with no birds from St Abb's Head reaching Alpha (Table 6.15, Figure 6.18). The proportion of trips crossing Alpha from the Isle of May was lower than that at Inch Cape (~24%) and around half of that for Neart na Gaoithe (~32%), in keeping with the relative distance of the sites from the Isle of May. Whilst the number of trips from Fowlsheugh was relatively low this was higher at Alpha than at the other sites, as perhaps to be expected from its relative proximity (~ 30 km).

6.2.99 Considering the distance travelled by birds from the different colonies, for birds from the Isle of May, the distance travelled is much more evenly divided between the different sites at 2-3% depending on whether this is expressed overall or by bird (Table 6.16). This suggests two things: 1) that birds spend the majority of any trip outside of wind farm areas and that 2) birds only travel relatively short distances across sites, such close to the colony such as Neart na Gaoithe.

Table 6.15 Number and proportion (% in parentheses) of trips by GPS tagged breeding Kittiwakes from the Isle of May, Fowlsheugh and St Abb's Head crossing the different proposed wind farm sites. Data are expressed by trip and as a mean by bird.

Site	Subject	Total number	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
Isle of May	All	91	14 (15.38)	11 (12.09)	21 (23.08)	29 (31.87)
	By bird	2.53	0.39 (15.00)	0.31 (13.84)	0.58 (24.03)	0.81 (33.94)
Fowlsheugh	All	93	9 (9.68)	6 (6.45)	2 (2.15)	0
	By bird	2.66	0.26 (11.43)	0.17 (6.19)	0.06 (1.67)	0
St Abb's Head	All	70	0	1 (1.43)	0	0
	By bird	2.80	0	0.04 (2.00)	0	0

Table 6.16 Distance (km) and proportion (% in parentheses) of trips by GPS tagged breeding Kittiwakes from the Isle of May, Fowlsheugh and St Abb's Head within the different proposed wind farm sites. Data are expressed by trip and mean by bird.

Site	Subject	Total number	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
Isle of May	All	10,491.93	257.25 (2.45)	207.33 (1.98)	250.50 (2.39)	295.12 (2.81)
	By bird	291.44	7.15 (1.90)	5.76 (1.27)	6.96 (2.16)	8.20 (3.08)
Fowlsheugh	All	9,135.91	192.97 (2.11)	130.95 (1.43)	31.70 (0.35)	0
	By bird	261.03	5.51 (2.57)	3.74 (1.503)	5.50 (0.19)	0
St Abb's Head	All	5,886.27	0	2.15 (0.04)	0	0
	By bird	235.45	0	0.09 (0.03)	0	0

6.2.100 The short distance across sites close to the colony, especially Neart na Gaoithe for birds from the Isle of May relative to Alpha appears to be linked to the change in the relative proportion of different behaviours (flight and non-flight) as birds ranged further from the colony (Table 6.17). For example, although a slightly greater proportion of flight behaviour indicative of commuting was shown by birds in Neart na Gaoithe relative to Alpha, the proportion of non-flight behaviour was considerably higher at around 5-fold (6-fold by bird) for Alpha (Table 6.17).

6.2.101 Around 4-5% of non-flight behaviours of birds from the Isle of May were contained within Alpha, which was very similar to the values for birds from Fowlsheugh. The proportion of non-flight behaviours of birds from Fowlsheugh was at its highest in Alpha compared to other wind farm sites. Whilst it may be implied that birds may be foraging once they slow down, non-flight behaviour as determined from GPS tagging may actually indicate a range of behaviours that includes simply resting on the sea surface or perhaps even engaging in social activity.

Table 6.17 Number and proportion (% in parentheses) of total fixes according to different behaviours (combined behaviour = CB, flight = F and non-flight = NF) obtained for GPS tagged breeding Kittiwake from the Isle of May within the different proposed wind farm sites. Data are expressed for all trips and as a mean by bird.

Site	Subject	Activity	Total number	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
Isle of May	All	CB	26,545	939 (3.54)	585 (2.20)	658 (2.48)	415 (1.56)
		F	10,847	275 (2.54)	239 (2.20)	281 (2.59)	312 (2.88)
		NF	15,698	664 (4.23)	346 (2.20)	377 (2.40)	103 (0.66)
	By bird	CB	737.36	26.08 (3.34)	16.25 (1.38)	18.28 (1.73)	11.53 (1.97)
		F	303.31	7.64 (1.68)	6.64 (1.23)	7.78 (2.29)	8.67 (2.98)
		NF	436.06	18.44 (4.87)	9.61 (1.53)	10.50 (1.32)	2.86 (1.07)
Fowlsheugh	All	CB	32,875	1150 (3.50)	427 (1.30)	190 (0.58)	0
		F	11,708	224 (1.91)	164 (1.40)	36 (0.31)	0
		NF	21,167	926 (4.37)	263 (1.24)	154 (0.73)	0
	By bird	CB	939.29	32.86 (3.64)	12.20 (1.15)	5.59 (0.30)	0
		F	334.51	6.40 (2.37)	4.69 (1.50)	1.03 (0.17)	0
		NF	604.77	26.46 (4.10)	7.51 (1.00)	4.40 (0.39)	0
St Abb's Head	All	CB	20,012	0	5 (0.02)	0	0
		F	6,964	0	3 (0.04)	0	0
		NF	1,3051	0	2 (0.02)	0	0
	By bird	CB	800.60	0	0.20 (0.01)	0	0
		F	278.56	0	0.12 (0.03)	0	0
		NF	522.04	0	0.08 (0.01)	0	0

6.2.102 Kernel analysis of the birds from the Isle of May conducted by Daunt *et al*. (2011a) suggested that the core area of use represented by the 50% kernel reached part of Scalp Bank to the west of Alpha with this kernel perhaps just clipping the western edge of Alpha, with a second part of the core area perhaps also just clipping the south-eastern corner. However, although the core area clearly did not include much of Alpha, it did include part of Inch Cape, Wee Bankie and part of the Marr Bank complex as well as inshore waters to the north of the colony.

6.2.103 Similarly, at Fowlsheugh one of the isolated parts of the core area for Kittiwakes appeared to clip the very northwest corner of Alpha (Daunt *et al*. 2011a). Otherwise the core extended to the northeast from Alpha with other scattered patches to the west along the coast and to the north, although the main part of core range was immediately offshore of the colony.

6.2.104 In conclusion, in the breeding season it would seem most likely that adult Kittiwakes represented in Alpha are a mixture of birds from as far away as the Isle of May (52 km), Fowlsheugh (30 km) as well as nine other non-SPA colonies at similar range

(28-48 km). This assumes however that the tracking of a small numbers of individuals over a single season at each colony is broadly representative of the foraging patterns of Kittiwake.

6.2.105 The fact that birds from St Abb's Head at 68 km did not reach Alpha closely adheres to the maximum foraging distance of 72 km suggested by Daunt et al (2002) and the mean maximum foraging range of 60 km (Thaxter *et al*. 2012) although the latter is partly based on the work of the former. It would thus seem that birds from Buchan Ness to Collieston Coast SPA are generally unlikely to reach Project Alpha

6.2.106 The fact that a broadly similar proportion of trips (10-15%) from the smaller but more distant Isle of May colony, compared to the closer, but larger Fowlsheugh colony crossed Alpha indicates the prospect of broadly equal mixing between colonies. If this is indeed the case, then the number of birds in Alpha may be apportioned between the size of the colonies likely to reach it. The latest colony counts in Table 6.10, suggests that 51.7% of birds in the breeding season originate from Fowlsheugh with just 9.8% from the Isle of May, with the remainder divided between the rest of the colonies.

6.2.107 Analysis of flight direction appears to show a southeast – northwest flight axis consistent with birds coming from and going to Fowlsheugh (Table 6.18). However, a reasonable proportion of flights are also noted to the southwest suggesting a return to the Isle of May although there is no clear reciprocal northeast flight path. Moreover, the highest proportion of birds show no flight direction indicative of foraging rather than commuting flight. This is consistent with the idea from tracking that birds from the colonies show a increased frequency of commuting flight within Alpha compared to other areas.

Table 6.18 Number and proportion (%) of flight directions recorded for Kittiwake during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	156	380	133	526	183	298	188	648	1,421
	%	3.97	9.66	3.38	13.37	4.65	7.58	4.78	16.48	36.13
Breeding season	Count	45	82	50	206	98	173	62	156	352
	%	3.68	6.70	4.08	16.83	8.01	14.13	5.07	12.75	28.76

6.2.108 Outside the breeding season, 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). Frederiksen *et al*. (2011) and Bodganova *et al*. (2011) show that birds from the Isle of May reached the Western Atlantic >3,000 km distant with others in the East Atlantic at a distance of 1,000 km although some stayed in the North Sea.

6.2.109 During passage and winter periods there is thought to be much mixing of individuals from different populations, evidenced by a gathering of over 1,000 juveniles feeding off the coast of Yell, Shetland in late August 1997, a year when breeding success in Shetland was extremely low. Small numbers do occur widely around the Scottish coast, but in some winters substantial coastal movements are recorded. It would thus seem best to assume that birds in Alpha in the passage and wintering season are likely to originate from a much wider area than suggested by the extralimital foraging ranges during the summer, in contrast to Fulmar.

6.2.110 Mitchell *et al*. (2004) suggests the biogeographic population is 2.75 million pairs (5.5 million individuals). with around 2.55 million of these (5.1 million individuals) within Europe (BirdLife International 2004). At the very least, the origin of birds within Alpha in the passage and winter periods could perhaps be partitioned between the 1,245,000 individuals of all ages (415,000 pairs x 3 according to Wetlands International 2006) suggested to be part of the population breeding in the North Sea by Skov *et al*. (1995).

Project Bravo

6.2.111 The utilisation of Bravo by tracked birds was similar to that shown for Alpha with a slightly lower percentage of trips– thus the same patterns hold. However, one trip of one Kittiwake breeding at St Abb's Head did fly through the very south-east corner of Bravo and foraged immediately east and north-east of Bravo on one occasion accounting for just over 1% of trips or 2% as mean by bird (Table 6.15). The proportion of distance travelled was however, extremely low at 0.04 % with the proportion of non-flight behaviours lower than this at 0.02 or 0.01% as mean by bird (Table 6.17) suggesting that this was unimportant.

6.2.112 In relation to kernel analysis conducted by Daunt *et al*. (2011a), the core area represented by 50% kernels for birds from the Isle of May appeared to only clip the very edge of the southeast corner of Bravo. Similarly, none of the core foraging areas for Kittiwakes breeding at Fowlsheugh were located in Bravo. Overall, it would appear that Bravo does not fall within key foraging habitat for breeding Kittiwakes, although it does fall within the area of use represented by the 90% kernel for birds from both colonies.

6.2.113 As for Alpha, analysis of flight direction shows a high proportion of birds involved in non-commuting flight (Table 6.19). However, a higher proportion of birds appear to be travelling on a southeast flight path suggesting origin from Fowlsheugh, but with a reduced proportion of northwesterly flights potentially returning to the colony. There is no clear southwesterly flight path in the direction of the Isle of May which links with the lower use of Bravo compared to Alpha for tracked birds (Tables 6.15, 6.16 & 6.17).

Table 6.19 Number and proportion (%) of flight directions recorded for Kittiwake during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	134	162	197	387	184	234	198	382	686
	%	5.23	6.32	7.68	15.09	7.18	9.13	7.72	14.90	26.76
Breeding season	Count	58	64	86	259	95	83	62	136	271
	%	5.21	5.75	7.72	23.25	8.53	7.45	5.57	12.21	24.33

6.2.114 For birds outside the breeding season, the same conclusion is drawn as presented for Alpha, in that any birds present in the passage and winter periods may be drawn from an extremely large pool of individuals (at least 1.2 million birds), and that any contribution from any particular colony may be apportioned accordingly.

Summary of risks

6.2.115 In the sensitivity index to wind farms derived by Garthe & Hüppop (2004), Kittiwake was ranked 25th out of 26 seabird species. Dividing the main risks, Furness & Wade (2012) ranked Kittiwake as 6th (of 37 seabirds) in terms of vulnerability to collision with turbines but considered Kittiwake at relatively low risk of displacement, ranking the species 24th.

6.2.116 The risk of collision to Kittiwake despite its high manoeuvrability stems from the high proportion of time in flight coupled with the time spent at risk height. The data for Alpha derived from boat-based survey supports the basis of this concern with 66% of all birds observed in flight, with 10.7% judged to be at >20 m. In Bravo, there was a slightly lower proportion of birds in flight (58%), with a greater proportion of these at >20 m (15.7%), in close agreement with the 16.1% derived by Cook *et al.* (2011) from a range of sites. As described for Gannet, the differences in the values for the different sites may relate to subtle differences in the behaviour of birds within each of the areas. In the case of Kittiwake, birds in commuting flight may do so at slightly greater height. The slightly lower proportion of non-direct flight in Bravo compared to Alpha (Table 6.19 and Table 6.18) may have been enough to increase the proportion of birds at greater height. Although densities during the breeding season did not consistently reach regionally important values, based on the estimates for flying birds and the recorded flight details, Kittiwake requires CRM within the ES chapter.

6.2.117 Furness & Wade (2012) ranked Kittiwake 24th in the context of displacement from wind farms, with the species considered to be flexible in regard to habitat use. Considering the species is not adapted for diving but feeds on small fish near the surface, and thus requires tidal fronts or suitable habitat to create upwelling or deep diving auks, to bring prey to the surface, a low ranking seems somewhat counterintuitive as foraging opportunities may be restricted in both time and space for Kittiwakes (Embling *et al*. 2012).

6.2.118 There is clear evidence that Kittiwake have feeding grounds within the Alpha boundary. There were 2,227 records, (37%) of direct feeding behaviour over the two year period, with 1,674 birds within multi-species foraging associations, primarily with auks. Whilst the data suggests that the area within the Bravo site boundary are less important as foraging grounds, 26% of all birds recorded were observed in direct feeding behaviour.

6.2.119 However, it is key to note that the proportion of feeding records was greatly reduced during the breeding season, with 7% and 9% of all birds recorded in Alpha and Bravo respectively between April and August. This is not to say that there is no evidence of foraging, with birds in flight during this period recording no specific direction with more frequency than obvious commuting flights (Tables 6.14 & 6.15). Moreover, tracking data suggested that although a low proportion of birds from different colonies reached the sites, these did tend to exhibit a greater proportion of non-flight behaviours in Alpha and Bravo than in other areas.

6.2.120 Tracking data from the two nearby colonies of Isle of May and Fowlsheugh and Fowlsheugh showed that a low proportion of trips reached Alpha or Bravo. From the Isle of May 15% of birds reached Alpha with 14% reaching Bravo. From Fowlsheugh the equivalent values were 11% and 6%. Despite the relatively low proportions and the fact that neither site could be considered to be an integral part of the core foraging range for Kittiwakes from either colony, the potential for barrier effects on what are breeding birds cannot be entirely discounted at this stage according to the principles established by Masden *et al*. (2010) and McDonald *et al*. (2012).

6.2.121 Moreover, indirect effects on prey abundance and distribution from construction noise could conceivably extend far beyond the wind farm footprint to include the core foraging area for Kittiwakes from at least the Isle of May and Fowlsheugh and perhaps even those at St Abb's Head. The area affected will depend on the technologies used and the sensitivities of different fish species. Whilst sandeels, a key prey species for Kittiwakes are thought to be less sensitive, the area that could be affected is as yet unknown. Considering that the sandeel fishery was closed as a result of its affects on seabirds, perhaps especially Kittiwake, and that Kittiwake continues to decline at its internationally important colonies in the area, indirect effects have to be considered.

Project Alpha

6.2.122 The evidence gathered through specific tracking of birds in the breeding season from SPA colonies suggests that Project Alpha does not form an integral part of core foraging habitat of Kittiwakes in the breeding season. This helps explain why the size of the population present recorded in boat-based surveys is only occasionally of regional importance at this time. In fact, the area appears to become generally more important for Kittiwakes in the winter months, with birds most likely originating from an extremely large pool .

6.2.123 Overall, the potential impacts of collision with turbines and potential displacement including through barrier effects upon breeding birds and also through indirect effects on prey abundance require further examination in the Impact Assessment of the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

Project Bravo

6.2.124 As with Alpha, Project Bravo does not form an integral part of core foraging habitat of Kittiwakes in the breeding season, receiving even fewer birds from SPA colonies. This is reflected in generally lower abundance in the breeding season, but with occasional peaks. Although like Alpha, Project Bravo appears to become generally more important for Kittiwakes in the winter months, far fewer feeding aggregations were recorded.

6.2.125 Despite the relative lack of key importance of Bravo especially for breeding birds, the high conservation status of Kittiwake populations means that the potential for collision, displacement, barrier effects upon breeding birds and indirect effects on prey abundance all require further examination in the Impact Assessment of the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

Lesser Black-backed Gull

Population ecology

6.2.126 The global population of Lesser Black-backed Gull is estimated to be 910,000-1,100,000 mature individuals (Birdlife International 2012b), with a European population of 300,000 to 350,000 breeding pairs (Birdlife International 2004). It has a 'Secure' conservation status in a European context.

6.2.127 There are a number of subspecies of Lesser Black-backed Gull with all birds breeding in Britain and Ireland of the *graellsii* race (Parkin & Knox 2010). Colonies are distributed widely across all coasts of the UK, and some of these are the largest breeding colonies in Europe. Mitchell *et al.* (2004) recorded 112,000 breeding pairs of Lesser Black-backed Gulls, equating to 63% of the global *graellsii* population.

6.2.128 Lesser Black-backed Gull numbers in the UK increased up to the mid 1990s, suffered a marked decline during the early 2000s and then smaller decreases since, with an overall 36% decline between 2000 and 2010 (Eaton *et al.* 2011). Once generally a migratory species, wintering birds have become increasingly common (Cramp *et al.* 1974), with many birds accumulating at inland reservoirs. Lesser Black-backed Gull has 'Amber' conservation status (Eaton *et al.* 2009) due to the UK supporting internationally important breeding populations with at least 20% of the European population occurring in ten or fewer sites.

6.2.129 Like most gulls, Lesser Black-backed Gulls are omnivorous and opportunistic in their feeding habits. When breeding they forage mostly at sea with their diet consisting of shoaling fish, invertebrates, and offal (BirdLife International 2012b). However, they also utilise inland areas and scavenge in tips and landfill sites (Mitchell *et al.* 2004). Predatory behaviour in relation to other seabirds, nuisance in towns and cities and the risk to human health has led to culling of Lesser Black-backed Gulls in many areas including to the present day (2005 in Norfolk – Taylor & Marchant 2011) despite their conservation status. In the past, large numbers have been killed such as the 50,000 birds between 1978 and 1982 at the Bowland colony in Lancashire (Brown & Grice 2005). At the Isle of May, Forrester *et al*. (2007) document the initial cull of 1,700 in 1972 in the general cull of Herring and Lesser Black-backed Gulls and the destruction of 8,000 pairs at Flanders Moss in the Upper Forth.

6.2.130 Lesser Black-backed Gulls are very versatile breeders, commonly nesting colonially on grassy slopes, offshore islands, sand dunes and on buildings, and inland particularly on heather moorland and blanket bogs (Forrester *et al.* 2007). Significant colonies in relative proximity to the Alpha and Bravo include those on the islands of Inchkeith (3,500 pairs) and Inchcolm (2,600 pairs) in the Firth of Forth and inland on St Serfs Island, Loch Leven (1,456 pairs) (SMP Online Database 2012).

6.2.131 Adult Lesser Black-backed Gulls return to their breeding colonies in March with egg laying usually commencing in May (Forrester *et al.* 2007). A normal clutch comprises three eggs, which are incubated by both the male and female (Cramp *et al.* 1974). The majority of chicks hatch around late May and early June, and take seven weeks to fledge (Cramp *et al.* 1974). Colonies are vacated from July onwards, with the population becoming more widely dispersed from September onwards.

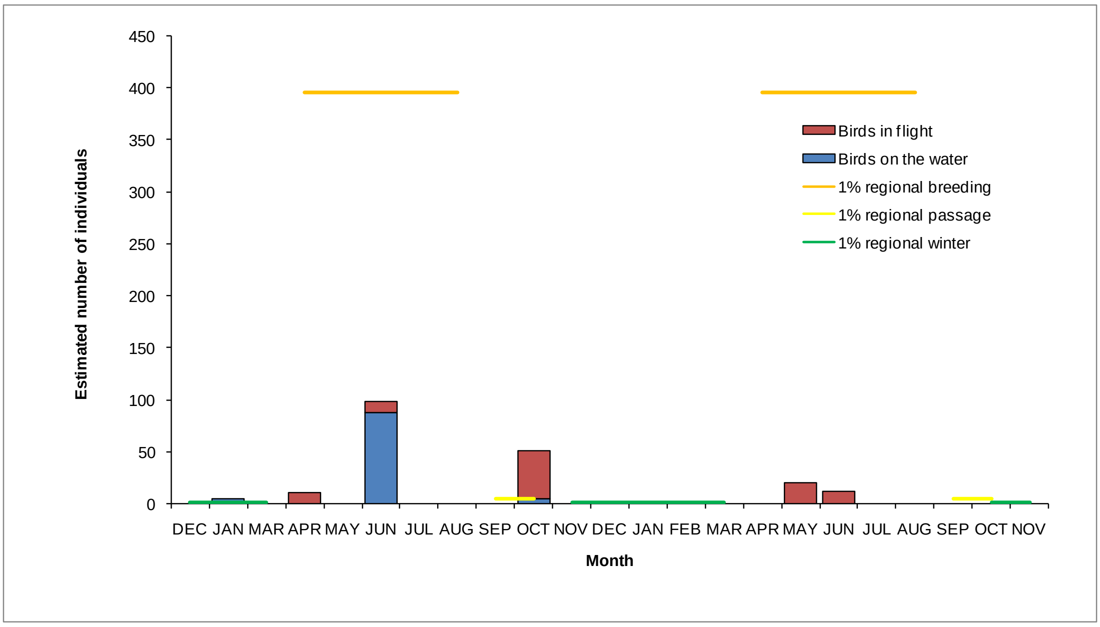
Density distribution and population size

Project Alpha

6.2.132 Only 42 Lesser Black-backed Gulls were observed in ten surveys, with densities derived for six (Appendix F1 Annex 1). In 2010, the species was present from February through to October, incorporating winter, breeding and passage periods (Figure 6.19). In 2011, Lesser Black-backed Gull was only present at the start of the breeding season, from April to June.

6.2.133 The estimated population sizes were relatively low, with the peak population of Lesser Black-backed Gulls in the breeding season, estimated at 98 individuals (Figure 6.19), approximately a quarter of the 1% threshold of the regional breeding population. The single population estimate for passage (50 individuals in October 2010) and winter (5 individuals in February 2010) both exceeded the 1% regional threshold for their respective seasons, but were both derived from low numbers of individuals seen (5 and 2 respectively).

Project Alpha



Project Bravo

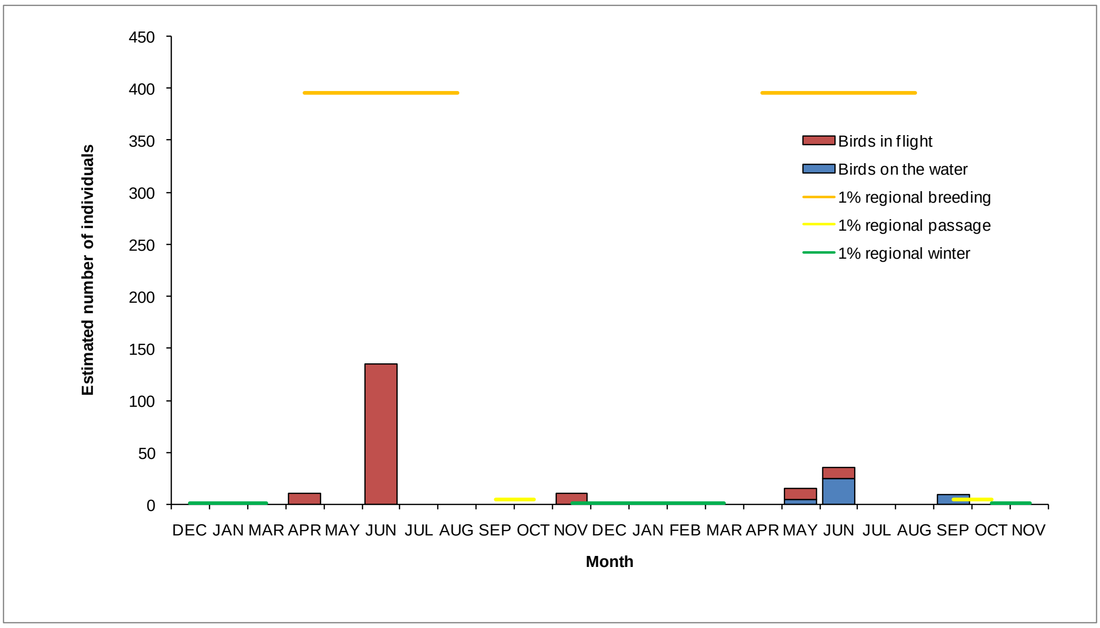


Figure 6.19 Lesser Black-backed Gull population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from density derived from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect. Criteria for regional importance in the breeding, passage and winter periods are shown.

6.2.134 The mean monthly densities derived for the Alpha development site were generally low with a range from 0.01 to 0.3 ind. km^{-2} (Table 6.20). The densities for April and June at <0.1 ind. km^{-2} are comparable to the general densities for the western North Sea (Stone *et al*. 1995), with the mean density in June similar to that previously reported for the Forth of Firth to Farn Deeps (0.1 ind. km^{-2}) by Skov *et al*. (1995). Important areas of the North Sea support densities between 4-14 km^{-2} at this time (Skov *et al*. 1995).

Table 6.20 Monthly mean (± 1SD) density of Lesser Black-backed Gull in Project Alpha and Bravo as 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
Alpha	<0.1 ± 0.1	-	-	<0.1 ±0.1	<0.1 ±0.1	0.3 ± 0.3	-	-	-	0.1 ± 0.2	-	-
Bravo	-	-	-	<0.1 ± 0.1	<0.1 ± 0.1	0.4 ± 0.4	-	-	<0.1 ± 0.1	-	<0.1 ± 0.1	-

6.2.135 In the passage period, the October density is at the lower end of the density range of 0.1 to 0.99 ind. km^{-2} recorded by Skov *et al*. (1995) at the Orkney-Aberdeen Bank (to the north of Alpha) in September to October.

6.2.136 Of all 78 Lesser Black-backed Gulls recorded in both Projects Alpha and Bravo combined, 76.5% were aged. Birds were generally recorded as singletons with the 88.1% of these being aged. In the passage/winter period, 80% of birds were immatures (Appendix F1 Annex 7). In contrast in the breeding season between April and August, of the 18 birds recorded in Alpha, 88.9% were aged as adults (Table 6.21).

Table 6.21 Number and proportion of adult Lesser Black-backed Gulls relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	1	0	0	5	4	6	0	1	0	0	0	0
%	100	-	-	83.3	100	85.7	-	100	-	0.0	-	-
Total	1	0	0	6	4	7	0	1	0	4	0	0

6.2.137 The low numbers of Lesser Black-backed Gulls present within the Alpha site boundary, was reflected in the distribution map for flying birds utilising all data from boat-based surveys (Figure 6.20). The distribution is patchy and very sparse with no flying birds recorded over large areas of the site.

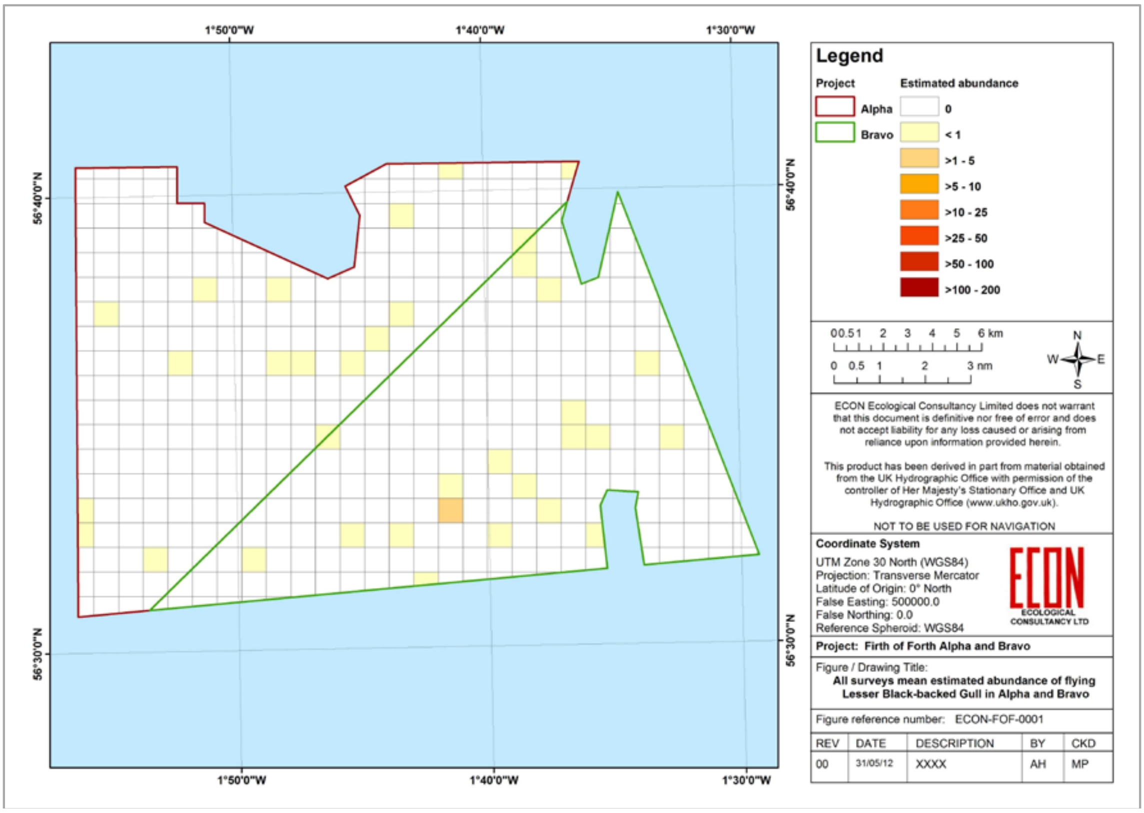


Figure 6.20 Relative abundance of Lesser Black-backed Gull expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in all surveys.

Project Bravo

6.2.138 A similar seasonal pattern was recorded for Bravo as Alpha. Lesser Black-backed Gulls were present in 2010 from February, through the breeding season with the last birds recorded in October. In 2011, birds were present in the breeding season (May and June), but also during the passage in September and October (Figure 6.19).

6.2.139 As with Alpha, the peak population estimate was recorded in June 2010 (135 ind.), with next highest just 35 Lesser Black-backed Gulls in June 2011 (Figure 6.19). The peak numbers recorded in June corresponds to the chick rearing period, and could equating to adults foraging to feed chicks. However, apart from a flock of nine birds associating with a fishing vessel, no records of foraging were recorded.

6.2.140 The mean monthly densities recorded in Project Bravo were similar to those in Alpha and generally low up to 0.4 ind. km^{-2} (Table 6.20) and similar to those previously recorded from the Forth of Firth to Farn Deeps by Skov *et al*. (1995) and much of the western North Sea (Stone *et al*. 1995).

6.2.141 Adults comprised the majority (69%) of the aged sample (*n* = 16) of birds in the breeding season between April and August (Table 6.21), although this was a lower fraction than in Alpha.

Table 6.21 Number and proportion of adult Lesser Black-backed Gulls relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	0	0	0	2	3	5	1	0	0	0	0	0
%	0.0	-	-	66.7	75.0	71.4	50.0	-	0.0	0.0	0.0	-
Total	1	0	0	3	4	7	2	0	2	1	1	0

6.2.142 The distribution map created from all flying birds revealed large areas of Bravo in which not a single Lesser Black-backed Gull was recorded (Figure 6.20).

Foraging range and potential origin

6.2.143 Lesser Black-backed Gull has a mean maximum foraging range of 141 km and a mean maximum foraging range + 1SD of 191.8 km (Figure 6.21), which means that 24,790 and 39,546 individuals respectively breed within each range (Table 6.22). These birds are distributed amongst 138 colonies (53 in mean max foraging range) extending in a fairly even distribution along the coasts of Northumberland north to east Sutherland, and with a greater number of inland colonies, particularly in urban areas around Glasgow (Figure 6.21).

6.2.144 Within mean maximum foraging range Lesser Black-backed Gull is designated within one SPA (Forth Islands) containing multiple colonies (Isle of May, Bass Rock, Fidra, The Lamb, Craigleith, Inchmickery) and one SSSI (Fowlsheugh), with no further designated sites between mean maximum and mean maximum +1SD foraging ranges. Considering the colonies themselves, a total of six (11.3%) are within the SPA in mean maximum range, with this proportion falling to just 4.3% within the entire mean maximum +1SD range.

6.2.145 However, the number of Lesser Black-backed Gulls contained within SPAs is proportionally higher than in non-designated colonies. Therefore, of the 17,874 individuals within mean maximum foraging range, 6,914 (38.7%) are from the Forth Islands SPA. With no further SPAs in the mean maximum + 1SD range, the proportion of birds within an SPA drops to 17.5% of the 39,546 birds in colonies.

Project Alpha

6.2.146 The closest breeding Lesser Black-backed Gulls are at Fowlsheugh, 30 km north-west of Alpha, but this is just a single pair. The next two nearest breeding sites are at Aberdeen and Dundee, both within 65 km, but these two colonies are relatively small, supporting 308 and 130 birds respectively. A total of six further colonies lie within 75 km of Alpha, the designated colonies within the Forth Islands SPA, which together support 6,914 individuals, while a further 16,276 individuals breed at four sites between 75 km and 100 km.

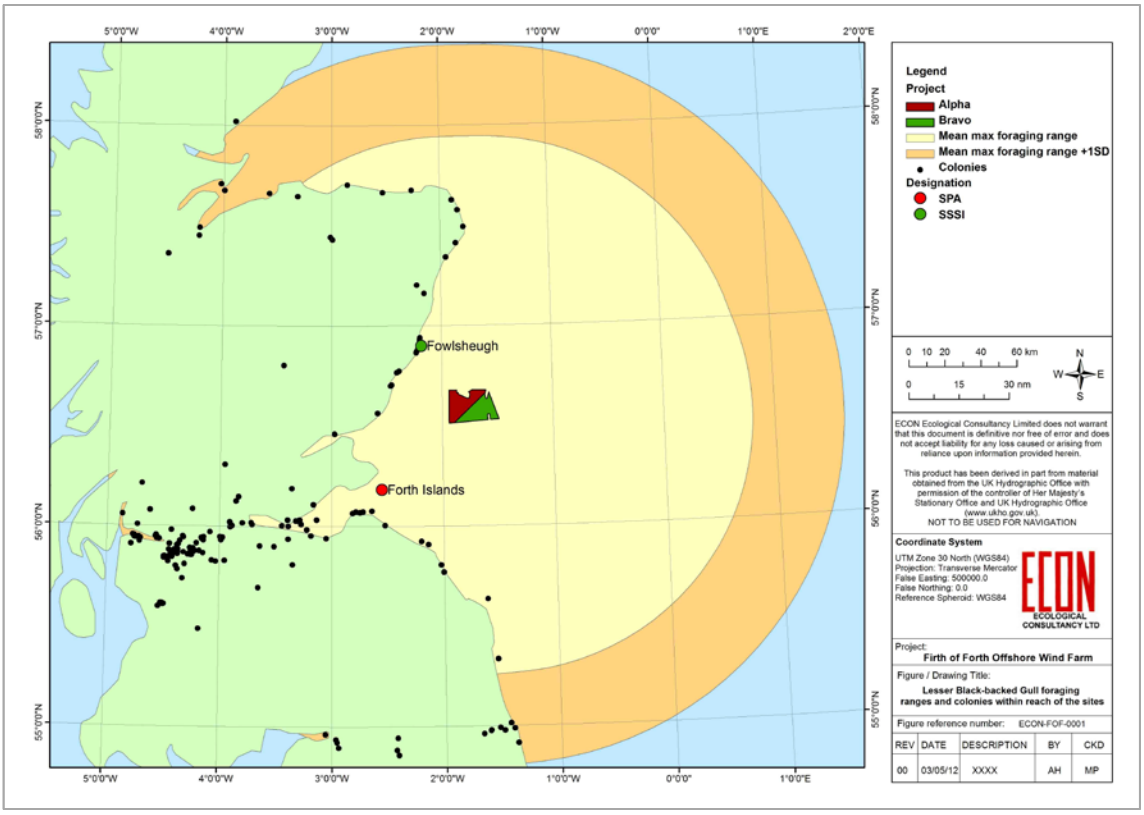


Figure 6.21. Distribution of Lesser Black-backed Gull breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.2.147 An extensive review of studies of Lesser Black-backed Gull colonies at Galloper Offshore Wind 2011 has shown that the core foraging range is within 40 km of the colony, although far longer trips may be made (*op cit* Ratcliffe 2000 and Thaxter in 2011 in the UK, Camphuysen 2008, 2011 and Gyimesi 2011 in the Netherlands, and Vanermen 2009 in Belgium). Furthermore, although Lesser Black-backed Gulls tend to forage at sea, birds also make use of onshore food resources, e.g. many birds regularly utilise landfill sites (Wernham *et al.* 2002).

6.2.148 Limited foraging range helps explain why this species is uncommon in Alpha during the breeding season and the small number of birds recorded this seem most likely to originate from the closest colonies. The flight directions of the birds with a westerly or northwesterly bias offer tentative support for this point of view (Table 6.23) However, the scope of the species to make far longer foraging trips coupled with the fact that the large colonies in the Forth Island SPA are only a few kilometres further, means that a few birds from the SPA may be represented within the site.

Table 6.22 Details of Lesser Black-backed Gull breeding colonies at increasing distance from Projects Alpha or Bravo and within mean maximum and mean maximum ± 1SD foraging ranges (141.0 and 191.8 km respectively). 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.

Foraging range	Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
					Number	Year
	Fowlsheugh SSSI	31.09		0	2	2010
Mean Max	Aberdeen City	55.42		308	308	2001
	Dundee	63.88		130	130	2000
	Forth Islands SPA	71.68	3,000	4,584	6,914	2011
	Inchkeith	91.25		6,552	7,000	2010
	St. Serfs Island, Loch Leven NNR	94.64		2,206	2,912	2011
	Farne Islands	98.98		1,330	1,164	2011
	Inchcolm	100.04		2,442	5,200	2009
	Mortlach Hills	106.44		202	202	1998
	Grangemouth to Gardrum Moss	130.44		358	358	1999
	Cumbernauld (buildings)	142.08		856	856	2001
	Kirkintilloch	150.99		238	238	2001[2]
Mean Max + 1 SD	Bishopbriggs	155.28		420	420	2001
	Glasgow	160.32		1,274	1,274	2002[1]
	Milngavie	160.51		234	234	2001
	Renfrew	167.42		520	520	2001
	Clydebank	167.65		140	140	2001
	Inchinnan	170.78		126	126	1999
	Paisley	171.78		694	694	2001[2]
	Dumbarton	174.09		266	266	1999
	Dumbarton Warehouse colonies	174.26		266	266	1999
	Linwood	174.78		196	196	2001
	South Solway	186.63		5,400	8,300	2009
	Kilmarnock	188.84		268	268	1999
	Carlisle City	190.71		4	324	2009
	Greenock	210.06		370	370	1999

[1]2001 & 2002; [2]1999 & 2001

Table 6.23 Number and proportion (%) of flight directions recorded for Lesser Black-backed Gull during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	2	2	0	1	2	2	3	3	6
	%	9.52	9.52	0.00	4.76	9.52	9.52	14.29	14.29	28.57
Breeding season	Count	1	2	0	1	2	1	3	3	3
	%	6.25	12.50	0.00	6.25	12.50	6.25	18.75	18.75	18.75

6.2.149 Most Lesser Black-backed Gulls leave Scotland in winter, moving to south-west Europe and north-west Africa, with those that do remain concentrated inland around Glasgow (Forrester *et al.* 2007). Indeed, none were seen on boat-based surveys of Alpha between early October and late February. During passage periods the origin of Lesser Black-backed Gulls is difficult to ascertain, as birds from more northerly colonies in Scotland, together with those from colonies in Denmark, Norway, Sweden, the Netherlands and Germany, are likely to migrate through the area (Wernham *et al.* 2002).

Project Bravo

6.2.150 Although the same conclusions on the likely origin of Lesser Black-backed Gulls in the breeding season may be reached for Project Bravo as was offered for Project Alpha, it is of note that a southeasterly flight direction predominated amongst birds in the breeding season (Table 6.24). Sample size was limited to a few individuals however. Such a flight line is consistent with return to the Forth Islands, reinforcing the view that a few birds from the SPA may reach Project Bravo at least.

Table 6.24 Number and proportion (%) of flight directions recorded for Lesser Black-backed Gull during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	0	1	1	6	1	0	2	2	15
	%	0.00	3.57	3.57	21.43	3.57	0.00	7.14	7.14	53.57
Breeding season	Count	0	1	1	6	0	0	2	2	13
	%	0.00	4.00	4.00	24.00	0.00	0.00	8.00	8.00	52.00

Summary of risks

6.2.151 Lesser Black-backed Gull were considered the 12th most vulnerable seabird to offshore wind farms by Garthe & Hüppop (2004). In more recent work by Furness & Wade (2012) in which collision and displacement were separated ranked Lesser

Black-backed Gull was 3rd of the 37 species of seabird considered in relation to collision but 31st in relation to displacement.

6.2.152 Garthe & Hüppop (2004) recognised that Lesser Black-backed Gull was at risk due to their flight altitude. Cook *et al*. (2011) found that 27.2% of flights were above 20 m from modelling data from 23 study sites. The proportion of birds flying at >20 m varied between 62% at Alpha and 29% at Bravo. Such variability was simply a function of the low number of birds recorded in flight with just 21 individuals within the Alpha boundary and 28 individuals in Bravo. Experience shows that such values would invariably produce extremely variable results within collision risk modelling. Moreover, the low densities of birds would produce very low collision rates.

6.2.153 Of the Lesser Black-backed Gulls recorded in both Alpha and Bravo, no birds were recorded as exhibiting direct feeding behaviour. Whilst birds observed with no apparent direction that could have been foraging were frequently recorded, there is no evidence that either Alpha or Bravo are an important foraging ground. Distribution patterns may be particularly influenced by the presence of boats, perhaps even including the survey vessel. Given the species is also flexible in terms of habitat use, neither displacement nor indirect effects on prey could be considered likely to generate impacts that had the potential to be of ecological significance. Coupled with the low use breeding birds, the potential to generate ecologically significant barrier effects was also considered to be extremely low.

Project Alpha

6.2.154 The boat-based surveys indicates that the area contained within Project is not of importance to breeding Lesser Black-backed Gulls, with small and unexceptional numbers using the area on passage and in winter. Low numbers and low susceptibility to any form of displacement meant that there was no requirement to consider displacement, indirect effects or barrier effects.

6.2.155 Although the literature indicates that the species is susceptible to collision, given the very low density of Lesser Black-backed Gulls the likelihood of significant ecological impact from Alpha in isolation was considered to be very low especially if the true likely avoidance rate of ~99% (Galloper Wind Limited 2011) is applied. However, a cumulative effect in combination with Bravo and the STW sites could not be discounted at this stage and as a precautionary measure, Lesser Black-backed Gull is taken forward into the ES Ornithological chapter (Chapter 10: Ornithology of ES Volume I). This is also in keeping with the possible need to consider the species further in HRA as the use of Project Alpha by a very few birds from the Forth Islands SPA cannot be entirely discounted.

Project Bravo

6.2.156 As with Project Alpha, the low numbers recorded within Project Bravo mean that there is a very low likelihood of a significant ecological impact upon Lesser Black-backed Gull from Bravo alone, but a cumulative impact with Alpha (and especially the

STW sites) cannot be entirely discounted. As such, this species is carried forward as a sensitive receptor in relation to EIA. The potential for some use of Bravo and other sites by birds from the Forth Islands may also require consideration in HRA.

European Herring Gull

Population ecology

6.2.157 The global population of Herring Gull is very large, and estimated at 2,700,000-5,700,000 mature individuals (Birdlife International 2012c). Herring Gulls breed across much of northern Europe, which holds > 50% of their global breeding population. Numbers have fluctuated, but with an underlying increase, and therefore the European breeding population of 760,000-1,400,000 pairs is classed as 'Secure' (BirdLife International 2004).

6.2.158 In contrast, in the UK the breeding population of the race *argenteus* estimated at 139,200 pairs (18.5% of the European breeding population and 12.1% of the world population) had declined by more than 50% since 1969 by the time of the Seabird 2000 surveys (Mitchell *et al*. 2004). Decline has continued with a further 38% loss between 2000 and 2010 (JNCC 2011). As a consequence, Herring Gull was moved to the 'Red' list of species of conservation concern (Eaton *et al.* 2009) and is also a priority UK Biodiversity Action Planning (BAP) species.

6.2.159 Reasons for the population decline are not fully understood, but may include botulism, decreases in the availability of food scavenged from refuse tips associated with changes in refuse management in recent years and reductions in discarded fish from fishing boats (Furness *et al.* 1992, Mitchell *et al.* 2004). Changes in food availability belie the fact that Herring Gull is very similar to other large gulls in being opportunistic in its feeding habits and able to take advantage of a wide food base. They tend to forage in the intertidal zone and inshore, rather than offshore, waters and regularly scavenge for food from fishing vessels and human rubbish (Lloyd *et al.* 1991), as well as predate small birds and rodents (Birdlife International 2012c). It appears that urban nesters are faring better than those in natural habitats, so the main declines would appear to be at coastal colonies (Eaton *et al.* 2011).

6.2.160 Like Lesser Black-backed Gull**,** Herring Gull has been subject to culling campaigns in the past. For example, most of the 44,000 gulls culled at the Isle of May were of this species. Coulson *et al*. (1982) document the changing the changing dynamics of the population as a result of this persecution, indicating that density-dependent effects may be released to part compensate for the artificial rate of mortality.

6.2.161 Despite a decline in abundance, Herring Gull remains a widespread breeding species around the coasts of the UK, with more colonies around the west coast. Herring Gulls breed colonially, nesting on coastal cliffs, shingle banks, sand dunes and artificial structures as well as inland, and have been known to physically displace other breeding seabirds such as terns from their breeding grounds (Cramp *et al.* 1974). Adults return to their colonies during early March, with the clutches of eggs (normally consisting of three eggs) being laid from mid April (Cramp *et al.* 1974). The chicks hatch from mid June onwards and take seven weeks to fledge.

6.2.162 Outside the breeding season and especially during the winter the Herring Gull population in Scotland is inflated by the arrival of large numbers of the nominate race *argentatus* from northern Europe. Most arrive along the east coast and are present in greatest numbers in January and early February (Forrester *et al.* 2007).

Density distribution and population size

Project Alpha

6.2.163 With the exception of three surveys, Herring Gull was consistently present throughout the two year study period (Figure 6.21, Appendix F1 Annex 1). In 2010, population estimates were stable during the winter period, but fluctuated during the breeding season. In 2011, abundance was generally lower, but relatively consistent throughout both the winter and breeding periods (Figure 6.22). The numbers estimated indicate that Project Alpha is as important during the winter period, as it is during the breeding season.

6.2.164 The peak population estimate of 121 individuals was recorded in June 2010 (57% adults). A peak during the chick rearing stage was unusual in that less (potentially) breeding adults would be expected offshore as foraging range reduces during chick provisioning. However, the peak only represents approximately a quarter of the 1% regional threshold for the species suggesting that few birds are involved. In 2011, the population estimates from 0-26 birds were substantially lower (Figure 6.22).

6.2.165 In the winter period of 2009/2010, the overall population was consistent between 76 and 92 individuals, equating to approximately 0.5% of the regional wintering population. A single survey in the passage period in October 2010, exceeded the 1% threshold (15 individuals) with an estimated 30 individuals (Figure 6.22).

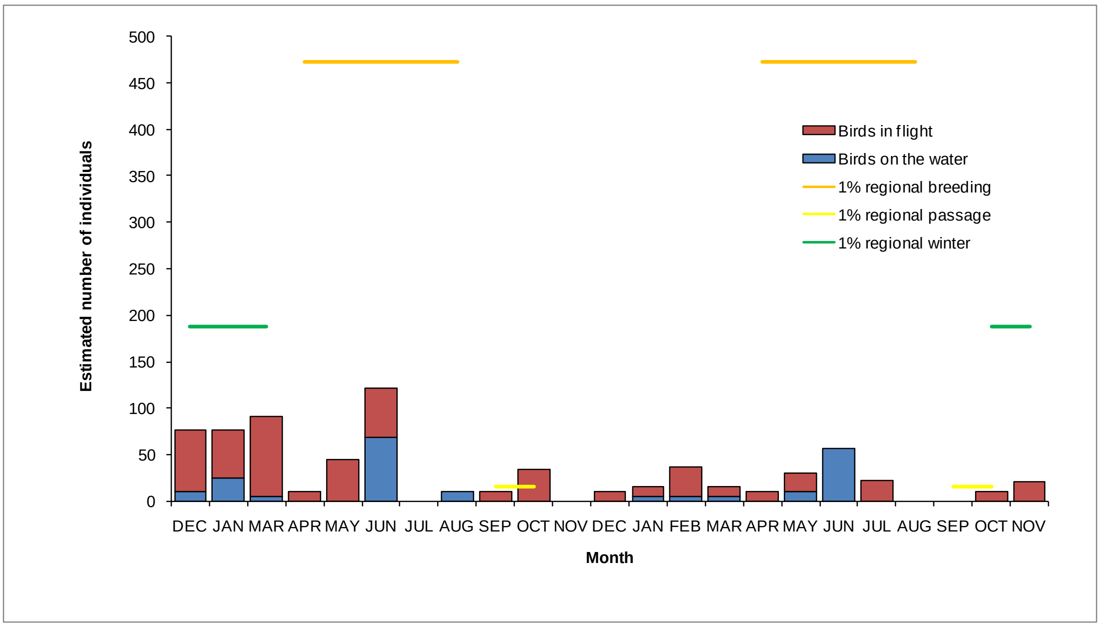
6.2.166 The mean monthly densities for Alpha ranged from 0.03 to 0.37 individuals km^{-2} (Table 6.25) with the higher densities in the breeding season. These densities are lower than those reported in the general literature, with a density of 1.1 individuals km^{-2} in the breeding season for the western North Sea (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).

Table 6.25 Monthly mean (± 1SD) density of Herring Gull in Project Alpha and Bravo as 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
Alpha	0.2 ± 0.2	0.2	0.3 ± 0.3	<0.1 ±0.1	0.2 ± 0.1	0.4 ± 0.3	<0.1 ± 0.1	<0.1 ± 0.1	<0.1 ± 0.1	0.1 ± 0.1	<0.1 ± 0.1	0.2 ± 0.2

Project	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bravo	<0.1 ± 0.1	<0.1	0.1 ± 0.2	-	<0.1 ± 0.1	0.7 ± 0.4	-	-	<0.1 ± 0.1	<0.1 ± 0.1	<0.1 ± 0.1	0.3 ± 0.3

Project Alpha



Project Bravo

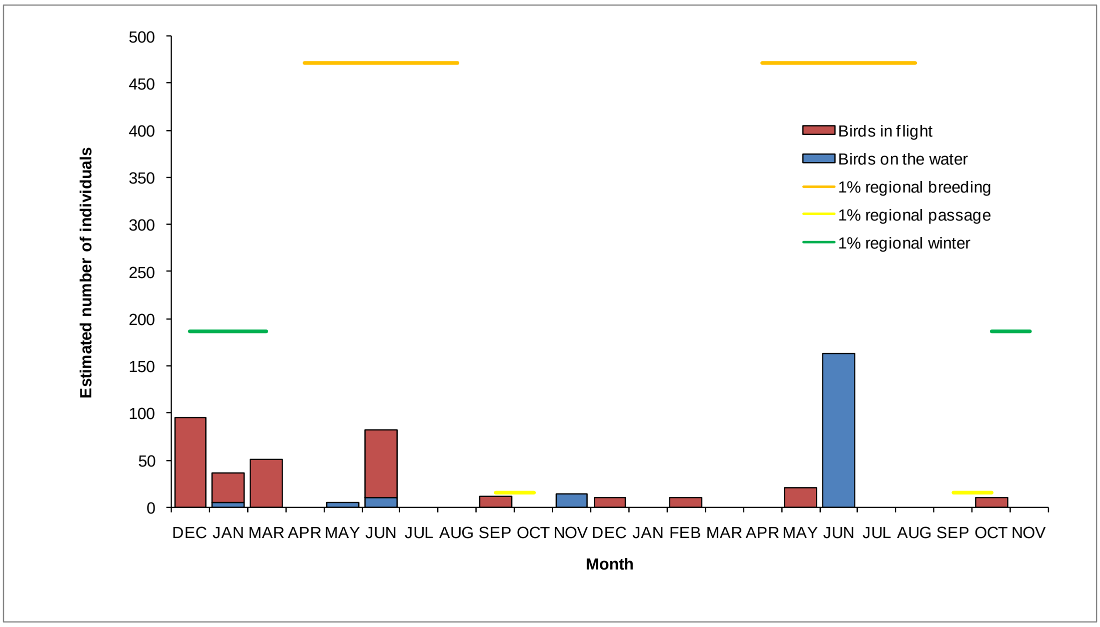


Figure 6.22 Herring Gull population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from density derived from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect. Criteria for regional importance in the breeding, passage and winter periods are shown.

6.2.167 Densities of Herring Gull typically increase in the North Sea in the winter months with the influx of birds from other countries. For example, Skov *et al*. (1995) reports densities to 11.5 individuals km^{-2} in the southern Moray Firth and 12.9 individuals km^{-2} at Dutch Bank to the north of Projects Alpha and Bravo in November to February. The densities in Alpha during the winter mirror those over a very large area of the North Sea incorporating the Firth of Forth at 0.35 individuals km^{-2} reported by Skov *et al*. (1995) and are slightly lower than the range from 0.4 to 0.8 individuals km^{-2} for the Western North Sea reported by Stone *et al*. (1995).

6.2.168 Of the 185 Herring Gulls recorded in Projects Alpha and Bravo combined, 84.9% were aged. Of the single birds, 92.1% were aged, with a much lower proportion (25%) aged in groups of 6-10 individuals. The majority of the population during the breeding season between April and August were adults (62%) compared to a greater mixture of ages in the passage/winter period with 50% being immature birds (Appendix F1 Annex 7). In Project Alpha, 63.6% of Herring Gulls were aged as adults in the breeding season (Table 6.26).

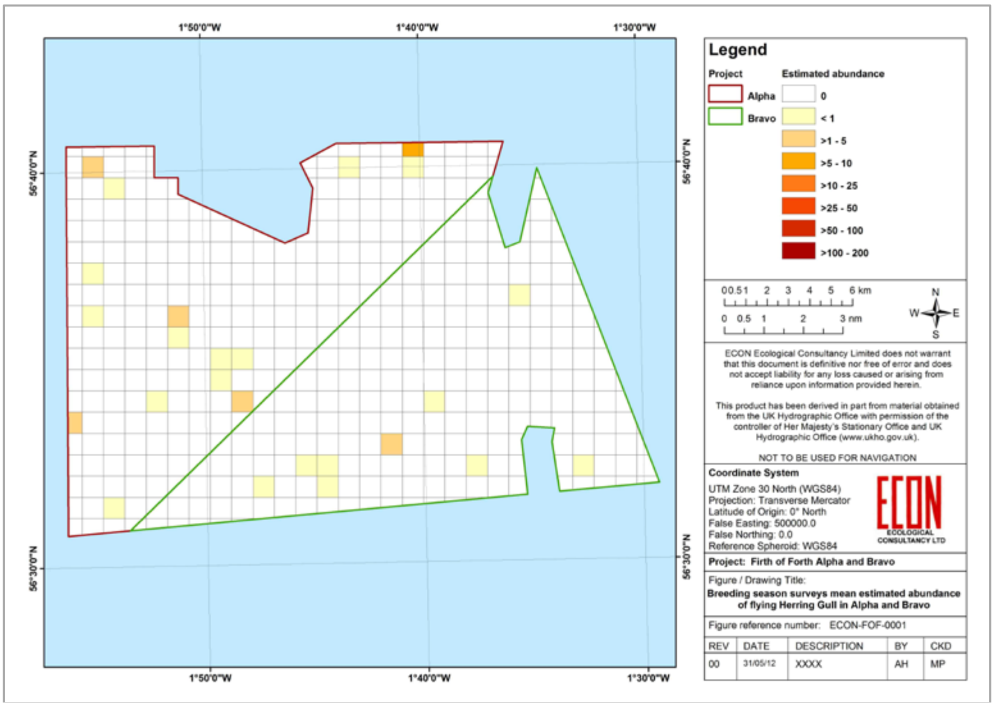
Table 6.26 Number and proportion of adult Herring Gulls relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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

6.2.169 The generally low numbers of Herring Gull recorded within the Alpha development site provided a patchy distribution across the site. Indeed, the majority of the site had no records of flying Herring Gull over the study period during the breeding season (Figure 6.23). In the passage and winter periods, birds were more widespread with a tendency to occur in the eastern half of the site generally nearer to Scalp Bank and the coast.

6.2.170 Although aerial surveys were unlikely to record every individual Herring Gull with some (especially immatures birds) being lumped in other non-specific categories, the relative distribution pattern is thought likely to be realistic. In general, aerial surveys supported the view that Herring Gulls were more prevalent closer to the coast in both summer and winter periods and very few were ever recorded in Alpha (Figure 6.24).

6.2.171 Jacob's selectivity index indicated that there was avoidance of the Alpha site overall (D= -0.81) as well as in summer (D=-1.00) and winter (D=-0.7). Conversely, there was negative albeit not significant selection of Inch Cape in all periods (D=-0.38, -0.24 and -0.46 overall, in summer and winter respectively), whereas for Neart na Gaoithe, the trend was positive overall (D=+0.34) as a result of significant positive selection in summer (D=+0.63) but not winter (D=-0.24).



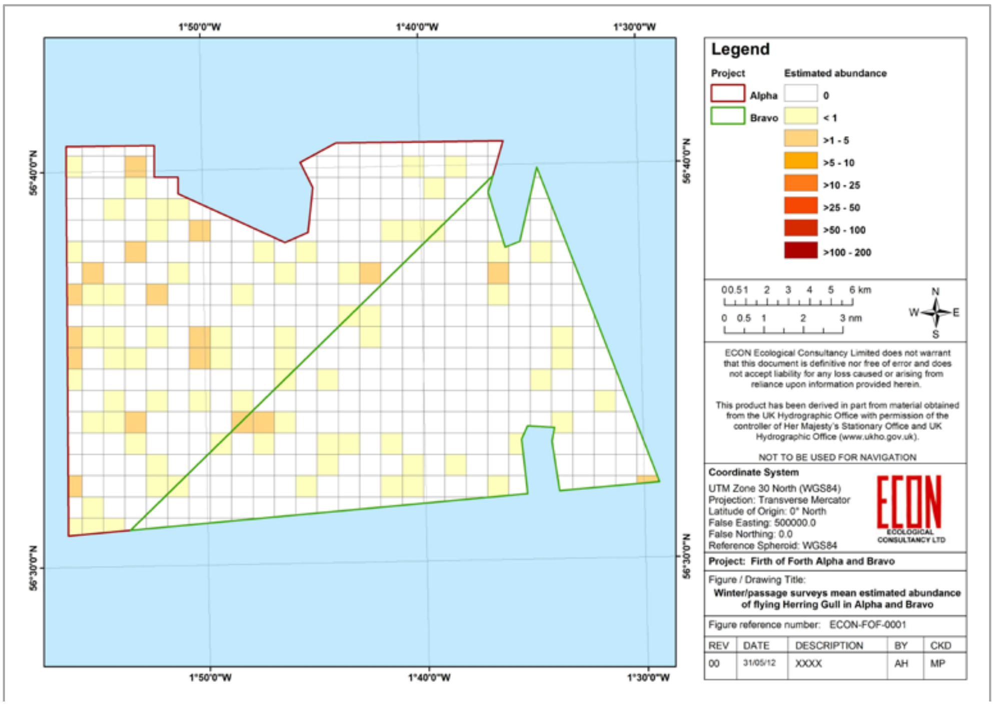
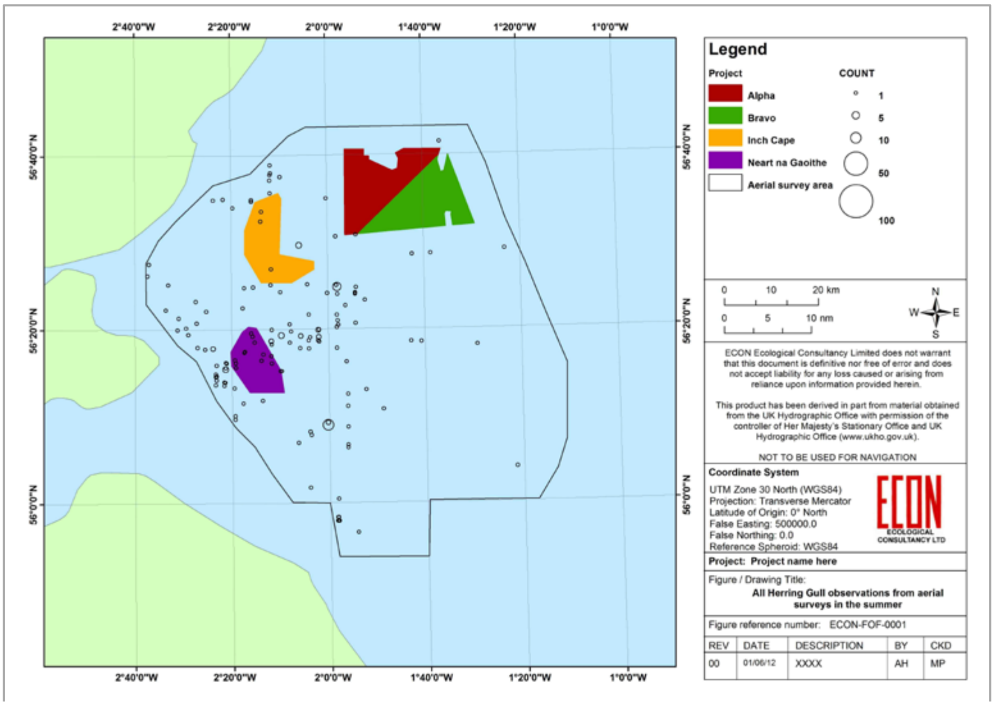


Figure 6.23 Relative abundance of Herring Gull expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August (above) compared to the passage/winter period (below).



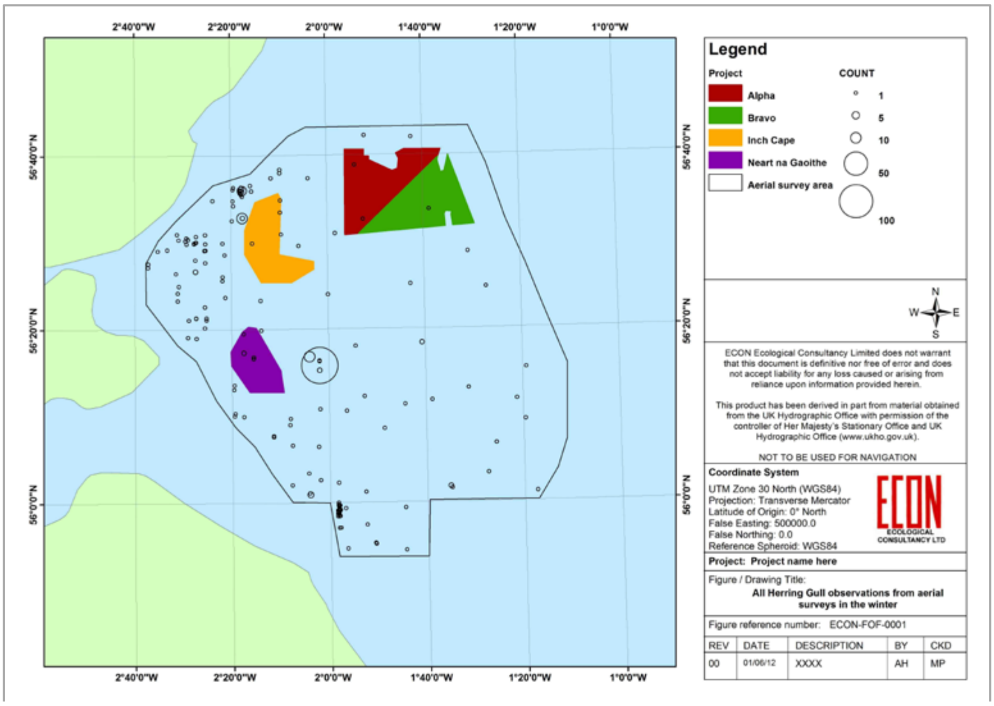


Figure 6.24 Relative distribution of Herring Gull within the Firth of Forth aerial survey area from pooled records of all birds from all surveys in the summer (above) and winter months (below) where $n = 3$ and $n = 4$ respectively.

Project Bravo

6.2.172 The seasonal distribution of Herring Gull within the Bravo site boundary was more sporadic than that of Alpha, with no birds recorded in seven surveys during the two year study period. No Herring Gulls were recorded in April or August surveys in the breeding season in either year, with otherwise patchy occurrence (Figure 6.22, Appendix F1 Annex 1).

6.2.173 As in Alpha, the highest population estimates in the breeding season were in June of both years in the chick provisioning period, but again did not reach the 1% threshold for a regionally important population, with a highest value of 193 birds in June 2011 (Figure 6.22). The peak winter population was much lower at 96 individuals recorded in December 2009 with bird numbers in this winter period being generally higher than the following winter period

6.2.174 The monthly mean densities derived for Bravo ranged from 0.03 to 0.7 ind. km^{-2} (Table 6.20), and as with Alpha, these fell within previous densities recorded in the North Sea throughout the year.

6.2.175 In Project Bravo, a slightly greater proportion of birds (77.8%) were aged as adult in the breeding season (Table 6.27) compared to Project Alpha.

Table 6.27 Number and proportion of adult Herring Gulls relative to the total number of birds aged in each month during boat-based surveys of Project Bravo.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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

6.2.176 As with Alpha, the limited number of records resulted in an even more patchy distribution across Project Bravo with the majority of cells not containing a single bird in either breeding season or passage/winter period (Figure 6.23).

6.2.177 Very few Herring Gulls were recorded in Project Bravo in the aerial surveys (Figure 6.24) with Jacob's selectivity index indicated significant avoidance overall (D= -0.89) as well as in summer (D=-1.00) and winter (D=-0.84).

Foraging range and potential origin

6.2.178 Herring Gull has a mean maximum foraging range of 61.1 km and a mean maximum foraging range + 1SD of 105.1 km (Figure 6.25), which means that 22,584 and 47,164 individuals respectively breed within each range (Table 6.28). These birds are distributed amongst 101 colonies overall with 53 of these within mean maximum foraging range, extending in a reasonably even distribution from the Farne Islands, Northumberland in the south along the coast to St Fergus, Aberdeenshire in the north, with a scattering of inland colonies (Figure 6.25).

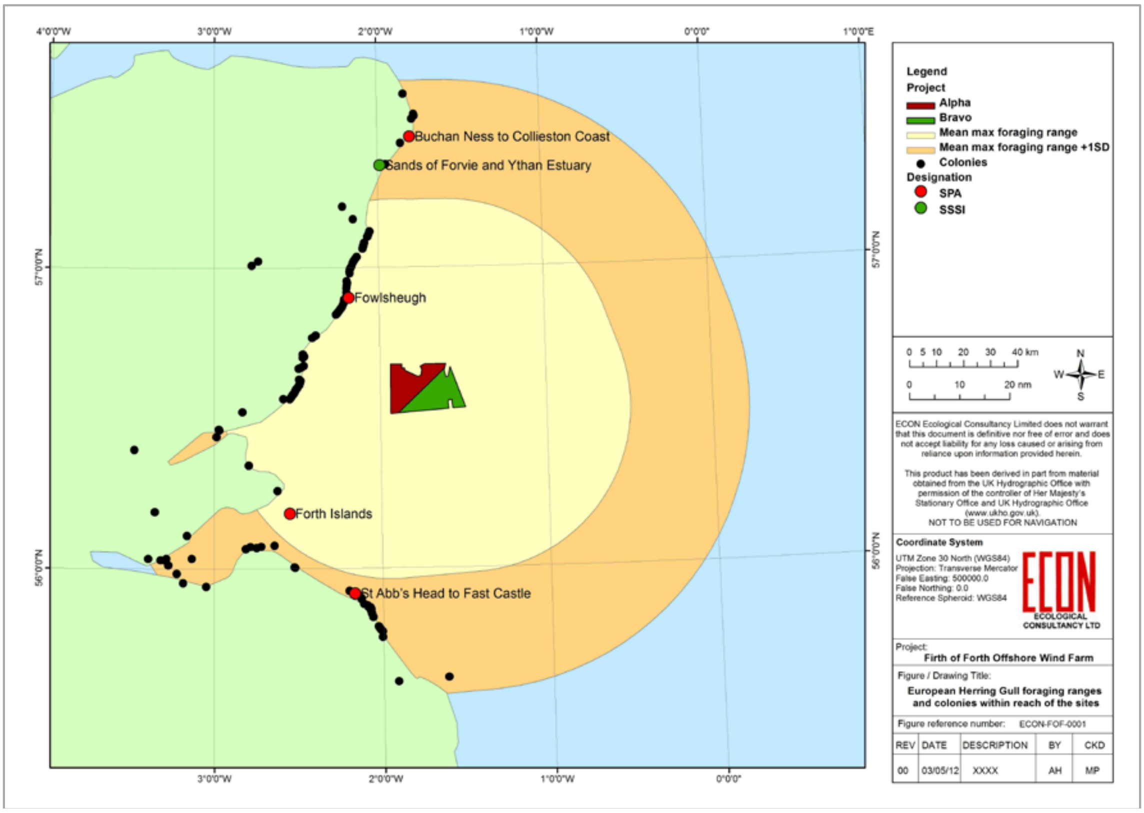


Figure 6.25 Distribution of Herring Gull breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.2.179 Within mean maximum foraging range Herring Gull is designated within two SPAs (Forth Islands and Fowlsheugh), with an additional two SPA (Buchan Ness to Colieston Coast and St Abb's to Fast Castle) together with one separate SSSI (i.e. not a SSSI contained within a SPA) between mean maximum and mean maximum +1SD foraging ranges. Just two colonies (1.9%) are designated within SPAs in mean maximum range, with 12 (11.9%) designated SPAs within the entire mean maximum + 1SD range.

6.2.180 As the SPA colonies contain a proportionally larger number of birds than non-designated colonies the contribution of SPAs to total bird numbers is higher than expected than if simply considering colonies. For example, of the 22,584 individuals within mean maximum foraging range, 30.3% (6,850 individuals) originate from the two SPAs. In mean maximum + 1SD range, 17,908 of the 47,164 individuals (38.0%) originate from SPAs.

Table 6.28 Details of Herring Gull breeding colonies at increasing distance from Projects Alpha or Bravo and within mean maximum and mean maximum ± 1SD foraging ranges (61.1 and 105.1 km respectively). 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.

Foraging range	Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
					Number	Year
Mean Max	Catterline to Inverbervie	27.81		3,402	3,402	1999
	Fowlsheugh SPA	30.41	6,380	734	428	2009
	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[1]
	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	6,422	2010
	Aberdeen City	55.42		6,700	6,700	2001
	Dundee	64.40		592	592	2001[1]
	St Abb's Head to Fast Castle SPA	67.90	2,320	1,082	908	2011[3]
Mean Max + 1 SD	Forth Islands SPA	69.88		6,272	4,162	2008[2]
	St Abb's to Eyemouth	70.37		398	398	2000
	Eyemouth to Burnmouth	73.18		166	166	2000
	Sands of Forvie and Ythan Estuary SSSI	74.05		544	288	2011
	Berwick to Scottish Border	79.83		164	164	2000
	Buchan Ness to Collieston Coast SPA	81.85	8,584	6,634	6,228	2007
	Berwick-on-tweed & Tweedmouth	82.70		492	492	1998
	Inchkeith	91.25		7,160	7,400	2010
	Peterhead	91.85		646	646	2001
	Farne Islands	98.98		1,148	1,518	2011
	Inchmickery, Inchgarvie, Forth Rail Bridge	99.71		484	240	2008
	Forth Islands - Bass Rock to Haystack	100.04		122	104	2011
	Inchcolm	100.04		1,242	1,300	2009

[1]2000 & 2001; [2]2002, 2004, 2005, 2006 & 2008; [3]2000 & 2011

Project Alpha

6.2.181 The closest breeding Herring Gulls to Alpha are at the non-designated colonies between Catterline and Inverbervie and within the Fowlsheugh SPA all at ~30 km distant. The population at Fowlsheugh has declined significantly over the last decade and now numbers only 428 individuals (Table 6.28). The colony at Catterline and Inverbervie may have suffered a similar fate although no recent counts are available. The current status of other once significant colonies between Arbroath and Montrose, together with Stonehaven is also unknown. The two largest sites in the area between 50 and 55 km away known to be active are the Forth Islands SPA and the City of Aberdeen, which support 6,422 and 6,700 individuals respectively.

6.2.182 Although not as extensively tracked as Lesser Black-backed Gulls, Herring Gulls are known to forage over shorter distances (Mitchell *et al.* 2004) and may be described as less marine than Lesser Black-backed Gull particularly during the breeding season (Cramp *et al.* 1974) or even strictly coastal (Camphuysen 2005). Hence it would be safe to assume that the core foraging area for this species is less than 40 km from the colony. Indeed, studies have shown that a high percentage (up to 85%) of food during the breeding season was obtained from refuse tips (Mitchell *et al.* 2004). Herring Gull is also a significant predator within seabird colonies.

6.2.183 On the basis of likely core foraging range it would seem most likely that the relatively few Herring Gulls reaching Alpha in the breeding season originate from the closest colonies at Fowlsheugh SPA and the non-designated colonies in the vicinity, that are currently of unknown size. However, although sample size was small, flight directions of birds in the breeding season within Alpha showed a strong bias to the northeast with flight lines indicative of birds coming from the direction of the largest colony in the Forth Islands SPA (Table 6.29). 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.

Table 6.29 Number and proportion (%) of flight directions recorded for Herring Gull during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	12	18	6	26	5	10	13	27	21
	%	8.70	13.04	4.35	18.84	3.62	7.25	9.42	19.57	15.22
Breeding season	Count	5	13	0	3	3	1	2	2	4
	%	15.15	39.39	0.00	9.09	9.09	3.03	6.06	6.06	12.12

6.2.184 Overall, it would seem most likely that a mixture of potentially breeding birds from different origins reach Alpha especially considering the patchy occurrence in time and space of Herring Gull. Any operational fishing vessels are also likely to attract birds from a wide area (Camphuysen 1995) with these perhaps attending vessels over a large distance.

Project Bravo

6.2.185 As for Alpha, it seems most likely that the adult Herring Gulls reaching Bravo in the breeding season originate for the closest colonies in Kincardine and Deeside and Angus. Nonetheless, flight direction of the birds recorded, again suggests an origin from a southwesterly direction, although sample size was even smaller than in Alpha (Table 6.30). Moreover, the majority of the small numbers of birds recorded demonstrate no flight direction indicative of foraging behaviour although no feeding activity was observed.

Table 6.30 Number and proportion (%) of flight directions recorded for Herring Gull during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	18	6	4	9	4	4	2	11	18
	%	23.68	7.89	5.26	11.84	5.26	5.26	2.63	14.47	23.68
Breeding season	Count	1	2	0	0	0	1	0	2	8
	%	7.14	14.29	0.00	0.00	0.00	7.14	0.00	14.29	57.14

6.2.186 As in project Alpha, it may be that breeding birds of a mixture of origins reach Project Bravo.

Summary of risks

6.2.187 Despite the species flight characteristics and high adult survival rates, Garthe & Hüppop (2004) considered Herring Gull as not sensitive to offshore wind farm development, ranking it 22nd of the 26 species considered. In contrast, Furness & Wade (2012) considered Herring Gull to be at considerable risk of collision, with a rank of 2nd from the 37 seabirds considered. A high proportion of flights at risk height (30.6%) according to Cook *et al.* (2011) coupled with a high score of night activity made important contributions to the assessment.

6.2.188 In both Projects Alpha and Bravo, a high proportion of the Herring Gulls recorded were observed in flight (79% and 63% respectively). Of these, 42% were flying above 20 m in Alpha compared to 62% in Bravo. Differences resulted from the relatively low sample size of observations and the influence of some larger groups encountered on the water surface, and are thought to reflect real differences in behaviour patterns of birds between the two Projects. Extensive experience of collision risk modelling dictates that the low densities of birds recorded especially within the different periods (i.e. breeding compared to passage/winter periods) would produce very low collision rates.

6.2.189 Herring Gull were ranked 29th in the context of displacement from habitat of the Scottish seabirds reviewed by Furness & Wade (2012). A low rank is in accordance with the lack of evidence of any avoidance of wind farms, with Herring Gull recorded at the sites of Lynn and Inner Dowsing, Nysted and Horns Rev after construction (Kahlert *et al*. 2004, Petersen 2004, Petersen *et al*. 2006). Indeed an increase in numbers was recorded at Horns Rev during construction (Dierschke & Garthe 2006). These studies indicate that barrier effects are unlikely to operate.

6.2.190 Given the generally low numbers recorded and with little evidence that the development sites are utilised as foraging grounds (2% of Herring Gull were recorded as feeding) and the fact that Herring Gull distribution and activity may be determined by fishing vessels (Camphuysen 1995) there seems to be no evidence for Herring Gull to be considered for displacement nor indirect effects.

Project Alpha

6.2.191 Low numbers of Herring Gulls and low susceptibility to any form of displacement meant that there was no likelihood of significant ecological impact of displacement, indirect effects or barrier effects and these were not to be considered further in EIA.

6.2.192 Even with apparently high susceptibility to collision, given the low density of Herring Gulls the likelihood of significant ecological impact from Project Alpha in isolation was considered to be very low. However, in the same manner as described for Lesser Black-backed Gull a cumulative effect in combination with Bravo and the STW sites could not be discounted at this stage and as a precautionary measure, collision risk of Herring Gull is taken forward into the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I). This is also in keeping with the possible need to consider the species further in HRA as the use of Project Alpha by birds from Fowlsheugh or even the Forth Islands SPA cannot be discounted.

Project Bravo

6.2.193 As with Project Alpha, the potential ecological impact on the population from collision with turbines in a cumulative context with Project Alpha (and the STW sites) necessitates the inclusion of Herring Gull as a sensitive receptor in the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

Common Guillemot

Population ecology

6.2.194 Guillemot is one of the more abundant seabirds, with a world population of over seven million pairs (Mitchell *et al.* 2004). The European North Atlantic colonies account for less than 50% of its global range and population size, which still exceeds two million pairs. The population is classed as ‘Secure’ (BirdLife International 2004).

6.2.195 The UK holds 1.42 million birds, constituting 12.9% of the world population and 33.3% of the North Atlantic population (JNCC 2011). As a result of the presence of internationally important numbers of birds in ten or fewer colonies, Guillemot is of conservation concern in the UK with ‘Amber’ status (Eaton *et al.* 2009).

6.2.196 Guillemot populations have fluctuated in recent times. Between 1969-70 and Seabird 2000 the Guillemot population rose by 43%, peaking in 2001 (JNCC 2011). Peaks and troughs have followed but with a 17% increase in numbers between 2000 and 2010. Following signs that increase had slowed, the population index increased by 14% between 2009 and 2010 (Eaton *et al.* 2011). Numbers of guillemots are probably now higher than at any time since the first census in the late 1960s.

6.2.197 Productivity was exceptionally low in 2005 - 2008, but increased thereafter, though it remains below the long-term mean (JNCC 2011). This is perhaps not unexpected in populations that may be approaching carrying capacity. The reasons for the recent increase in productivity are not known, although sandeels were apparently abundant at some colonies when they had been scarce previously. Guillemot experienced higher productivity In areas where the prey was predominantly Sprat.

6.2.198 The broad diet that includes a range of fish species such as sandeels, clupeids (Herring and Sprat), gadoids and a variety of benthic species, coupled with the ability to dive considerable depth (>60 m) (BWPi 2004) means that Guillemot may be buffered against population fluctuation of a particular prey species.

6.2.199 In the UK, Guillemots breed along all coasts, with the majority of large colonies in the west and north on exposed steep cliffs situated on the mainland, offshore stacks and islands (Mitchell *et al.* 2004). At the time of Seabird 2000, the colony at Fowlsheugh, some 30 km from Alpha and Bravo, was the third largest in the UK.

6.2.200 Guillemots attend colonies from January onwards and by March and April large numbers congregate in the waters around colonies. Each pair lay a single egg, usually in the month of May and both adults share incubation. Hatching occurs throughout June (Cramp *et al.* 1974). Chicks fledge from July through to early August at around one third size, leaping from breeding cliffs into the sea to spend the next six to seven weeks accompanied by their paternal parent. Both birds are flightless at this time as the adult moults and the chick develops its flight feathers.

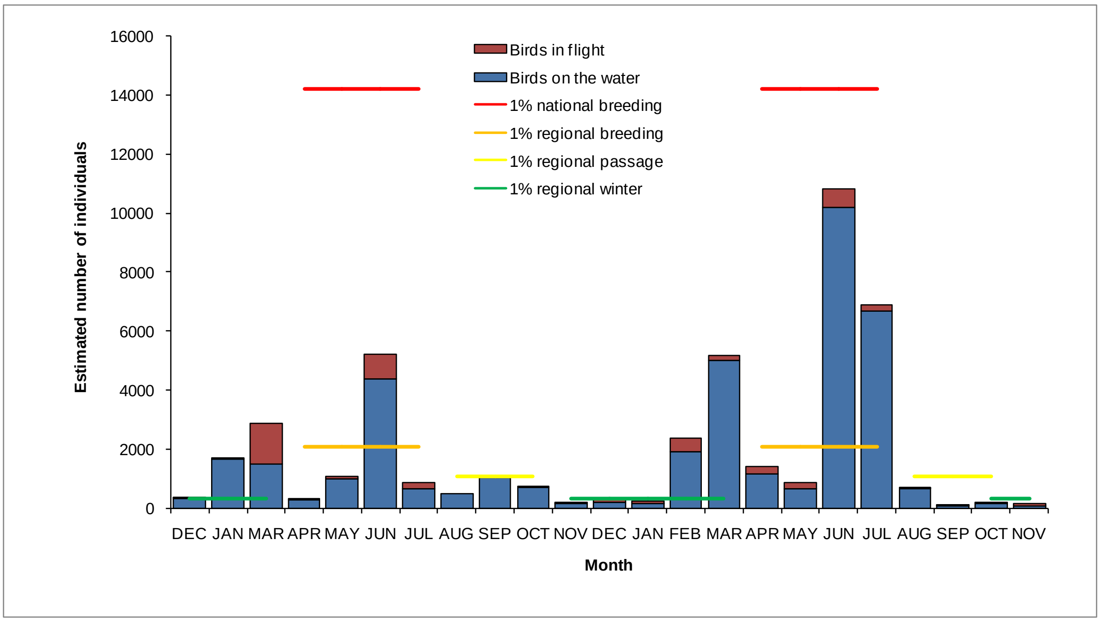
6.2.201 Guillemots breeding in Scotland winter at sea, apparently mostly outside Scottish waters, with the winter range extending from western Iberia to central Norway (Forrester *et al.* 2007).

Density distribution and population size

Project Alpha

6.2.202 Guillemot was present in Project Alpha throughout the study period. Peak numbers were recorded during the breeding season, especially June (and into July in 2011) corresponding with chick provisioning. Numbers also increased during the late winter/early spring period in March after birds returned to colonies. Population estimates prior to and during the breeding season were generally higher in 2011, although numbers were lower during the following passage and early winter suggesting rapid dispersal from the area (Figure 6.26).

Project Alpha



Project Bravo

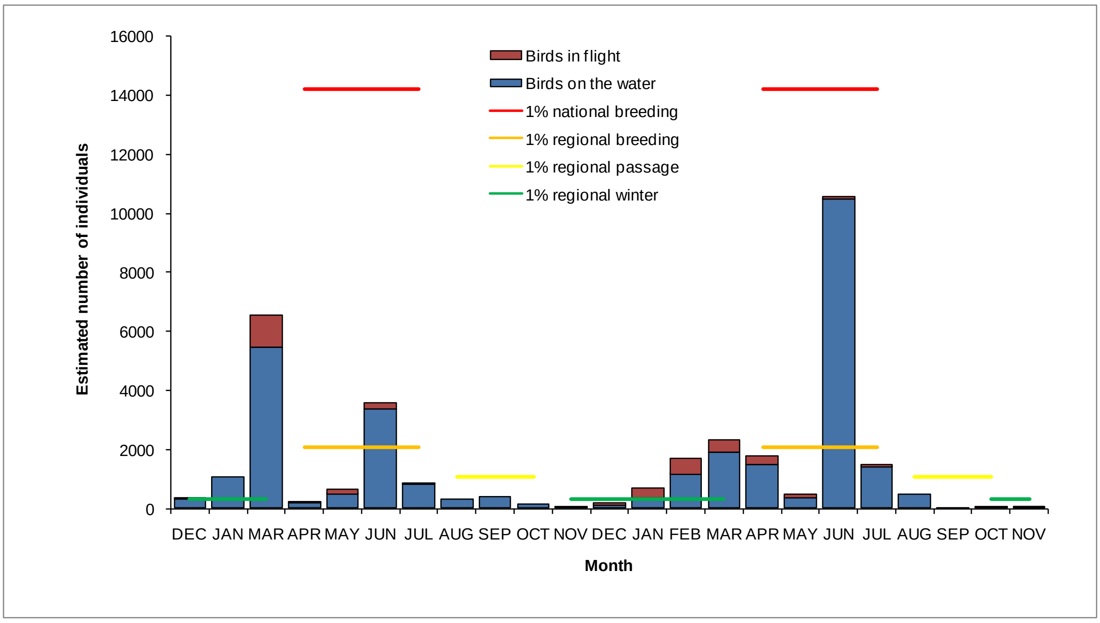


Figure 6.26 Guillemot population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from DISTANCE-corrected density of birds on the water combined with density derived from snapshots of birds in flight. Criteria for regional importance in the breeding, passage and winter periods are shown for Alpha, with criteria for national importance in the breeding season also shown for Bravo. Note the change in scale in relation to Bravo.

6.2.203 The 1% regional threshold (2,067 ind.) during the breeding season was exceeded in June 2010 (5,202 individuals) and June and July in 2011 (10,811 individuals and 6,889 individuals respectively) (Figure 6.26). As expected for a species predominantly observed on the water, the population estimates stem from DISTANCE calculations. The DISTANCE density estimate for June and July 2011 were both in excess of 30 individuals km^{-2}, with UCI exceeding 70 individuals km^{-2} (Figure 6.27). It is worthy of note that the density derived using simple correction factors for Guillemot, also exceeded 30 individuals km^{-2} in June 2011.

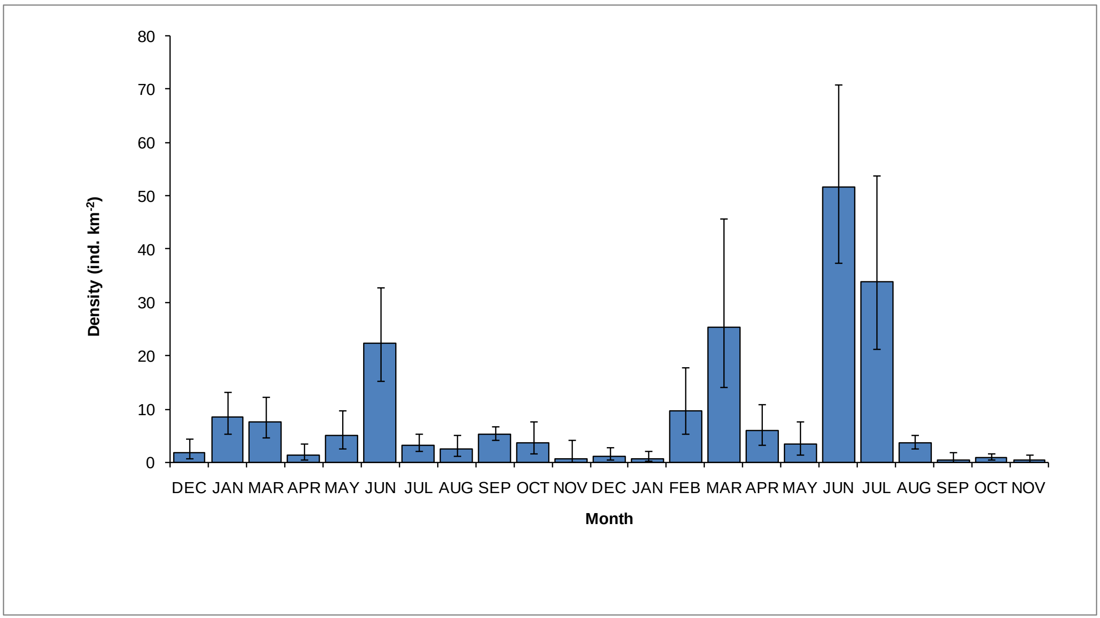


Figure 6.27 Monthly mean (± 95% confidence intervals) density of Guillemot in Project Alpha as derived from DISTANCE correction of birds on the water.

6.2.204 The regional threshold for the passage period was not exceeded during the study period, although the winter threshold was exceeded in 2010 and 2011, with estimates of 1,721 and 2,862 individuals in 2010 and 2,378 and 5,193 individuals in 2011 after birds had returned to colonies (Figure 6.26).

6.2.205 Monthly mean densities calculated for Alpha using DISTANCE for birds on the water, were higher than typical values 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), compared with 40.6 and 19.4 individuals km^{-2} within Alpha (Table 6.32). However, Skov *et al*. (1995) report a density of 59 individuals km^{-2} for Wee Bankie, to the south of the site during the breeding season, 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.

Table 6.31 Monthly mean (± 1SD) density of Guillemot in Project Alpha and Bravo as 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
Alpha	5.0 ± 5.3	12.1	20.4 ± 8.4	4.5 ±3.9	4.6 ± 0.2	40.6 ± 20	19.4 ± 22	3.1 ± 0.8	2.5 ± 2.8	2.0 ± 1.7	0.7 ± 0.1	1.6 ± 0.1
Bravo	4.4 ± 1.0	8.7	21.0 ± 13	5.2 ± 5.7	3.2 ± 0.6	36.5 ± 25	7.7 ± 3.8	2.1 ± 0.7	1.2 ± 1.5	0.6 ± 0.5	0.4 ± 0.0	1.6 ± 0.7

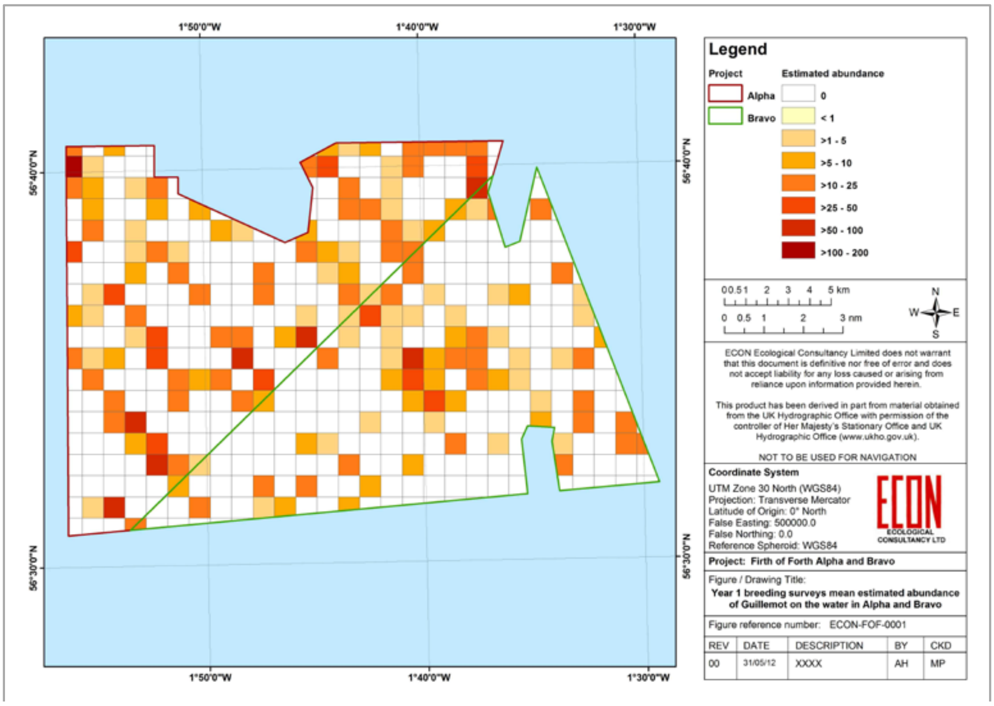
6.2.206 In general, the proportion of Guillemot aged was very low at 6.1%. Of the single birds observed in Projects Alpha and Bravo combined, only 6.8% of the records were aged. The proportion increased to 8.2% for two birds recorded together. The reason for this was a result of adult and chick combination in the post breeding period, which increased confidence in the ageing of the adult. Although immature birds were recorded (Appendix F1 Annex 7), confidence in separating these from adults was low. If it is assumed that all birds recorded during the breeding season were adults unless specified as immature or juvenile, 99.1% of birds would be considered as adults. In Alpha, of the n = 257 birds aged during the breeding season of April to July, 88.3% were recorded as adult.

Table 6.32 Number and proportion of adult Guillemots relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	0	0	2	0	72	121	34	28	0	0	0	0
%	-	-	100	-	96.0	98.4	57.6	65.1	-	-	-	-
Total	0	0	2	0	75	123	59	43	0	0	0	0

6.2.207 The density distribution maps (individuals km^{-2}) for birds on the water showed the patchy occurrence of birds in the breeding season with many cells recording no birds in bands A & B, but with others recording >50 individuals km^{-2} and even >100 individuals km^{-2} (Figure 6.28). In 2011, considerably more birds were present with more cells containing birds and more high density patches with marginally greater density in the northwest of the area.

6.2.208 The higher density in the northwest in the breeding season becomes more apparent when the two years of data are combined with higher density patches also extending to the southwest corner (Figure 6.29). In contrast, there is no clear preference for this area in the passage and winter period, with a tendency for higher density to the west of the central area and very few birds in the northeast (Figure 6.29). The difference in density between breeding season and winter/passage periods is also marked.



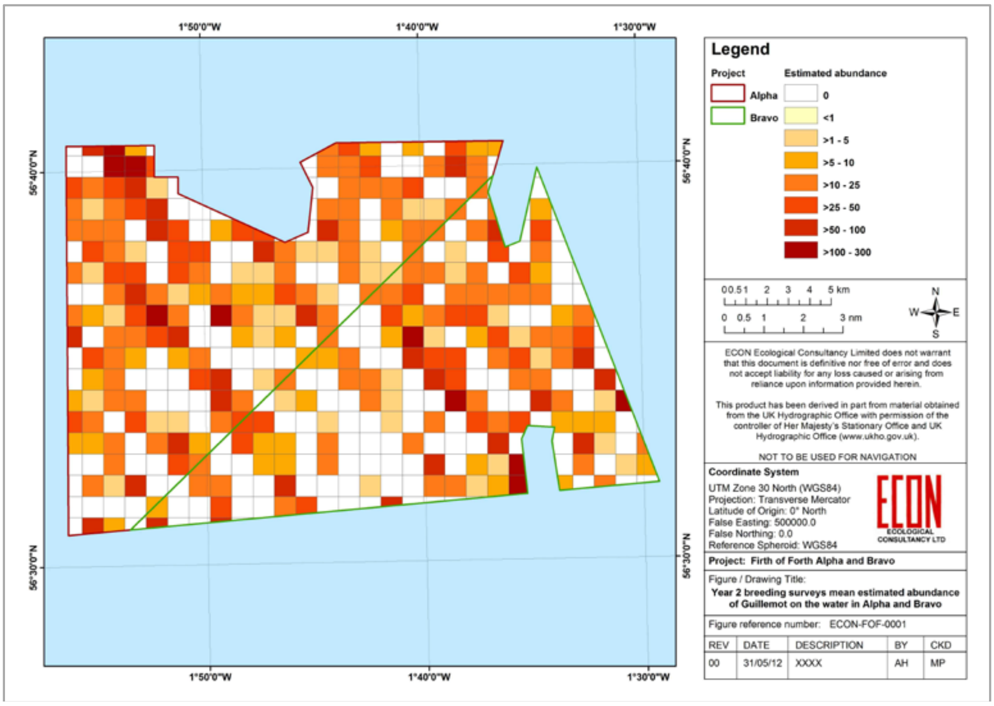
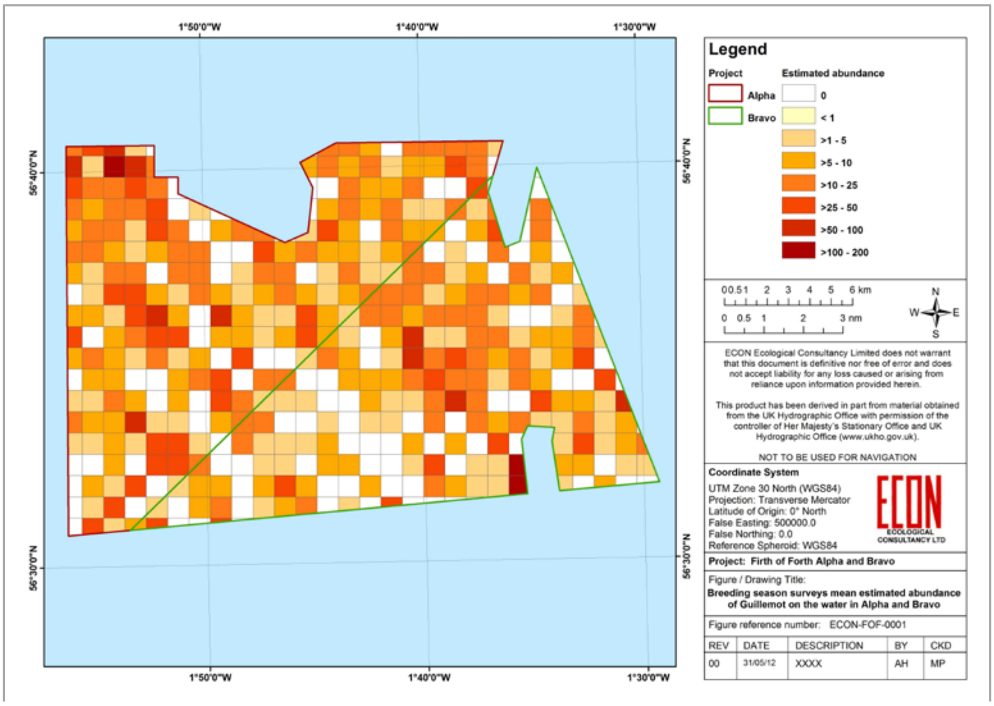


Figure 6.28 Relative abundance of Guillemot expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to July in 2010 (above) compared to 2011 (below).



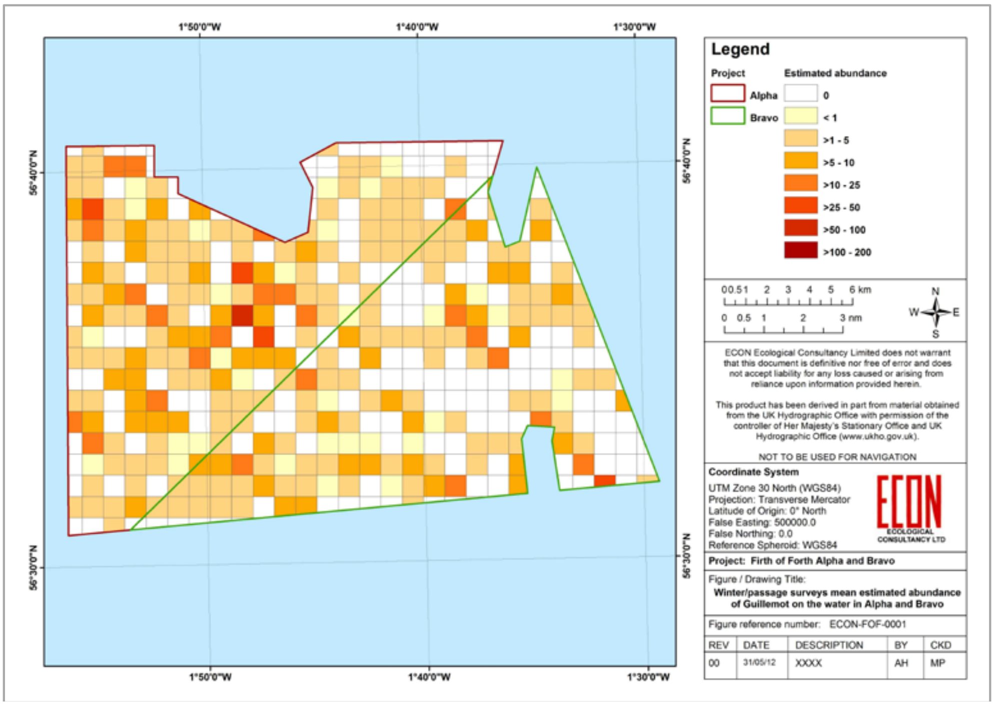


Figure 6.29 Relative abundance of Guillemot expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^{2} grid cells across Alpha and Bravo in the breeding season of April to July (above) compared to the passage/winter period (below).

Project Bravo

6.2.209 A similar seasonal distribution to that of Alpha was observed within Project Bravo. In essence, numbers increased over the winter period, peaking in March corresponding to the return of birds to the colonies. Abundance then declined at the start of the breeding season before peaking in June in both years, with relatively low numbers recorded during the autumn passage and early winter (Figure 6.26). Numbers were generally comparable between 2010 and 2011, although the peak population estimate in June 2011 was substantially higher than any other estimates in either Bravo or Alpha.

6.2.210 The peak population estimate of 10,569 birds exceeded the 1% regional threshold for the breeding season (Figure 6.25). This was a result of the DISTANCE estimate of 54.0 individuals km^{-2} (UCI of 63.8 individuals km^{-2}) (Figure 6.29). Using the simple correction factors derived from data gathered in the Firth of Forth R3 Zone, the density for birds on the water in June 2011 was 47.3 individuals km^{-2} (Appendix F1 Annex 1) and thus achieving regionally important numbers.

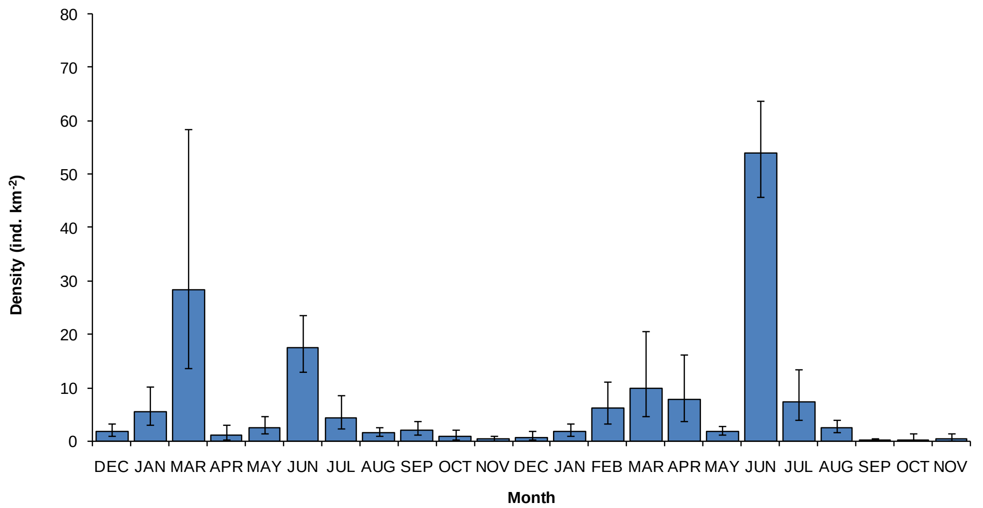


Figure 6.30 Monthly mean (± 95% confidence intervals) density of Guillemot in Project Bravo as derived from DISTANCE correction of birds on the water.

6.2.211 After this peak, the estimates for Guillemot during the rest of the breeding season failed to reach regionally important numbers, ranging from 291 to 1,986 individuals in 2010. Regionally important numbers were recorded at the end of each winter period reaching 5,831 and 2,285 birds in the March surveys of 2010 and 2011 (Figure 6.26).

6.2.212 As with Project Alpha, the monthly mean densities in derived from combining DISTANCE corrected densities for birds on the water combined with flying birds from snapshots (Table 6.24) in Project Bravo, exceed those in the North Sea recorded by

Stone *et al*. (1995). However, the peak density for June 2011 was in line with the density of 59 individuals km^{-2} previously recorded at Wee Bankie (Skov *et al*. 1995).

6.2.213 There was no clear reason for this very high density recorded over a single day with no large feeding aggregations within the 2,269 birds observed (largest group of *n* = 66 birds). There was also no evidence of early dispersal as a result of fledging or failure. Although the timing of the appearance of chicks was slightly earlier in 2010 in June it still peaked in July and the proportion of adult-chick combinations was similar between years at 38-39%. Data from the Isle of May also indicates little variation in productivity with 0.80 chick pair^{-1} in 2010 compared to 0.71 chick pair^{-1} in 2011 (SMP online database 2012).

6.2.214 Of the *n* = 160 Guillemots aged during the breeding season of April to July, 76.3% were recorded as adult (Table 6.32). a slightly lower proportion than in Alpha.

Table 6.32 Number and proportion of adult Guillemots relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	8	0	0	7	26	44	45	22	0	1	0	0
%	88.9	-	*	100	86.7	89.8	60.8	66.7	-	100	-	-
Total	9	0	0	7	30	49	74	33	0	1	0	0

6.2.215 The peak population estimate in June 2011 appeared to have relatively little effect on the distribution patterns of Guillemot within Project Bravo, as although it enhanced density in some parts of the site, the focus was still on the east-central part of the area (Figure 6.28). The same area appears to be preferred in 2010 (Figure 6.28). Overall, there are areas within the site in the breeding season where Guillemots were not recorded in bands A and B at least (Figure 6.29). In contrast, there is almost a complete dearth of birds in the same area in the passage/winter period. This points to temporally patchy prey resources perhaps associated with a particular habitat feature. In turn, this habitat feature may not be a permanent hard bed feature but some temporary patch of productivity created by particular water circulation patterns as previously recorded by Scott *et al*. (2010) in the Firth of Forth.

Foraging range and potential origin

6.2.216 Guillemot has a mean maximum foraging range of 84 km and a mean maximum foraging range + 1SD of 134.3 km (Figure 6.31), with these ranges containing 141,027 and 206,736 breeding individuals respectively (Table 6.25). Birds are distributed amongst 38 colonies in mean maximum foraging range and 42 colonies within the range incorporating 1SD, the latter extending from Troup, Pennan and Lion's Head in Aberdeenshire in the north, and down to the Farne Islands, Northumberland in the south.

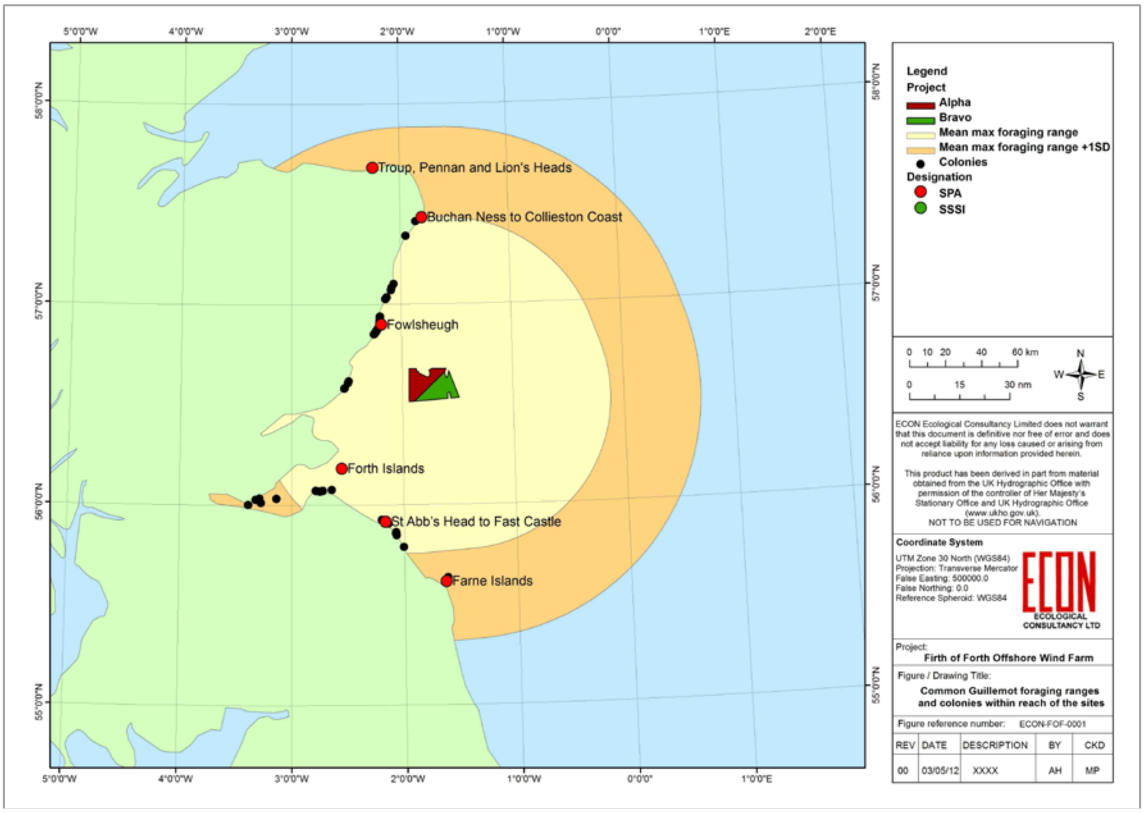


Figure 6.31. Distribution of Guillemot breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.2.217 Four SPAs (Fowlsheugh, Forth Islands, St Abb's Head to Fast Castle and Buchan Ness to Collieston Coast) containing six SSSIs, designated for Guillemot fall within the mean maximum foraging range. A further two SPAs (and two SSSIs within these) are within range incorporating the 1SD. In regard to individual colonies, the designated colonies represent 26% of the total (10 from 38 in total), increasing to 28% (12 from 42) using the range +1 SD.

6.2.218 The apparent importance in proportional terms of the designated colonies increases substantially when the proportion of individual birds rather than colonies is considered. Within the mean maximum range, 130,810 (93%) of the 141,027 individual Guillemot are contained within SPA colonies. The proportion increases to 95% as a result of 196,385 individuals from 206,736 individuals, within the mean maximum + 1 SD range.

Table 6.33 Details of all Guillemot breeding colonies at increasing distance from Projects Alpha or Bravo and within mean maximum and mean maximum ± 1SD foraging ranges (84.2 and 134.3 km respectively). 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.

Foraging range	Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
					Number	Year
	Catterline to Inverbervie	27.64		2,884	2,884	1999
Mean Max	Fowlsheugh SPA	30.41	56,450	62,330	50,556	2009
	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	23,798	2011
	St Abb's Head to Fast Castle SPA	67.90	31,750	43,137	35,598	2008[1]
	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	20,858	2007
	Inchkeith	91.25		48	133	2011
Mean Max + 1 SD	Farne Islands SPA	98.98	46,998[2]	31,497	47,977	2011
	Inchcolm	100.04		0	1	2007
	Troup, Pennan and Lion's Head SPA	112.92	44,600	45,254	17,598	2007

[1] 2000 & 2008; [2] From Stroud *et al*. 2001

Project Alpha

6.2.219 The largest Guillemot colony in the area at Fowlsheugh SPA supporting 50,556 individuals is also the second closest at 30 km to the north-west (Table 6.33). Other SPA designated large colonies containing >20,000 individuals situated within 100 km comprise those at Forth Islands SPA, St Abb's Head to Fast Castle SPA, Buchan Ness to Collieston Coast SPA and the Farne Islands SPA.

6.2.220 The study by Daunt *et al.* (2011b) for FTOWDG based on observing trip durations and flight directions to estimate at-sea distribution of adult Guillemots breeding at Fowlsheugh and St Abb's Head, concluded that the mean maximum range was just 12 km at Fowlsheugh and 16 km at St Abb's Head, with a maximum range of 55 km at both colonies. Offshore distribution was concentrated in an easterly to south-easterly direction at Fowlsheugh, which, when combined with the range data, suggests that Guillemots from this colony are likely to reach the whole of Alpha, albeit in low densities, with densities in the north-west corner being slightly higher. At St Abb's Head offshore distribution was concentrated in a north-easterly direction, which, when combined with the range data, suggests that Guillemots from this colony do not reach Alpha.

6.2.221 The estimated range data is supported by GPS tracking of 33 chick-rearing adult Guillemots on the Isle of May in the Forth Islands SPA (Daunt *et al.* 2011a). The tracklines obtained for breeding Guillemots from Isle of May did not cross Project Alpha (Figure 6.32, Table 6.34). In comparison, 19% and 26% of trips, expressed for all trips and by birds respectively, crossed Neart na Gaoithe and 2.7% and 2.2% of trips crossed Inch Cape (Table 6.34). This difference is readily explained by the smaller distance to Neart na Gaoithe and to Inch Cape.

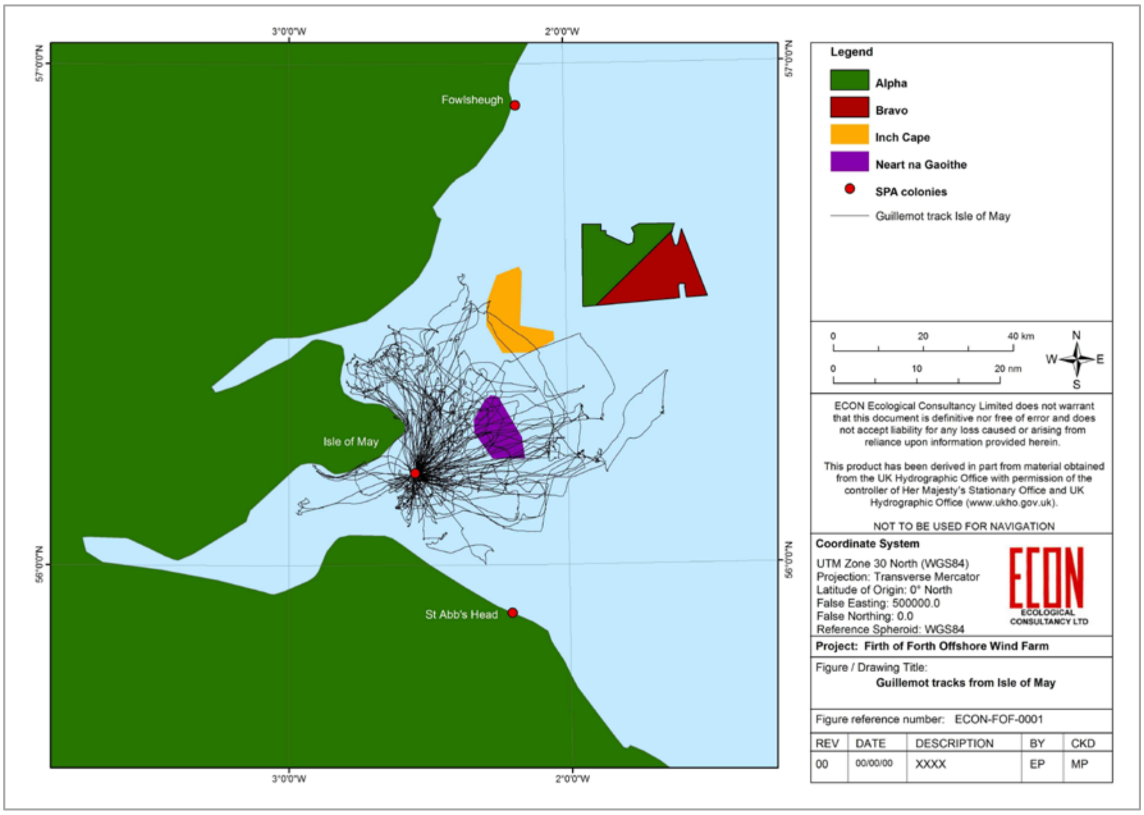


Figure 6.32 Tracklines of breeding Guillemots fitted with GPS tags from Isle of May (*n* = 33) in 2010.

6.2.222 Some 3-4% (both overall and mean by bird) of the distance travelled by foraging Guillemots from the Isle of May occurred within Neart na Gaoithe with less than 1% in Inch Cape (Table 6.35). Separating the behaviours emphasised that birds tended to show a greater proportion of the number of fixes (incorporating distance travelled and time) in flight across Neart na Gaoithe compared to Inch Cape, although the actual proportion of overall fixes was still higher in Neart na Gaoithe (Table 6.36). It would appear that Neart na Gaoithe, the site closest to the colony tends to be crossed *en-route* to more distant foraging grounds. At greater distance, e.g. at Inch Cape, the proportion of non-flight behaviours appears likely to increase. These patterns may simply reflect the distribution of prey resources around the colonies which in turn may be partly reflected by the size of the colony (Lewis *et al*. 2001).

Table 6.34 Number and proportion (% in parentheses) of trips of GPS tagged breeding Guillemots from the Isle of May crossing the different proposed wind farm sites. Data are expressed for all trips and mean by bird.

Subject	Trips	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	112	0	0	3 (2.68)	21 (18.75)
Mean by bird	3.39	0	0	0.09 (2.20)	0.64 (26.32)

Table 6.35 Distance (km) and proportion (% in parentheses) of trips obtained by GPS tagged breeding Guillemots from the Isle of May, Fowlsheugh and St Abb's Head within the different proposed wind farm sites. Data are expressed for all trips and mean by bird.

Subject	Total distance (km)	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	5,570.44	0	0	33.94(0.61)	197.27 (3.54)
Mean by bird	168.80	0	0	1.03 (0.36)	5.98 (3.25)

Table 6.36 Number and proportion (% in parentheses) of total fixes according to different behaviours (combined behaviour = CB, flight = F and non-flight = NF) obtained for GPS tagged breeding Guillemots from the Isle of May within the different proposed wind farm sites. Data are expressed for all trips and as a mean by bird.

Subject	Activity	Total fixes	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	CB	32,021	0	0	317 (0.99)	579 (1.81)
	F	4,599	0	0	25 (0.54)	173 (3.76)
	NF	27,422	0	0	292 (1.06)	405 (1.48)
Mean by bird	CB	970.33	0	0	9.61 (0.59)	17.52 (1.88)
	F	139.36	0	0	0.76 (0.33)	5.24 (3.36)
	NF	830.97	0	0	8.85 (0.64)	12.27 (1.47)

6.2.223 Kernel analysis by Daunt *et al*. (2011a) suggested that the core foraging area for Guillemot lay in inshore waters to the west of Neart na Gaoithe and Inch Cape (and thus Alpha), with a further core immediately to the east of Neart na Gaoithe in the area of the Wee Bankie. A link to the latter explains the relatively high proportion of flights crossing Neart na Gaoithe.

6.2.224 On the basis of tracking in 2010, Project Alpha would appear to be too far from the Isle of May to be reached by breeding Guillemots. The question remains if this is also the case in other years, perhaps when resources are less abundant close to the colony. A review of previous data by Daunt *et al*. (2011c) albeit using less sophisticated technology does indicate that this is indeed likely to the case, with even 90% kernels indicative of general use not extending to Project Alpha in any of the study years. In some years however (e.g. 1999) core range is likely to include Neart na Gaoithe but not Inch Cape.

6.2.225 In conclusion, it would appear that Guillemots in Project Alpha are most likely to originate from Fowlsheugh SPA, with some contribution from smaller colonies in Kincardine and Deeside and Angus. The flight direction of birds in Project Alpha reinforces this conclusion with a clear flight axis from southeast (from the colony) and especially northwest to the colony (Table 6.37). Further supplementary evidence of the link with Fowlsheugh or at least colonies to the northwest is provided by the records of birds carrying prey, with this focussed in Alpha and petering out in Bravo, consistent with a trajectory of returning birds to the northwest (Figure 6.33).

Table 6.37 Number and proportion (%) of flight directions recorded for Guillemot during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	147	81	25	143	64	136	154	664	7
	%	10.34	5.70	1.76	10.06	4.50	9.57	10.84	46.73	0.49
Breeding season	Count	61	30	18	98	43	97	52	269	2
	%	9.10	4.48	2.69	14.63	6.42	14.48	7.76	40.15	0.30

6.2.226 Outside the breeding season, the Guillemots that could utilise Alpha may be drawn from an extremely large pool. More than 200,000 adults are within mean maximum +1SD foraging range, which could provide a minimum population of 300,000 individuals accounting for non-adults. This is in line with observations of huge concentrations of moulting flightless adult Guillemots and young off the east coast of Scotland (Forrester *et al.* 2007). August surveys up to 65 km offshore between Fraserburgh, Aberdeenshire and Montrose in Angus produced 326,000 individuals in 1984, 165,000 individuals in 1985 and 238,000 individuals in 1994.

6.2.227 In fact, Skov *et al*. (1995) estimated that 1.8 million birds may be present in the North Sea after breeding. Assuming equal mixing of populations, the potential effects on any particular colony may be apportioned according to its size against this total estimated population.

Project Bravo

6.2.228 As for Project Alpha, there was no evidence from GPS tracking (Figure 6.32, Table 6.34) that Guillemot from the Isle of May or thus indeed any part of the Forth Islands SPA would reach Project Bravo. There was also no evidence that this was likely in years of reduced resources (Daunt *et al*. 2011c).

6.2.229 The flight direction of birds recorded in Bravo with dominance of a northwest flight direction is supportive of a link to Fowlsheugh situated to the northwest of the site (Table 6.38). The number of birds carrying fish to provision chicks was much lower than that recorded in Alpha illustrating that much of Bravo may also be on the limit of foraging range from Fowlsheugh (Figure 6.33). The high density of birds in June 2011 may thus have mostly been comprised of failed and non-breeding birds as the first chicks did not appear until July, as opposed to June in 2010 (Appendix F1 Annex 7).

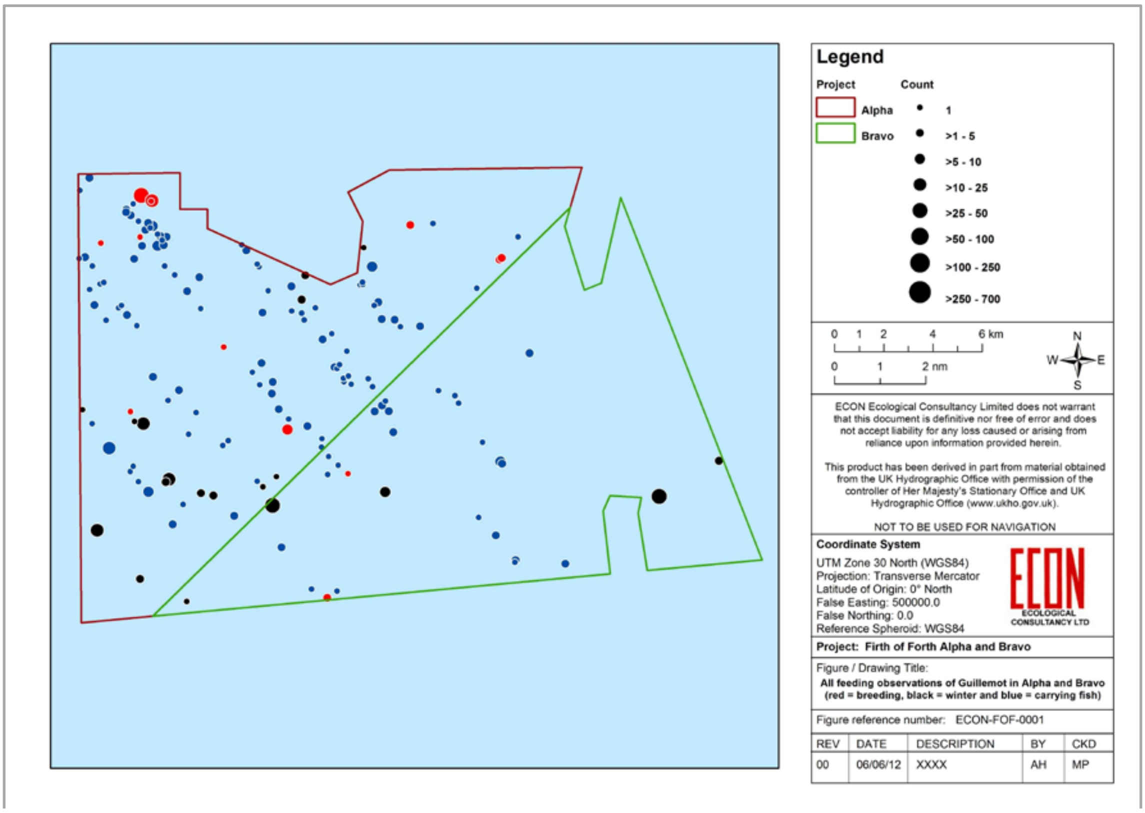


Figure 6.33 Distribution and group size of Guillemots carrying fish (blue) and feeding recorded in all surveys of Alpha and Bravo with the latter separated between the breeding season (red) and passage/winter period (black).

6.2.230 Outside the breeding season, the same scenario of the origin of birds as adopted for Alpha may be applied.

Table 6.38 Number and proportion (%) of flight directions recorded for Guillemot during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	203	116	29	98	55	117	142	599	2
	%	14.92	8.52	2.13	7.20	4.04	8.60	10.43	44.01	0.15
Breeding season	Count	37	16	9	25	36	30	20	168	1
	%	10.82	4.68	2.63	7.31	10.53	8.77	5.85	49.12	0.29

Summary of risks

6.2.231 Guillemot was ranked 20th of 26 seabirds in the vulnerability index to offshore wind farms considered by Garthe & Hüppop (2004) with factors such as the secure conservation status, large biogeographical population size and lack of flight activity and moderate tolerance to disturbance by ships and helicopters all contributing to this ranking. Dividing the main risks of collision and displacement, Furness & Wade (2012) ranked Guillemot 21st from 37 seabirds in terms of collision risk, but 11th in terms of potential displacement.

6.2.232 The flight agility of Guillemot is considered to relatively poor (Garthe & Hüppop 2004), but yet the potential for ecological effects from collision with turbines is generally minimal. This is predominantly a result of the species low flight height. Cook *et al*. (2011) derived a modelled proportion of flights above 20 m of 4.1% for Guillemot. Boat-based surveys of Alpha and Bravo derived an even lower proportion with <1% for Guillemots flying above 20m within the Alpha boundary and 1% for Bravo. Despite the high densities within both development sites, especially during the breeding season, extensive experience of collision risk modelling suggests that the potential for significant ecological impact through collision with turbines is extremely low in relation to large populations.

6.2.233 In contrast, there would appear to be potential for ecological impact due to displacement from the development sites as a result of the presence of high density during the breeding season. At this time, whilst there is potential for an effect on adults if the site concerned is of particular importance, it is much more likely that any impact of displacement would be manifested through the reduced potential for adults to successfully provision chicks. A reduction in provisioning rate as a result of exclusion from resources could potentially leading to reduced chick growth and development and thus enhanced vulnerability to predation.

6.2.234 Of the birds recorded, 5% and 2% of birds were exhibiting feeding behaviour within Alpha and Bravo respectively. Whilst this appears to be relatively low, the proportion of auks displaying feeding behaviours is always underestimated as this occurs underwater. In this case, feeding behaviour includes birds actively transporting prey back to chicks (131 within Alpha and 56 birds in Bravo) and whilst this does not conclusively demonstrate that foraging occurred within the area, the distribution of these records declining with distance across Alpha and Bravo does indicate that it is likely to broadly represent the location of feeding activity (Figure 6.32).

6.2.235 Moreover, disruption of active transport of prey through a barrier effect of the presence of turbines could conceivably have energetic consequences for both adults and the chicks they seek to provision. McDonald *et al*. (2012) have recently modelled the potential for barrier effects on the Guillemot population of the Isle of May in the presence of Neart na Gaoithe and concluded that displacement and barrier effects could affect time/energy budgets with consequences for breeding performance and/or survival (McDonald *et al*. 2012).

6.2.236 What remains less clear is whether birds will actually be displaced or if breeding birds will be subject to barrier effects. There appears to be no studies of the latter and the evidence for displacement at all is rather scant with some suggesting it could occur over several kilometres (e.g. Petersen *et al*. 2006) and others suggesting that it does not (e.g. at Egmond aan Zee – Krijgsveld *et al*. 2011).

6.2.237 In addition, to the evidence for displacement there is potential for construction in particular to influence the abundance and distribution of prey resources. Whilst this is typically thought to be of short-term duration, this may extend into the longer term for particularly sensitive species especially in relation to inappropriate timing of construction (Perrow *et al*. 2011).

6.2.238 Although Guillemot may be more adaptable than other auks in particular, as a result of less dependence on particular prey items, there is still potential for the footprint from the development sites to extend far beyond site boundaries, perhaps into core foraging areas for birds from several colonies. Although core areas are not specifically known for birds from Fowlsheugh, the fact that this is in relatively close proximity (~30 km) means that core areas may be affected. The core area for birds from the Isle of May (and probably other birds from within the Forth Islands SPA) is known to include Wee Bankie which could potentially be included within the footprint of construction.

Project Alpha

6.2.239 Given the potential for significant ecological impact on birds resulting from displacement, barrier effects and indirect effects on breeding birds, Guillemot is taken forward as a sensitive receptor for Project Alpha in the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I)

6.2.240 Potential impact upon birds originating from Fowlsheugh SPA in particular will also have to be considered within HRA. Further SPAs may have to be considered in relation to indirect effects if there is potential for construction noise and any impact upon fish to extend beyond the footprint of the development.

Project Bravo

6.2.241 As with Project Alpha, displacement, barrier effects and indirect effects on breeding Guillemots will be considered in the Impact Assessment of the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I) as a sensitive receptor.

6.2.242 Although Bravo is likely to be closer to the edge of range for breeding Guillemots from Fowlsheugh, any impact on the SPA will have to be considered in HRA, especially in relation to indirect effects should construction noise and any impact upon fish to extend beyond the footprint of the development.

Razorbill

Population ecology

6.2.243 Razorbill is far less numerous seabird than Guillemot with a World population estimated at 610,000 - 630,000 pairs (Mitchell *et al.* 2004). All breed in the northern Atlantic (Brown & Grice 2005), with 75% of its global range within Europe (BirdLife International 2004). With a secure population of >430,000 pairs, Razorbill has a 'Favourable' conservation status in a European context.

6.2.244 The UK supports 187,100 breeding individuals of the race *islandica*, which is some 20.2% of the world population of all Razorbills (JNCC 2011). Razorbill is 'Amber'-listed as a species of conservation concern in the UK as at least 50% of the breeding population is found in ten or fewer sites (Eaton *et al.* 2009). The UK population peaked in 2005 with a 22% decline since, although there was an overall increase of 1% in the period 2000-2010 (JNCC 2011).

6.2.245 There was catastrophic breeding failure in 2004, 2007, 2008 and 2010. This coincided with food shortages, especially notable at colonies in the north and east of the UK and, at the colony on the Isle of May in the Firth of Forth, a decrease in the energy content of fish brought to chicks. The association of years of low Razorbill productivity with rising sea surface temperatures due to climate change is uncertain, though there are indications that declines in the productivity of sandeels may be linked in complex ways to warming sea temperatures.

6.2.246 Razorbill colonies are located along all coasts of Britain and Ireland, although the majority occur in Scotland and the west coasts of Wales, England and Ireland. Razorbill often shares breeding colonies with Guillemot, albeit generally nesting in crevices rather than on open cliff ledges (Lloyd *et al.* 1991). A single egg is laid during late April or early May, with both parents participating in incubation (Cramp *et al.* 1974). The majority of chicks hatch in June and fledge in July. Like Guillemot, adults accompany their chicks when they leave the colony (Cramp *et al.* 1974).

6.2.247 There is much overlap between the prey taken by Razorbills and Guillemots in that both species consuming prey such as sandeels and clupeids, although there are some clear differences in their feeding ecology (Ouwehand *et al.* 2004). Razorbills are more specific in their prey choice, favouring smaller shoaling species and rarely dive deeper than 35 metres and often much less (Benvenuti *et al.* 2001). 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 reproductive and fledging success and post fledging mortality between the two species at any colony.

6.2.248 The main wintering areas of Scottish breeding Razorbills are along the coasts of the North Sea, western Britain, the English Channel and the Bay of Biscay, with many young birds wintering further south off western Iberia and North Africa. Most breeding birds have returned to colonies by the end of March (Forrester *et al.* 2007).

Density distribution and population size

Project Alpha

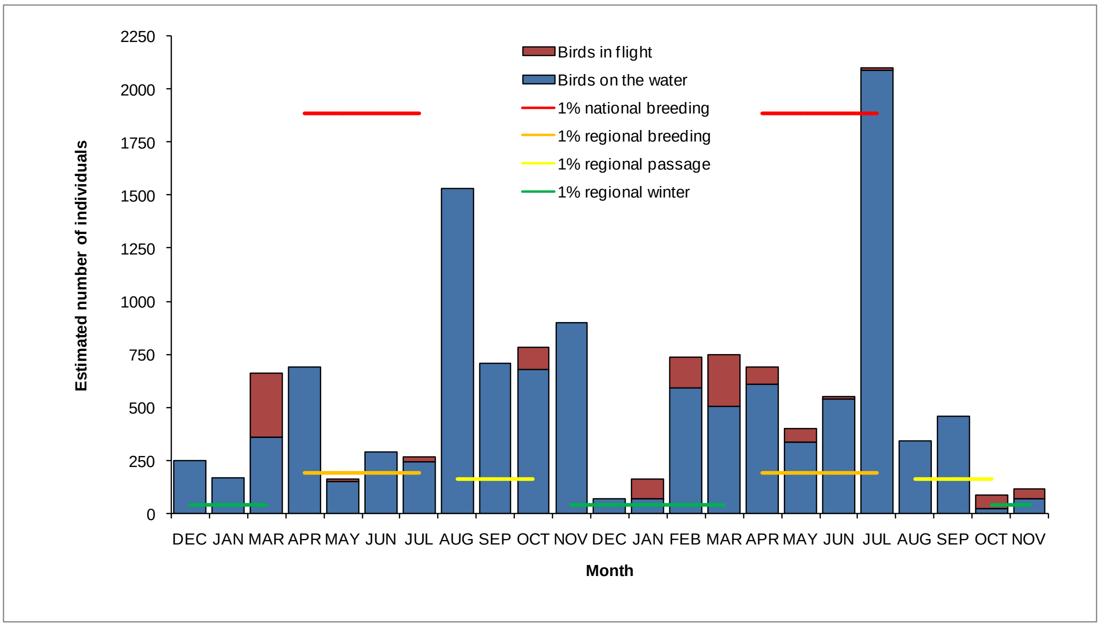
6.2.249 Razorbill was observed within the Bravo site boundary in all boat-based surveys, with some differences in seasonal patterns between the two years. In both years however, estimates were relatively high immediately before and at the start of the breeding season followed by a decline during the incubation/chick provisioning periods in May and June. A peak in abundance followed at the end of the breeding season in July in 2011, with the peak after the breeding season in August in 2010. Populations then remained relatively high during autumn passage period in 2010, whereas they were generally lower in 2011 (Figure 6.34).

6.2.250 The overall peak population estimate recorded in July 2011 of 2,091 Razorbill, exceeded the national 1% breeding threshold of 1,886 birds (Figure 6.34), resulting from a DISTANCE corrected density for birds on the water of 10.6 ind. km^{-2} (UCI 17.0 ind. km^{-2}) (Figure 6.35), compared with 4.7 ind. km^{-2} (Appendix F1 Annex 1) derived from simple correction factors created from data from the wider Zone. With the exception of May 2010, all other estimates in the breeding season exceeded the regional 1% threshold, with population sizes ranging from 163 to 694 individuals in 2010 and from 402 to 2,102 individuals in 2011 (Figure 6.34).

6.2.251 With the exception of October 2011, the regional 1% threshold for the passage period was exceeded in every survey, to a peak estimate of 1,535 birds in August, the highest value for 2010 (Figure 6.34). At this time, 48% of the birds recorded were adults with fledgling chicks showing dispersal from colonies (Appendix F1 Annex 7). Winter surveys recorded comparable numbers of birds in both years with between 660 and 742 individuals, generally exceeding regional thresholds (Figure 6.34).

6.2.252 The mean densities by month (Table 6.39) exceed those derived by Stone *et al*. (1995) for the western North Sea in March, July and August (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}) adjacent to Project Alpha in August. The peak over 10 individuals km^{-2} in July is within the range previously recorded in parts of the Firth of Forth in June/July by Camphuysen (2005).

Project Alpha



Project Bravo

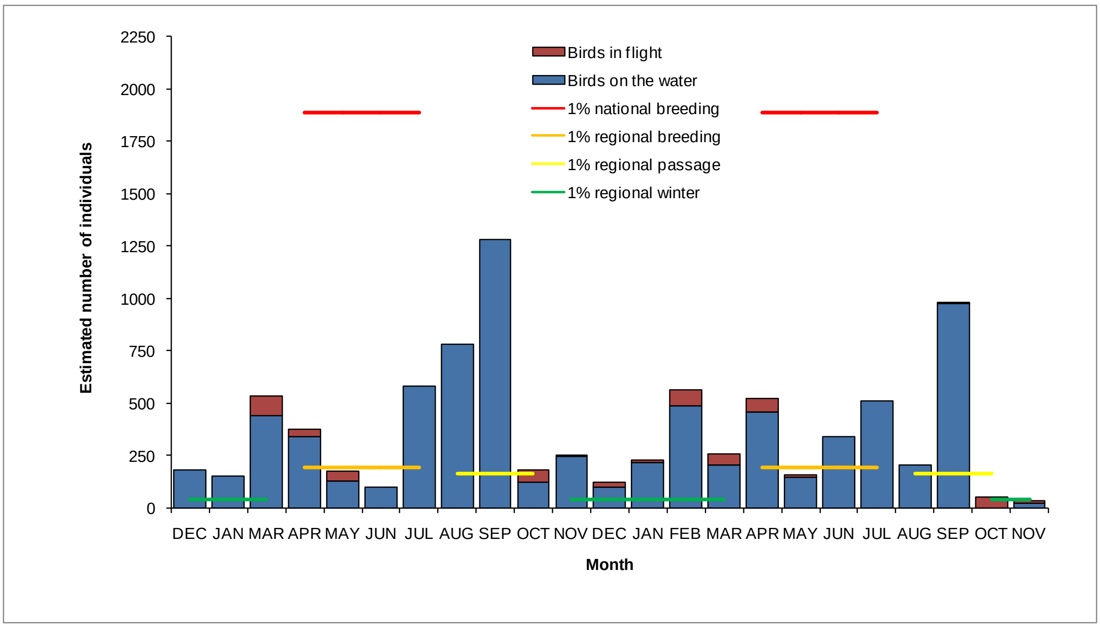


Figure 6.34 Razorbill population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from DISTANCE-corrected density of birds on the water combined with density derived from snapshots of birds in flight. Criteria for regional importance in the breeding, passage and winter periods are shown with criteria for national importance in the breeding season also shown for Alpha.

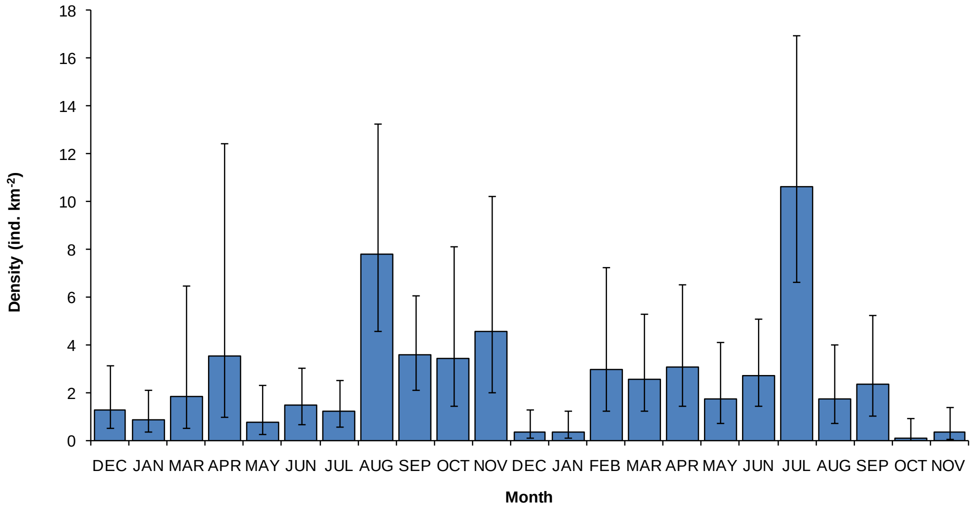


Figure 6.35 Monthly mean (± 95% confidence intervals) density of Razorbill in Project Alpha as derived from DISTANCE correction of birds on the water.

Table 6.39 Monthly mean (± 1SD) density of Razorbill in Project Alpha and Bravo as 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
Alpha	0.8 ± 0.1	3.7	3.6 ± 0.3	3.5 ±0.1	1.4 ± 0.9	2.1 ± 0.9	6.0 ± 6.6	4.8 ± 4.3	2.9 ± 0.9	2.0 ± 2.5	2.5 ± 2.8	0.8 ± 0.6
Bravo	1.0 ± 0.3	2.9	2.1 ± 1.0	2.3 ± 0.5	0.9 ± 0.1	1.1 ± 0.9	2.9 ± 0.3	2.5 ± 2.1	5.9 ± 1.1	0.6 ± 0.5	0.8 ± 0.8	0.8 ± 0.2

6.2.253 A greater proportion (11.7%) of Razorbills were aged compared to Guillemots in the surveys of Projects Alpha and Bravo combined. The contrast between the proportion of birds aged with a single bird (3%) or with two together (26.4%) was also more apparent. This again highlights the increase confidence of ageing an adult bird when with a fledged chick. Assuming that all birds recorded during the breeding season were adults unless stated otherwise, 95.3% would be considered to be adult. In Alpha, of the n = 40 birds aged during the breeding season of April to July, 62.5% were recorded as adults (Table 6.40).

Table 6.40 Number and proportion of adult Razorbills relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	0	0	0	0	6	1	18	61	0	0	0	0
%	-	-	-	-	100	66.7	86.7	57.5	16.7	78.6	-	50.0
Total	0	0	0	0	6	2	32	108	0	0	0	0

6.2.254 In general, despite the regionally important numbers recorded throughout the study period, the distribution of Razorbill across the site was patchy in both the breeding season and in the passage (and including winter) period when a greater density of birds was generally present (Figure 6.36). The density of Razorbills did not match that of Guillemots (see Figure 6.26) with patches rarely >10 individuals km^{-2} in summer and >25 individuals km^{-2} on passage and in winter.

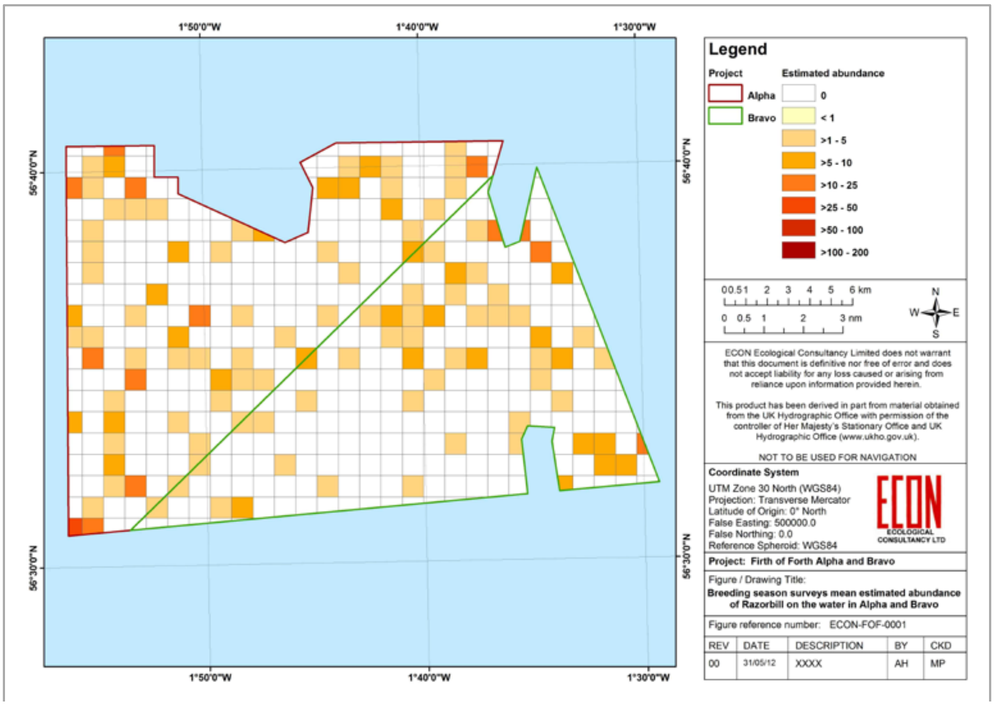
6.2.255 Moreover, there was some difference in distribution between the two breeding seasons with the majority of the records in the northeast corner of the site in 2010, whereas in 2011, the majority of the birds were observed along the western edge of Project Alpha close to Scalp Bank. The latter period incorporates the high density of birds in July of that year (Figure 6.37).

Project Bravo

6.2.256 The seasonal pattern established from boat-based surveys largely corresponds to that for Alpha, with the exception that the numbers continued to increase from June through to September in 2010. The seasonal pattern of a peak at the end of the winter period and then at the end of the breeding season, with an overall peak recorded during the dispersal from colonies, was observed in both years (Figure 6.33). In general, the higher peaks were recorded in 2010.

6.2.1 Population estimates were generally lower within Project Bravo than in Alpha, although the 1% regional threshold for the breeding season was still exceeded on most occasions (with the exception of June 2010 and May 2011) with a range of 97 to 583 birds in 2010 and 156 to 521 birds in 2011 (Figure 6.34).

6.2.2 The peak population estimates were recorded in September in both years with estimates of 1,293 and 994 birds in 2010 and 2011 respectively. In 2010, the DISTANCE corrected estimate for birds on the water was 6.7 individuals km^{-2} (UCI 11.0 ind. km^{-2}). The highest density for 2011, 5.1 ind. km^{-2} (UCI 8.8 individuals km^{-2}) (Figure 6.38), was only increased by 0.05 ind. km^{-2} with the addition flying birds in snapshots.



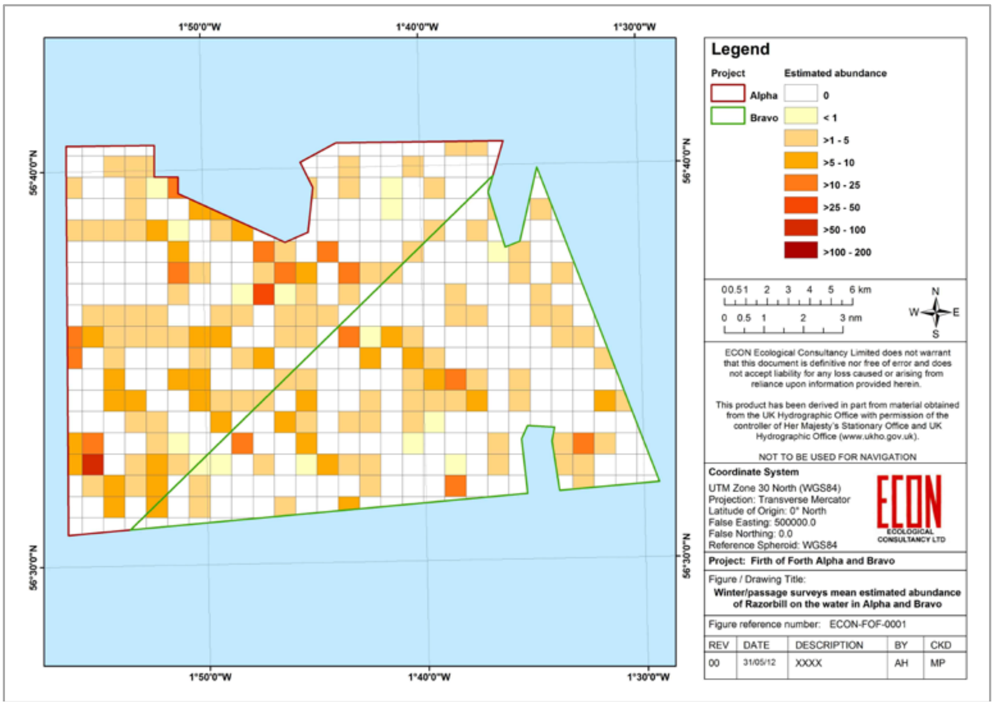
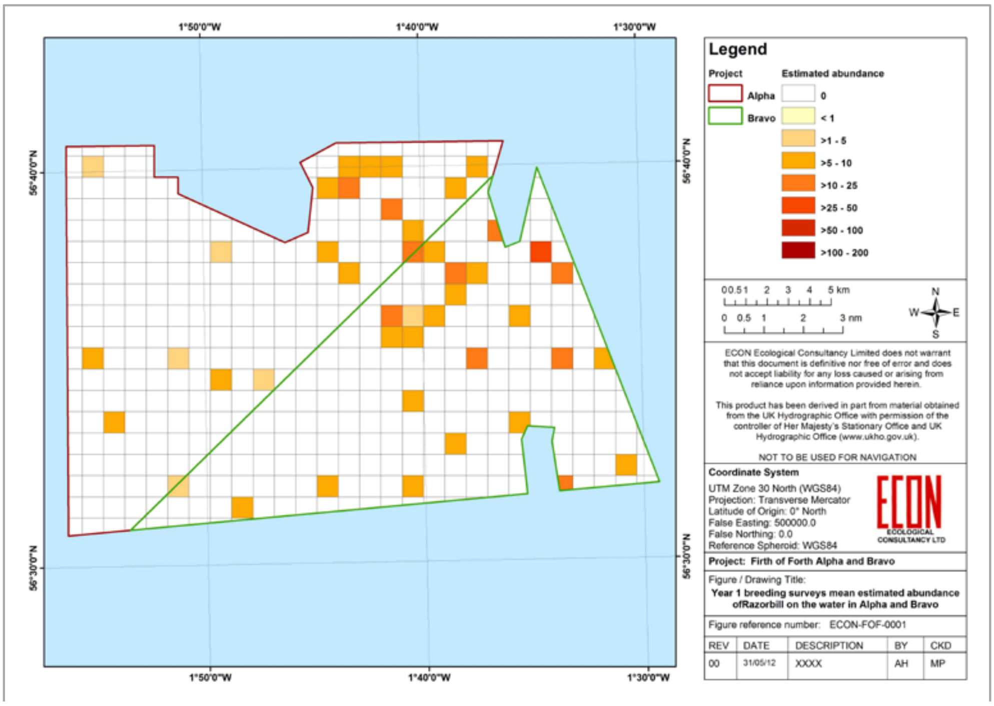


Figure 6.36 Relative abundance of Razorbill expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August (above) compared to the passage/winter period (below).



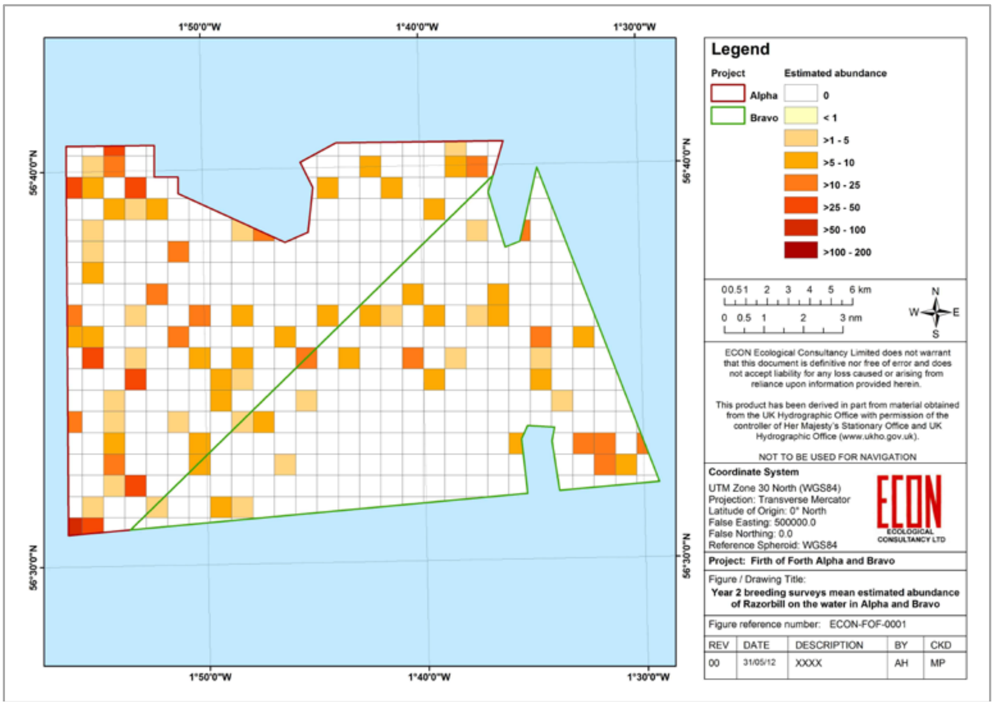


Figure 6.37 Relative abundance of Razorbill expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to July in 2010 (above) compared to 2011 (below).

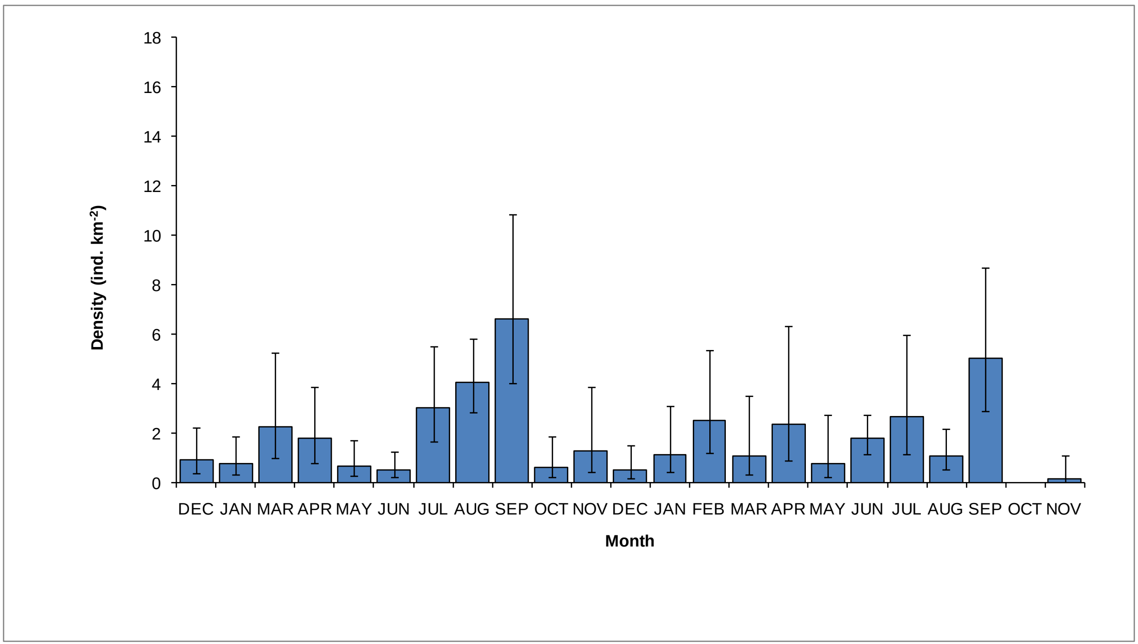


Figure 6.38 Monthly mean (± 95% confidence intervals) density of Razorbill in Project Alpha as derived from DISTANCE correction of birds on the water.

6.2.3 With the exception of January and September, the monthly means calculated for Bravo were lower than those of Alpha (Table 6.31). The September mean density of 5.9 individuals. km^{-2} approaches that of Scalp Bank to Aberdeen Bank (7.1 individuals km^{-2}) and exceeds that of Wee Bankie to Farn Deeps (1.2 individuals km^{-2}), documented by Skov *et al*. (1995) between the months of July to September. Even the peak densities recorded are well within the range of the 2-10+ individuals km^{-2} recorded in different parts of the Firth of Forth in June/July by Camphuysen (2005).

6.2.4 In general, Razorbill distribution in the Bravo development site was patchy, with particularly the central to southern areas of the site, supporting no records of the species especially in the breeding season (Figure 6.35). This pattern is especially evident considering the two breeding seasons separately (Figure 6.37).

Foraging range and potential origin

6.2.5 Razorbill has a mean maximum foraging range of 48.5 km and a mean maximum foraging range + 1SD of 83.5 km (Figure 6.39), which means that 8,331 and 19,395 individuals respectively breed within each range (Table 6.41). These birds are distributed amongst 45 colonies (26 in mean max foraging range) extending along the Scottish coastline from north of Aberdeen in the north down to Berwick-upon-Tweed (Figure 6.39).

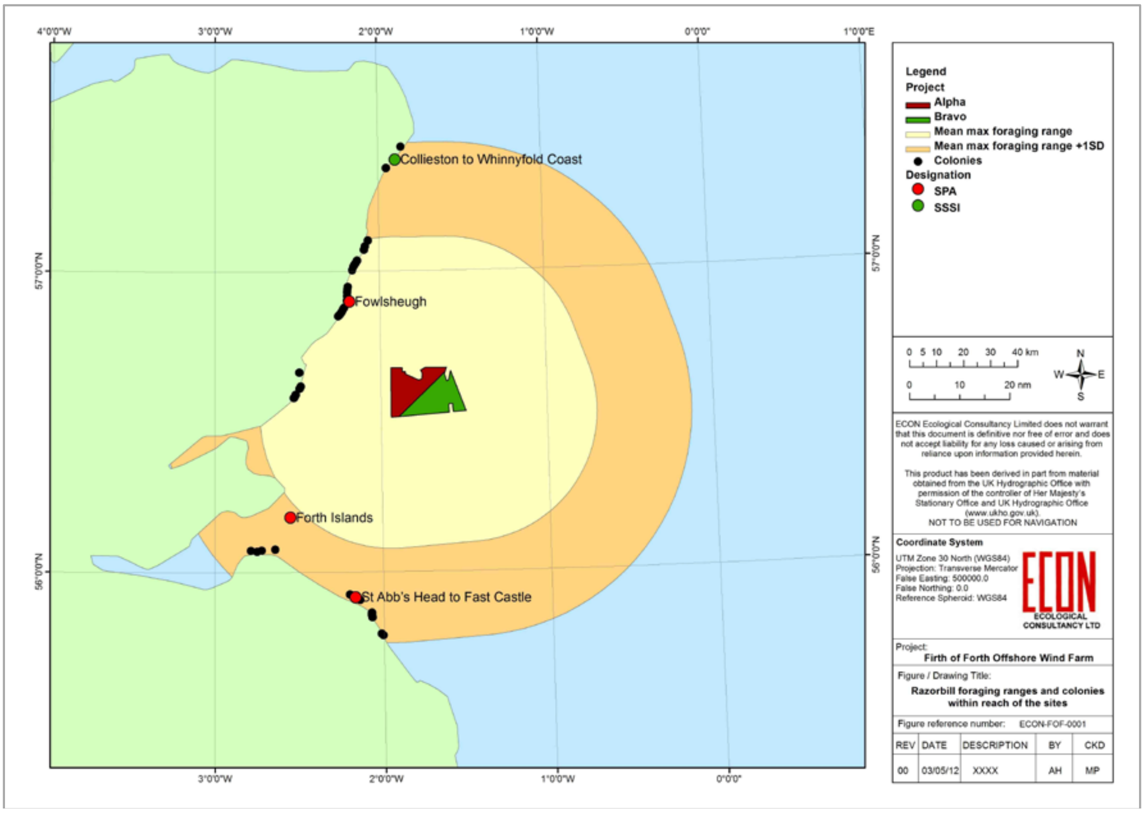


Figure 6.39 Distribution of Razorbill breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.2.6 Within mean maximum foraging range Razorbill is designated at one SPA (Fowlsheugh), with a further two (Forth Islands SPA and St. Abb's to Fast Castle SPA) containing four SSSIs within the mean maximum +1SD foraging ranges. The individual Fowlsheugh colony represents 4% of all the colonies within mean maximum range, with the proportion of designated colonies increasing to 22% within the entire mean maximum +1SD range.

6.2.7 Based on the number of birds contained within the Fowlsheugh SPA (4,632 individuals) the proportion of Razorbills within SPAs within the mean maximum foraging range is 56% (from a total of 8,331 individuals). The proportion increases slightly to 58% within the mean maximum + 1SD range, with 11,255 individuals within SPAs from a total of 19,395 individuals (Table 6.41).

Table 6.41 Details of all Razorbill breeding colonies at increasing distance from Projects Alpha or Bravo and within mean maximum and mean maximum ± 1SD foraging ranges (48.5 and 83.5 km respectively). 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.

Foraging range	Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
					Number	Year
	Catterline to Inverbervie	27.64		1,962	1,962	1999
Mean Max	Fowlsheugh SPA	30.41	5,800	6,362	4,632	2009
	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
	Isle of May	52.61		4,114	3,012	2011
Mean Max + 1 SD	St Abb's Head to Fast Castle SPA	67.90	2,180	2,875	2,348	2008
	Forth Islands SPA	68.99	2,800	564	734	2011
	Eyemouth to Burnmouth	73.35		377	377	2000
	Sands Of Forvie	74.05		30	90	2010
	Berwick to Scottish Border	80.45		48	48	2000
	Collieston to Whinnyfold Coast SSSI	81.85		3,044	4,275	2007

Project Alpha

6.2.8 As for Guillemot, the largest Razorbill colony in the area, the SPA-designated colony at Fowlsheugh is also the second closest at 30 km to the north-west. The other two SPA-designated colonies in the area, at Forth Islands and St Abb's Head to Fast Castle, are both almost 70 km away.

6.2.9 Of the trips undertaken by GPS tracked Razorbills breeding on the Isle of May in the Forth Islands SPA (Daunt *et al.* 2011a), only a low proportion (1.8%) reached Project Alpha correspond to 0.11 trips per bird (Table 6.42). In fact, this was the result of two trips, with one just reaching the southwestern corner of Alpha and the other crossing the western half of Alpha (Figure 6.40).

Table 6.42 Number and proportion (% in parentheses) of trips obtained by GPS tagged breeding Razorbills from the Isle of May crossing the different proposed wind farm sites. Data are expressed for all trips and mean by bird.

Subject	Trips	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	110	2 (1.82)	0	5 (4.55)	7 (6.36)
Mean by bird	6.11	0.11 (3.70)	0	0.28 (6.36)	0.39 (6.36)

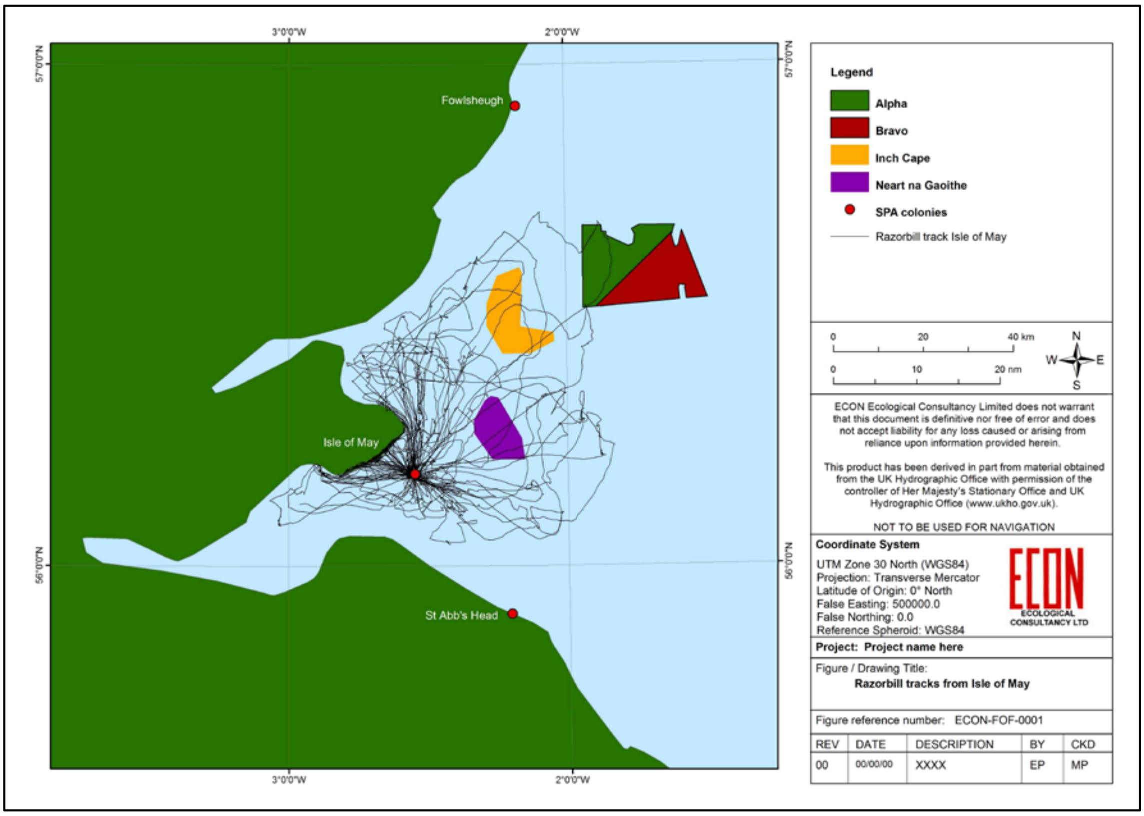


Figure 6.40 Tracklines of breeding Razorbills fitted with GPS tags from Isle of May (*n* = 18) in 2010.

6.2.10 A higher proportion of trips were observed in both Neart na Gaoithe and Inch Cape (Table 6.42) which is perhaps to be expected considering these sites are closer to the Isle of May than Alpha. However, the proportion was still relatively low at 4-6% irrespective of whether this was considered by trip or as a mean by bird. Similarly, only a low percentage of the distance travelled (<1%) was noted for both STW sites as well as Alpha (Table 6.43)

Table 6.43 Distance (km) and proportion (% in parentheses) of trips obtained by GPS tagged breeding Razorbills from the Isle of May, Fowlsheugh and St Abb's Head within the different proposed wind farm sites. Data are expressed for all trips and mean by bird.

Subject	Total distance (km)	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	4,514.14	32.26 (0.71)	0	50.04 (1.11)	41.33 (0.92)
Mean by bird	250.79	1.79 (0.66)	0	2.78 (0.91)	2.30 (0.76)

6.2.11 Considering the behaviours of birds derived from the GPS fixes themselves, the proportion of non-flight behaviour indicative of foraging tended to be slightly higher for Alpha in comparison to Neart na Gaoithe and Inch Cape (Table 6.44). The pattern illustrated the tendency of Razorbills to commute across the sites closer to the colony. However the proportion of fixes in Alpha and all sites combined was still low overall (2.6% of all fixes and 2.5% of non-flight fixes) illustrating the relative unimportance of the sites to foraging Razorbills.

Table 6.44 Number and proportion (% in parentheses) of total fixes according to different behaviours (combined behaviour = CB, flight = F and non-flight = NF) obtained for GPS tagged breeding Razorbills from the Isle of May within the different proposed wind farm sites. Data are expressed for all trips and as a mean by bird.

Subject	Activity	Total Fixes	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	CB	19,462	329 (1.69)	0	117 (0.60)	57 (0.29)
	F	4,291	25 (0.58)	0	54 (1.26)	44 (1.03)
	NF	15,171	304 (2.00)	0	63 (0.42)	13 (0.09)
By bird	CB	1,081.22	18.28 (1.35)	0	6.50 (0.49)	3.17 (0.23)
	F	238.39	1.39 (0.63)	0	3.00 (1.06)	2.44 (0.88)
	NF	842.83	16.89 (1.53)	0	3.50 (0.34)	0.72 (0.06)

6.2.12 The kernel analysis conducted by Daunt *et al*. (2011a). showed the core of foraging distribution to the close to the shore both to the west and especially north of the colony, but with smaller important patches further offshore especially in association with the Wee Bankie area. Birds commuting to the Wee Bankie may cross Neart na Gaoithe, explaining the moderate proportion of trips crossing the site (Table 6.42). No part of Alpha falls within core range.

6.2.13 Previous information for razorbill reviewed by Daunt *et al*. (2011c) affirms that no part of Alpha is likely to fall within core range. However, in some years such as 1999 and 2006 core range did include the area to be occupied by Neart na Gaoithe.

6.2.14 Flight directions of Razorbills recorded during boat-based surveys of Project Alpha show a preponderance of northwesterly flights indicative of return to Fowlsheugh, the largest colony within mean maximum range (Table 6.45). However, unlike for

Guillemot (Figure 6.33) there was no indication of Razorbills transporting prey back to the colony (Figure 6.41), with relatively few records of feeding behaviour in the breeding season compared to the passage/winter period.

Table 6.45 Number and proportion (%) of flight directions recorded for Razorbill during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	66	25	20	2	29	33	37	196	1
	%	16.14	6.11	4.89	0.49	7.09	8.07	9.05	47.92	0.24
Breeding season	Count	25	4	5	2	5	4	14	36	1
	%	26.04	4.17	5.21	2.08	5.21	4.17	14.58	37.50	1.04

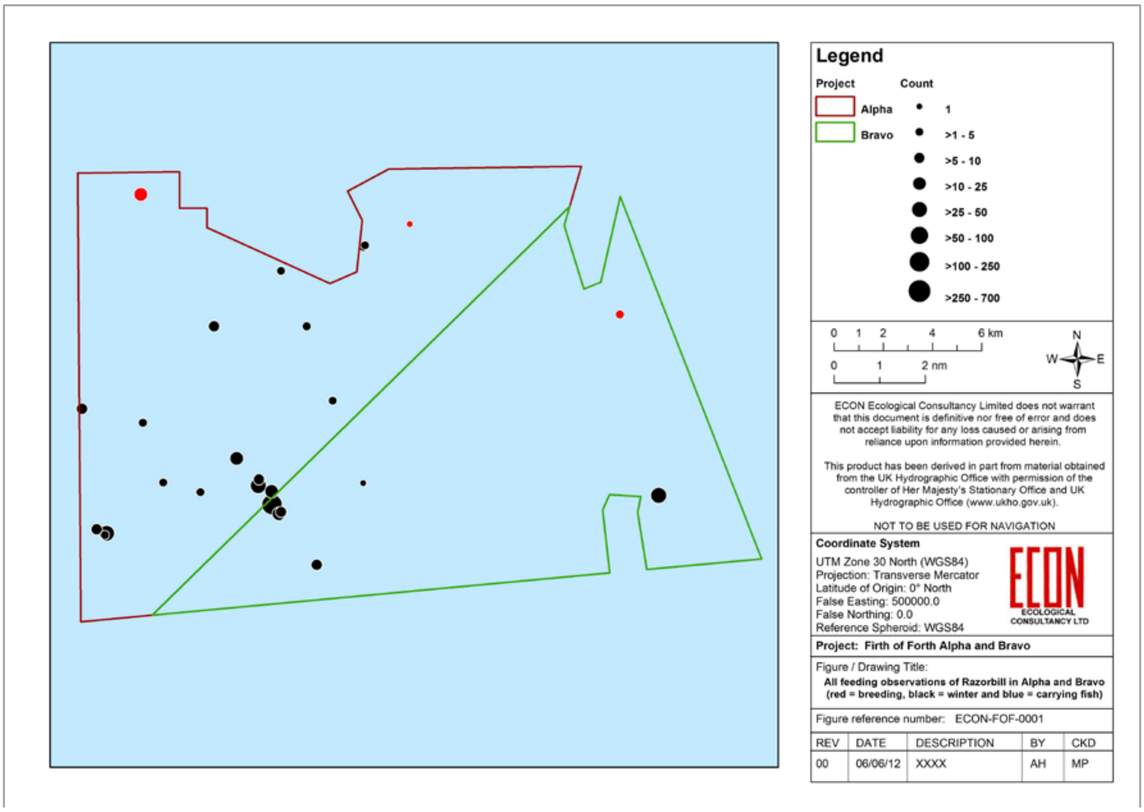


Figure 6.41 Distribution and group size of feeding Razorbills recorded in all surveys of Alpha and Bravo in the breeding season (red) and passage/winter period (black).

6.2.15 In conclusion, it would seem that although birds from Fowlsheugh are likely to form the bulk of the relatively low density of birds in the breeding season present on Alpha, some birds other smaller, non-designated colonies as well as from the Forth Islands SPA (at least the Isle of May) may reach the site. However, Alpha does not appear to be a particularly important foraging ground. Previous surveys (e.g. Skov *et al.* 1995) suggest Scalp Bank to the west of Alpha are more important.

6.2.16 Outside the breeding season, in the passage period Razorbills from all colonies within mean maximum range during the breeding season comprising >19,000 birds scaled to some 28,500 to include non-breeders and immatures (Wetlands International 2006) could be recorded in Project Alpha. In fact, the pool of birds that could be represented is likely to much larger than this as whilst a proportion of Scottish breeders along the east coast remain in Scottish coastal waters in the North Sea, other birds move south and are replaced by those from Iceland and other more northerly breeding areas. The pool of birds during passage may be in the order of 300,000 increasing to around 440,000 in winter (Skov *et al*. 1995). Assuming equal mixing, any effect on a particular colony may be apportioned in proportion to its abundance relative to this total.

Project Bravo

6.2.17 In contrast to Alpha, the results of the GPS-tracking study on the Isle of May (Daunt *et al.* 2011a) showed that no foraging activity occurred in Bravo (Table 6.42). It thus seems most likely that birds present in the breeding season thus seem most likely to originate from Fowlsheugh, with a few perhaps representing smaller non-designated colonies. The flight directions of birds in the breeding season in Project Bravo are less conclusive in that northerly flight directions are the most common, although northwesterly is also represented (Table 6.37). Any bias may result from the relatively small sample size of birds.

Table 6.46 Number and proportion (%) of flight directions recorded for Razorbill during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	41	13	5	9	16	29	16	86	1
	%	18.98	6.002	2.31	4.17	7.41	13.43	7.41	39.81	0.46
Breeding season	Count	13	3	0	0	2	5	1	9	1
	%	38.24	8.82	0.00	0.00	5.88	14.71	2.94	26.47	2.94

6.2.18 The apparent unimportance of Project Bravo in keeping with its generally greater distance from colonies is further suggested by only one feeding group in the breeding season (Figure 6.41) compared to some relatively large feeding aggregations at other times.

Summary of risks

6.2.19 Razorbill was ranked 13th of 26 seabirds in the vulnerability index to offshore wind farms considered by Garthe & Hüppop (2004). Greater conservation concern and smaller biogeographical population size were key differences compared to Guillemot.

Dividing the main risks of collision and displacement, Furness & Wade (2012) ranked Razorbill 19th from 37 seabirds in terms of collision risk, but 12th in terms of potential displacement (i.e. very similar to Guillemot)

6.2.20 The potential for ecological effects from collision with turbines is generally thought to be minimal as a result of the species low flight height. Cook *et al*. (2011) derived a modelled proportion of 6.8% for birds flying at risk height (>20 m) for Razorbill, which contributed to a ranking above Guillemot in the context of sensitivity to collision (Furness & Wade 2012). In Alpha, 22% of birds were observed in flight with only 1.2% of birds at >20 m, whereas in Bravo, of the 16% of Razorbill recorded in flight in the Bravo development site, no birds were observed flying above 20 m. The potential impact from collision with turbines appears to be extremely low and therefore does not require further examination.

6.2.21 In contrast, >75% of birds recorded in both Alpha and Bravo were on the water surface on the water with 9% of birds engaged in foraging activity in Alpha exhibiting direct feeding behaviour with 18% within Bravo including 200 Razorbills in a single multi-species foraging association. The bulk of these records were however outside of the breeding season, although given the peaks immediately before and at the end of the breeding season, birds from local colonies seem likely to be involved.

6.2.22 As argued for Guillemot, the potential for barrier and indirect effects upon Razorbill cannot be discounted at this stage particularly since links to important colonies at Fowlsheugh and even the Forth Islands SPA (through tracking) have been broadly established. In relation to indirect effects in particular, there appears to be evidence that Scalp Bank is an important site for Razorbill perhaps both in and out of the breeding season. Scalp Bank is immediately adjacent to Project Alpha and the potential for the footprint from both development sites to extend beyond site boundaries into Scalp Bank or even perhaps to Wee Bankie, known to be within the core foraging range of Razorbill from the Isle of May, requires consideration in EIA.

Project Alpha

6.2.23 Given the potential for significant ecological impact on birds resulting from displacement, barrier effects and indirect effects on breeding birds, Razorbill is taken forward as a sensitive receptor for Project Alpha in the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

6.2.24 Potential impact upon birds originating from Fowlsheugh SPA in particular but also perhaps Forth Islands SPA will also have to be considered within HRA. Both these SPAs and perhaps others will have to be considered in relation to indirect effects if there is potential for construction noise and any impact upon fish to extend beyond the footprint of the development.

Project Bravo

6.2.25 Although the potential for significant ecological impact on Razorbill from displacement, barrier effects and indirect effects of construction on prey is lower than that for Alpha, given the greater distance from colonies, these aspects still require consideration in EIA. Razorbill is therefore taken forward as a sensitive receptor for Project Bravo in the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

6.2.26 In relation to HRA, potential impact is limited to birds originating from Fowlsheugh SPA, although SPAs at greater distance may have to be considered if there is potential for construction noise and any impact upon fish to extend beyond the footprint of the development.

Atlantic Puffin

Population ecology

6.2.27 The global population of Puffin is estimated at 5.5 -6.6 million breeding pairs (Mitchell *et al.* 2004). In northwest Europe, Puffin is widespread but patchily distributed, comprising 75% of its global breeding range. Despite a recent increase, numbers are still below the pre-1970 level, and the population is classified as Depleted (BirdLife International 2004) and thus of European conservation concern.

6.2.28 In the UK there are 580,700 breeding pairs of which 85% breed in Scotland, representing ~10% of the World population, (JNCC 2011). Puffin has 'Amber' status of conservation concern in the UK as a result of being of European conservation concern and having a localised breeding population with at least 50% of birds breeding at 10 or fewer sites (Eaton *et al.* 2009).

6.2.29 The logistical difficulties of monitoring Puffin colonies means that few data are collected annually, and hence trends are difficult to determine. The UK Puffin population increased until at least Seabird 2000, and possibly beyond, as counts from two of the largest colonies at the Farne Islands and the Isle of May produced even greater numbers in 2003. However, a substantial decline at these two colonies was then recorded between 2003 and 2008/9. It is not known whether these decreases are representative of the UK as a whole (JNCC 2011).

6.2.30 Reasons for the decline in Puffin populations have been attributed to food shortage. The main prey species in the UK is the lesser sandeel *Ammodytes marinus*, although small clupeids such as Herring and Sprat are consumed when available. Birds dive from the surface and pursue prey underwater and may make multiple captures normally made at depths of no more than 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 coldwater plankton, the key prey of sandeels, and encouraged organisms that favour warm conditions such as Snake Pipefish *Entelurus aequoreus*. Although eaten by

Puffins, the latter are of poor nutritional value and difficult for chicks to swallow (Grémillet & Boulinier 2009).

6.2.31 Recent research has also pointed to reduced overwinter survival as a factor in any population decline and efforts have been made to determine overwintering movements and behaviour of Puffins from the Isle of May (Harris *et al.* 2010). Most birds fitted with geolocators moved into the eastern Atlantic in early winter although the northwestern North Sea was most intensively used area. Movement was speculated to be a response to worsening conditions in the North Sea and the prospect of increased mortality. Moreover, evidence from Skomer has shown that adults exhibit complex and highly dispersive and individualistic migration patterns outside the breeding season that appear to be repeated year on year (Guilford *et al.* 2011). It would seem worthwhile to repeat patterns that have led to the bird surviving the winter and returning to the colony to breed.

6.2.32 Being an extremely pelagic seabird, Puffins only return to land to breed, with colonies on offshore islands and remote mainland cliffs being occupied from March to August. Puffins nest underground where there are few ground predators (Harris & Wanless 2011), and although the majority lay their eggs in disused rabbit burrows, the birds are also capable of excavating their own burrow. A single egg is laid during late April, which is incubated by both parents (Cramp *et al.* 1974). The majority of chicks hatch in June and remain in their burrow whilst being provisioned by their parents for the next six weeks. Thereafter, the chick is abandoned but its parents to fend for itself. The chicks leave their colonies during July and are thought to quickly move offshore (Forrester *et al.* 2007).

Density distribution and population size

Project Alpha

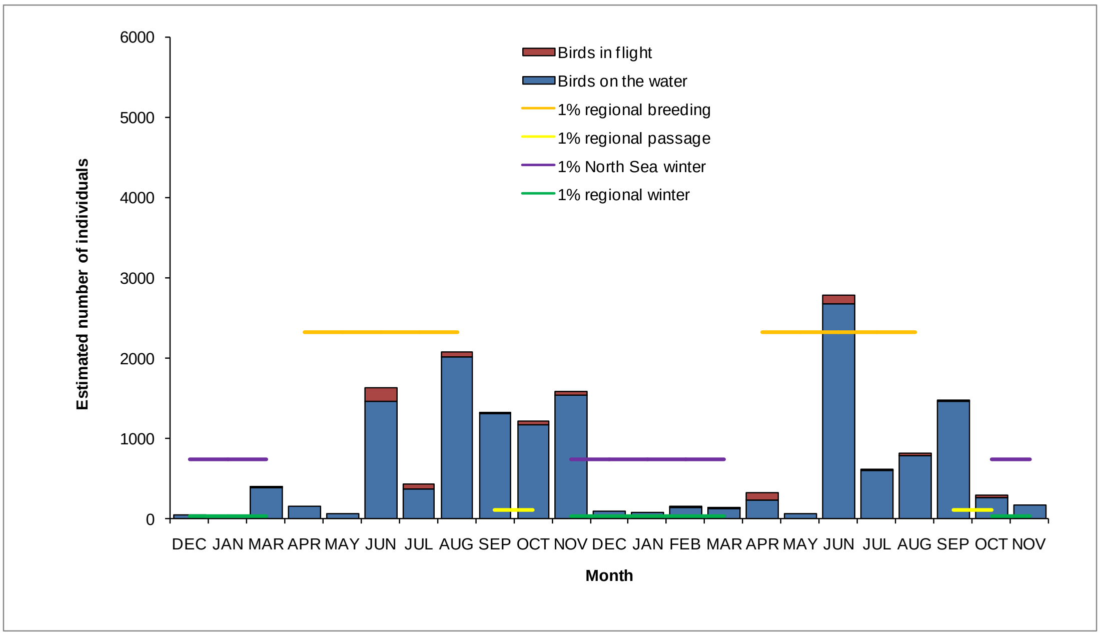
6.2.33 The seasonal pattern of Puffin in Alpha differed from the other auks, in that low numbers were present at the start of the year, before increasing midway through the breeding season during the chick provisioning period and maintaining relatively high numbers through to the passage period before dropping dramatically over winter (Figure 6.42). Puffins were consistently more abundant in Alpha in 2010, although the peak population estimate was recorded in June 2011.

6.2.34 The 1% regional population threshold was only exceeded once in the breeding season, with a population estimate of 2,787 individuals in June 2011. In 2010, the estimates ranged from 68 (May) to 2,080 birds (August), some 250 birds short of the threshold (Figure 6.41). The maximum density of 13.6 individuals km^{-2} derived from DISTANCE (Figure 6.42), was lower than that calculated using simple correction factors derived from for the wider Zone.

6.2.35 All surveys recorded values above the 1% threshold for the passage period, with peaks of 1,420 and 1,481 individuals in 2010 and 2011 respectively. The estimate was further surpassed in the winter in November 2010, when an estimated 1,578

Puffins were present, surpassing the 1% threshold for the North Sea during the winter (Skov *et al*. 1995). This DISTANCE-derived estimate was more than double the density derived applying the simple correction factor.

Project Alpha



Project Bravo

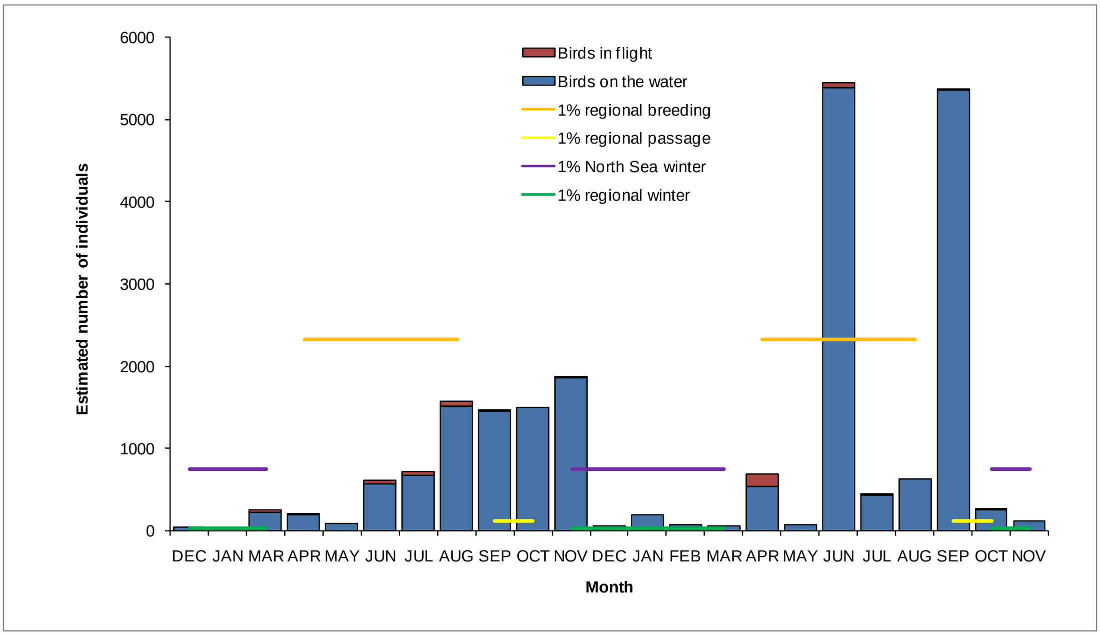


Figure 6.42 Puffin population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from DISTANCE-corrected

density of birds on the water combined with density derived from snapshots of birds in flight. Criteria for regional importance in the breeding, passage and winter periods are shown with criteria for 'super-national' importance (at the scale of the North Sea) in the winter season also shown.

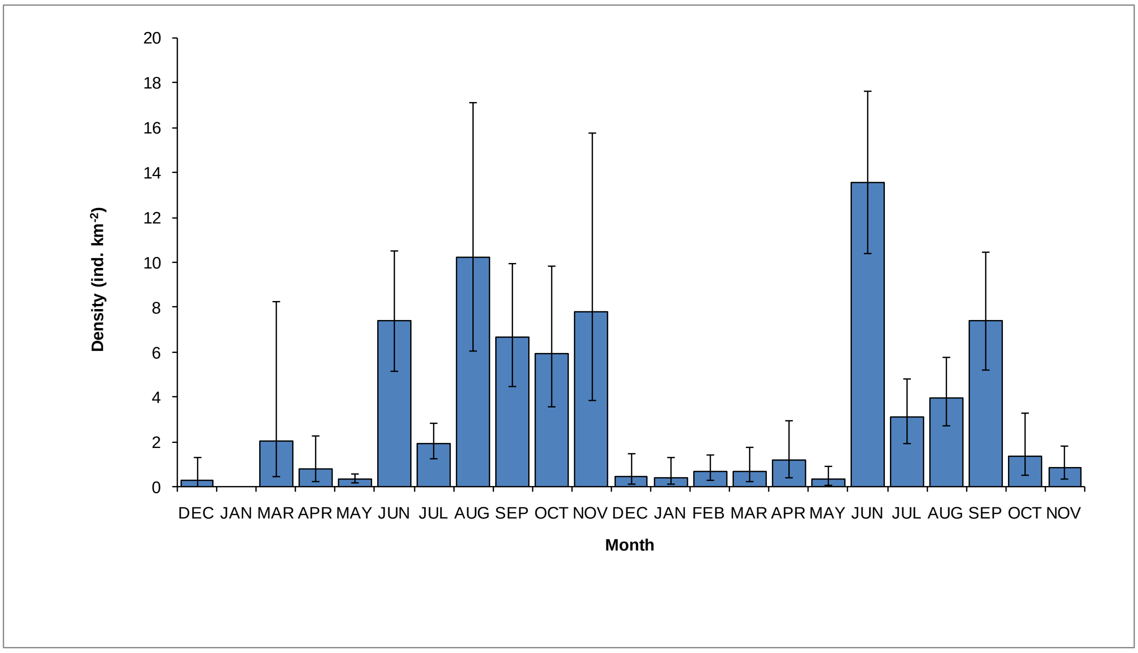


Figure 6.43 Monthly mean (± 95% confidence intervals) density of Puffin in Project Alpha as derived from DISTANCE correction of birds on the water.

6.2.36 The peak monthly mean densities between April and July are generally lower than those by Skov *et al*. (1995) for the area immediately around the Isle of May at this time (16.3 individuals km^{-2}) and more typical of those derived for the wider Forth (3.3 individuals km^{-2}) apart from June (Table 6.47). Camphuysen (2005) also records density of >10 individuals km^{-2} in several parts of the Firth of Forth in June and July. In August and September, Skov *et al*. (1995) report a density of 7.5 individuals km^{-2} in the wider Forth including the Isle of May, which corresponds closely to the density in Alpha at this time. Densities during the late winter correspond to the 0.33 individuals km^{-2} over the Northeast Bank including the Forth presented by Skov *et al*. (1995).

Table 6.47 Monthly mean (± 1SD) density of Puffin in Project Alpha and Bravo as 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
Alpha	0.2 ± 0.3	0.8	1.4 ± 0.9	1.2 ± 0.6	0.3 ± 0.1	11.2 ± 4.1	2.7 ± 0.6	7.3 ± 4.5	7.4 ± 0.2	3.8 ± 3.3	4.4 ± 5.1	0.4 ± 0.2

Project	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bravo	0.5 ± 0.7	0.4	0.8 ± 0.7	2.3 ± 1.8	0.4 ± 0.1	15.6 ± 17	3.0 ± 1.0	5.7 ± 3.4	17.7 ± 14.3	4.5 ± 4.5	5.1 ± 6.4	0.3 ± 0.1

6.2.37 The proportion of Puffins aged was low at 8.8% for both Projects Alpha and Bravo combined. Unlike the other auk species, the proportion of single birds aged was higher (11.4%) than when two birds were observed together (6.6%), which fits with the fact that Puffins do not associate with their fledged young. No groups of over six individuals were aged. Based on the assumption that all birds were adults unless recorded as immature or juvenile birds, 96.9% of all birds would be considered as adults. In contrast, 71.9% of the n= 114 birds aged in the breeding season from April to August were classed as adults in Project Alpha (Table 6.48).

Table 6.48 Number and proportion of adult Puffins relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

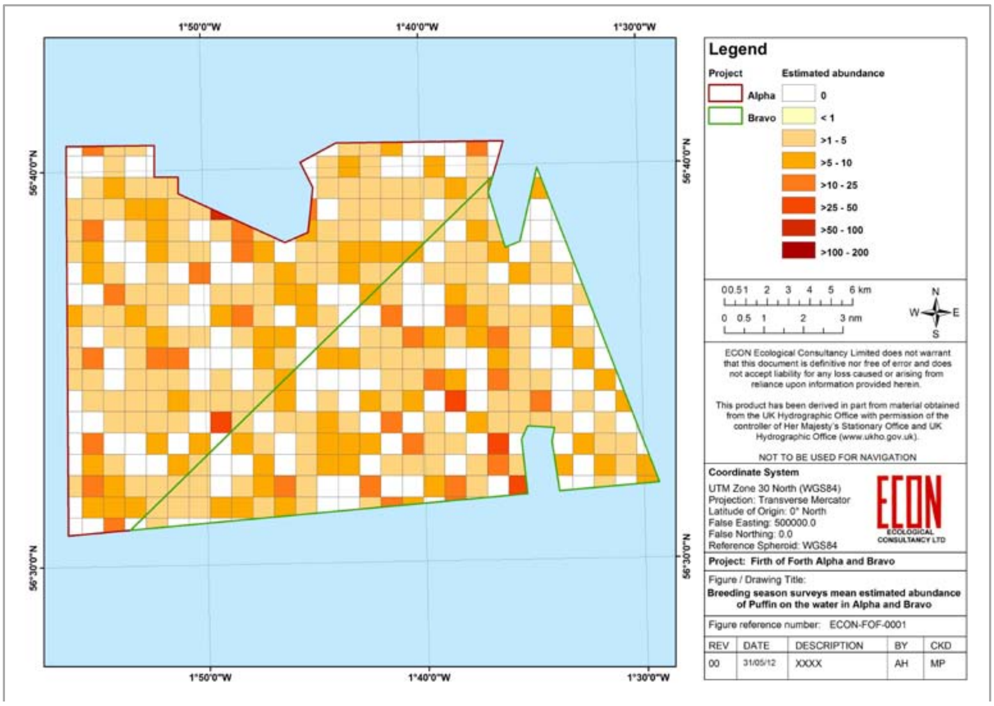
	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	0	0	0	0	5	18	12	47	3	0	0	1
%	-	-	0.0	-	55.6	72.0	92.3	70.1	37.5	0.0	-	100
Total	0	0	1	0	9	25	13	67	8	1	0	1

6.2.38 Puffin was widely distributed within Project Alpha in the breeding season at low density (1-5 individuals km^{-2}) with occasional patches of higher density (>10 individuals km^{-2}) especially in the western half of the site (Figure 6.44). The distribution pattern was similar between breeding seasons (Figure 6.45). Outside the breeding season, there appeared to be avoidance of the northwest corner of Project 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 6.46). It is of note that only observation of feeding birds was made in the breeding period with none transporting prey.

Project Bravo

6.2.39 The seasonal pattern of abundance of Puffins in Bravo was similar to that from Alpha apart from the lack of a peak in June 2010 (Figure 6.41). Whilst consistent population estimates were made throughout in the late breeding season and passage period in 2010, there were considerable peaks in both June and later in September 2011 (Figure 6.41).

6.2.40 The population estimate for June 2011 was 5,583 individuals, more than double the 1% threshold for the breeding season (Figure 6.41). The vast majority of the density was derived from birds on the water with a DISTANCE corrected value of 28.6 ind. km^{-2}, with a UCI of 35.4 ind. km^{-2} (Figure 6.46). There was no clear reason for the peak value in June 2011, as there were no recorded feeding aggregations and no evidence of early fledging. All other surveys conducted during the breeding season failed to achieve regionally important numbers, with estimates ranging from 209 to 1,571 individuals (Figure 6.41).



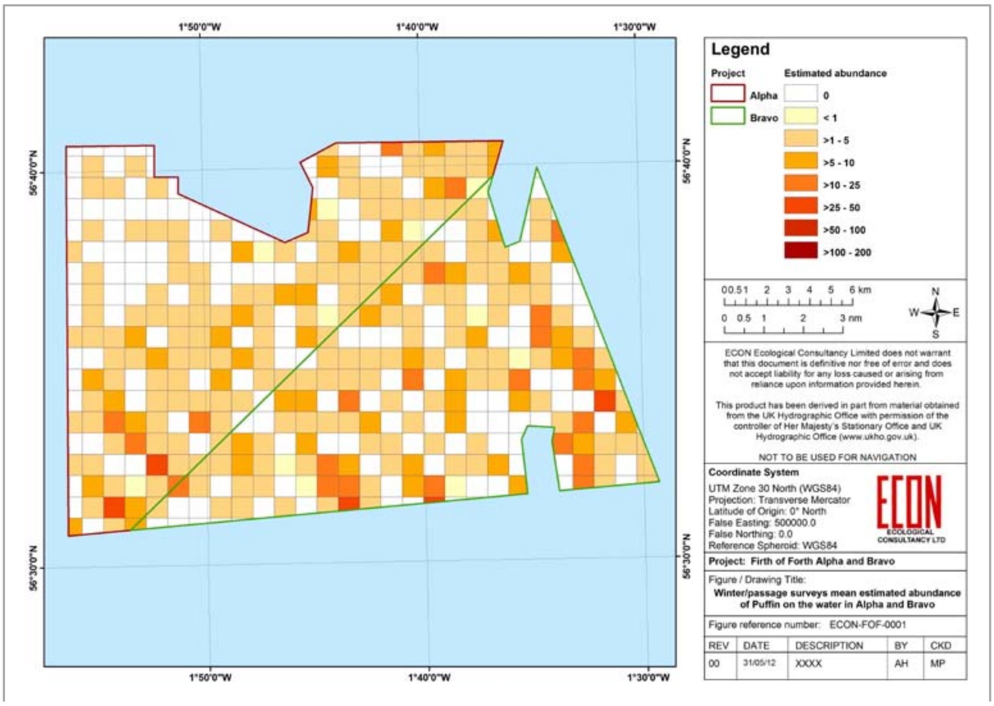
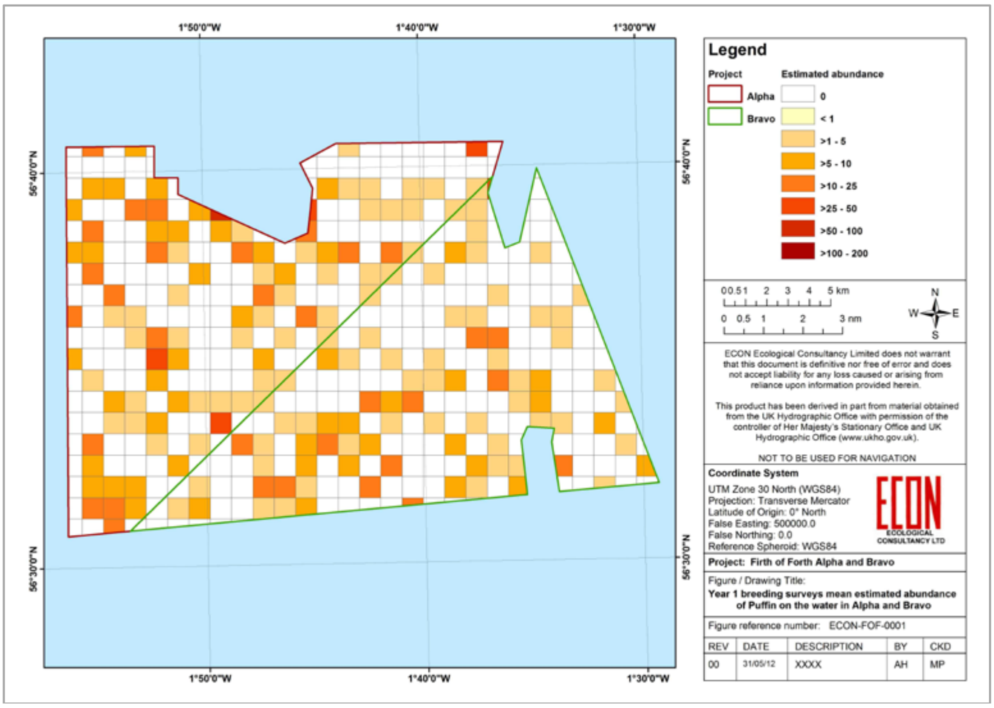


Figure 6.44 Relative abundance of Puffin expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August (above) compared to the passage/winter period (below).



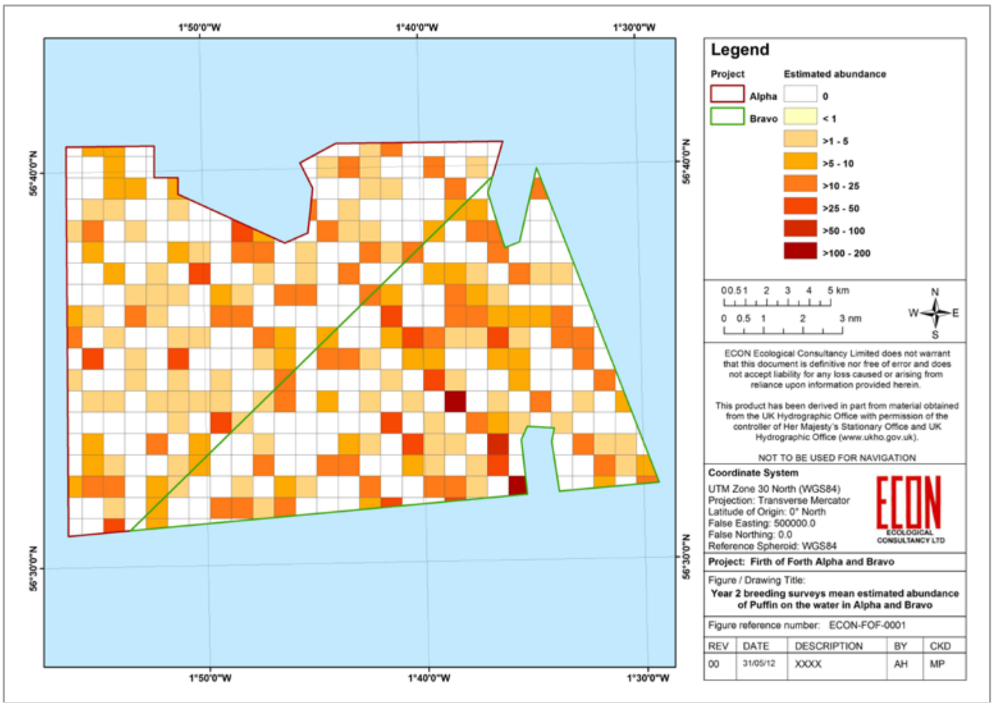


Figure 6.45 Relative abundance of Puffin expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August in 2010 (above) compared to 2011 (below).

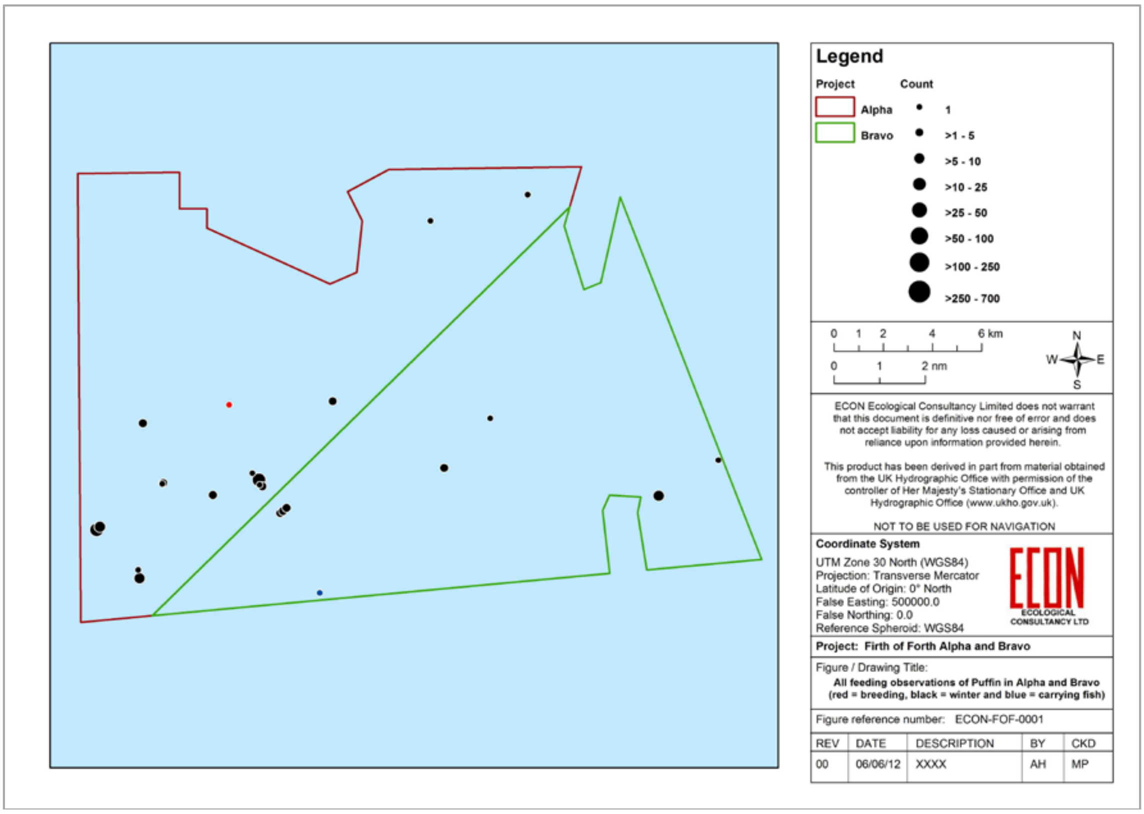


Figure 6.46 Distribution and group size of feeding Puffins recorded in all surveys of Alpha and Bravo in the breeding season (red) and passage/winter period (black).

6.2.41 As with Alpha all four surveys conducted during the passage period exceeded the 1% regional threshold, with estimates ranging from 260 to 5,370 individuals (Figure 6.41). Other than dispersal from colonies, there was no further explanation for the presence of large numbers of birds such as large feeding aggregations (see Figure 6.45). The vast majority of the Puffins in September were on the water and thus DISTANCE corrected. The density estimate of 27.7 ind. km^{-2} (UCI 37.8 ind. km^{-2}) was higher than 20.0 ind. km^{-2} derived from the simple correction factor for Puffin.

6.2.42 Although there was a general pattern of low winter abundance, the November survey of 2010 reached the 1% threshold for the North Sea during the winter (Skov *et al*. 1995) as it had in Alpha. The peak at this time appears to represent a persistence of numbers of birds present in the passage period rather than represent a further influx.

6.2.43 As for Alpha peak monthly mean densities between April and July were generally lower than those of Skov *et al*. (1995) for the Isle of May (16.3 individuals km^{-2}), but unlike Alpha were matched in June (Table 6.47). It is the mean density in September of >17 individuals km^{-2} that appears to be exceptional compared to Skov *et al*. (1995) Moreover, the densities in the early winter in both Bravo and Alpha exceed any densities presented by Skov *et al*. (1995) although these appear to be scant.

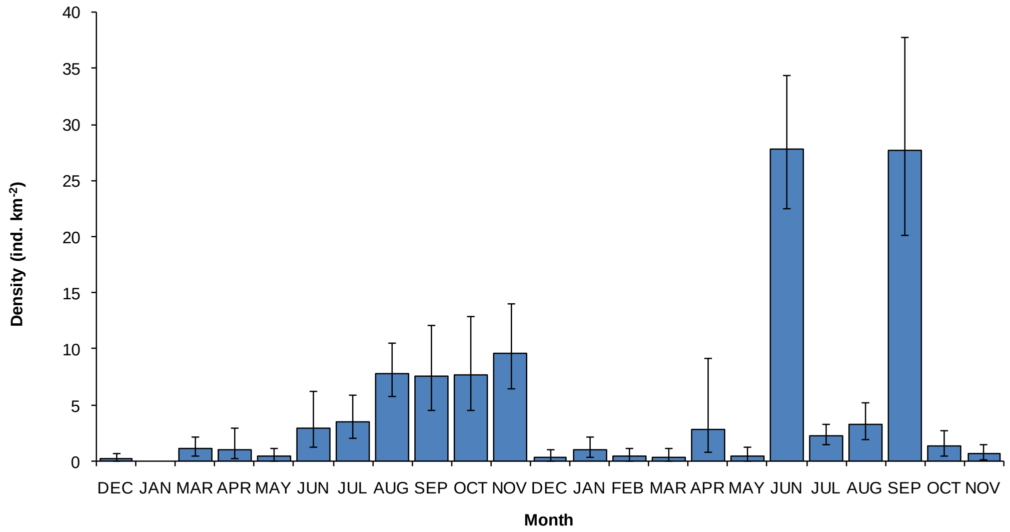


Figure 6.47 Monthly mean (± 95% confidence intervals) density of Puffin in Project Bravo as derived from DISTANCE correction of birds on the water.

6.2.44 In Project Bravo, 63.7% of the n = 113 birds aged in the breeding season of April to August (Table 6.49) were classed as adults, which was slightly lower than Alpha (Table 6.47).

Table 6.49 Number and proportion of adult Puffins relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	0	0	0	0	3	10	13	46	1	11	0	1
%	-	-	-	-	100	66.7	86.7	57.5	16.7	78.6	-	50.0
Total	0	0	0	0	3	15	15	80	6	14	0	2

6.2.45 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 6.43). 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 of >100 individuals km^{-2} were recorded in the central part of the site to the midpoint on the southern boundary (Figure 6.45). In 2010, birds were at very low density or even absent from many grid cells. There was however no evidence of feeding in 2011 (Figure 6.46), although this does not discount the possibility that birds were aggregating in association with a particular prey resource or habitat feature as noted for other auk species.

Foraging range and potential origin

6.2.46 Puffin has a mean maximum foraging range of 105 km and a mean maximum foraging range + 1SD of 151.4 km (Figure 6.48), which means that 200,801 and 232,828 individuals respectively breed within each range (Table 6.50). Birds are distributed amongst 40 colonies in mean maximum foraging range with 42 colonies in range + 1SD, from the Moray Firth to Northumberland in the south (Figure 6.48).

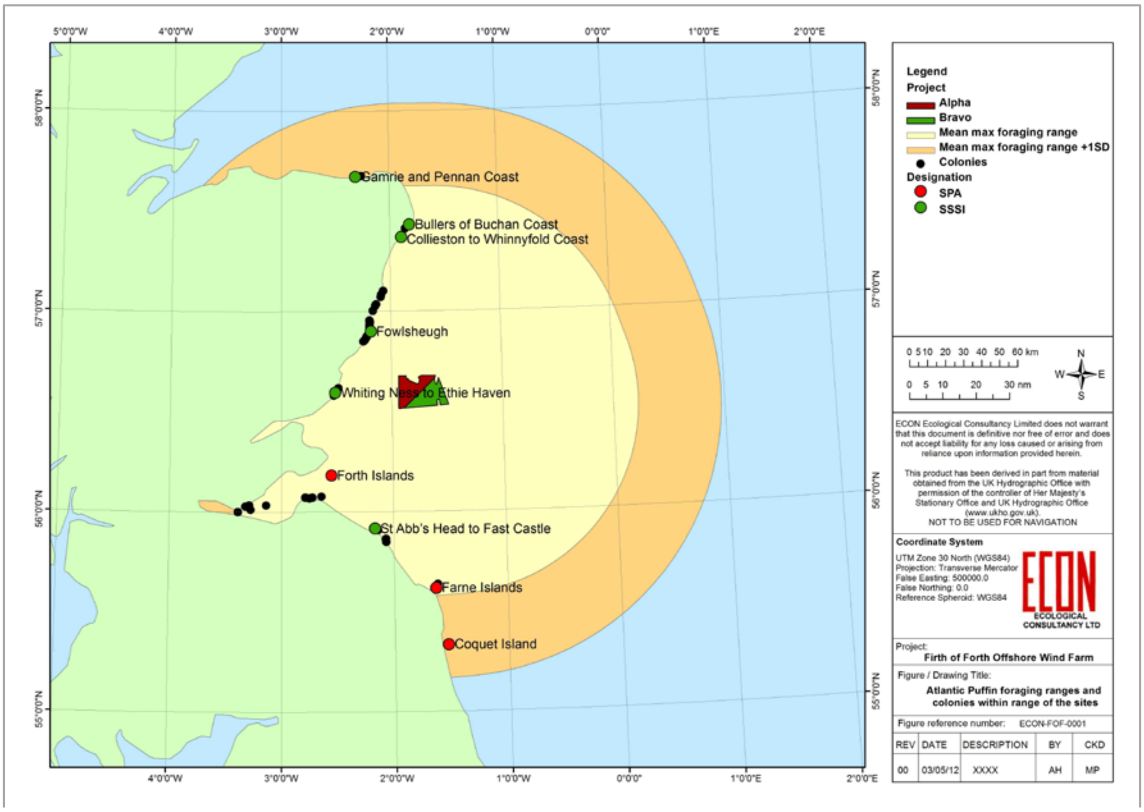


Figure 6.48 Distribution of Puffin breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.2.47 Within mean maximum foraging range Puffin is designated at the Forth Islands SPA and the Farne Islands SPA, and a further four SSSIs. Coquet Island SPA and Gamrie and Pennan Coast SSSI fall between mean maximum and mean maximum

+1SD foraging ranges. A total of seven (18%) colonies are contained within designated/notified sites in mean maximum range, with this proportion being similar (19%) in the entire mean maximum +1SD range.

Table 6.50 Details of all Puffin breeding colonies at increasing distance from Projects Alpha or Bravo within mean maximum and mean maximum ± 1SD foraging ranges (105.4 and 151.4 km respectively). 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.

Foraging range	Site and designation	Distance	Natura 2000	Seabird 2000	Latest count	
					Number	Year
Mean Max	Catterline to Inverbervie	27.64		344	344	1999
	Fowlsheugh	31.09		50	30	2006
	Stonehaven to Wine Cove	33.55		213	213	1999
	Whiting Ness to Ethie Haven	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
	St Abb's Head to Fast Castle	68.48		52	7	2011
	Forth Islands SPA	71.38	28,000	140,849	124,398	2010[2]
	Eyemouth to Burnmouth	73.31		21	21	2000
	Collieston to Whinnyfold Coast	81.85		623	623	2001
	Inchkeith	91.25		1,641	1,157	2009
	Farne Islands SPA	98.98	69,420[1]	111,348	73,670	2008
	Inchcolm	100.04		40	2	2010
Mean Max + 1 SD	Gamrie and Pennan Coast SSSI	112.92		403	403	2001
	Coquet Island SPA	132.67	22,800[1]	34,416	31,624	2009

[1]From Stroud et al 2001; [2]2008, 2009 & 2010

6.2.48 SPAs make a far larger contribution if the number of birds contained within them is considered. In fact, of the 200,801 individuals within mean maximum foraging range, 198,068 (98.1%) originate from SPAs. Within mean maximum + 1SD range, the 229,692 Puffins from SPAs equates to 98.7% of the total of 232,828 individuals (Table 6.50).

Project Alpha

6.2.49 All Puffin colonies within 70 km of Alpha are relatively insignificant, together totalling 930 breeding individuals. The largest of these small colonies is also the closest along the coastline between Catterline and Inverbervie, but as it was last surveyed in 1999 its current status is unknown. The extremely large, Forth Islands SPA supporting 124,398 individuals is then just over 70 km away with the smaller Farne Islands SPA containing 73,670 individuals at just under 100 km distant. It would be logical to surmise that during the breeding season the majority of Puffins seen in Alpha originate from the Forth Islands.

6.2.50 Only 7 tags were retrieved for breeding Puffins from the Isle of May, with these birds making 11 trips in total (Figure 6.49, Table 6.51). Of the trips recorded, one and thus 9% (or 7% as a mean by bird) reached project Alpha. A much higher proportion of trips crossed Neart na Gaoithe (45% of all trips and 36% as a mean by birds) and Inch Cape (45% of all trips and 33% by birds) reflecting the higher frequency of passage across sites closer to the colony (Figure 6.49, Table 6.51).

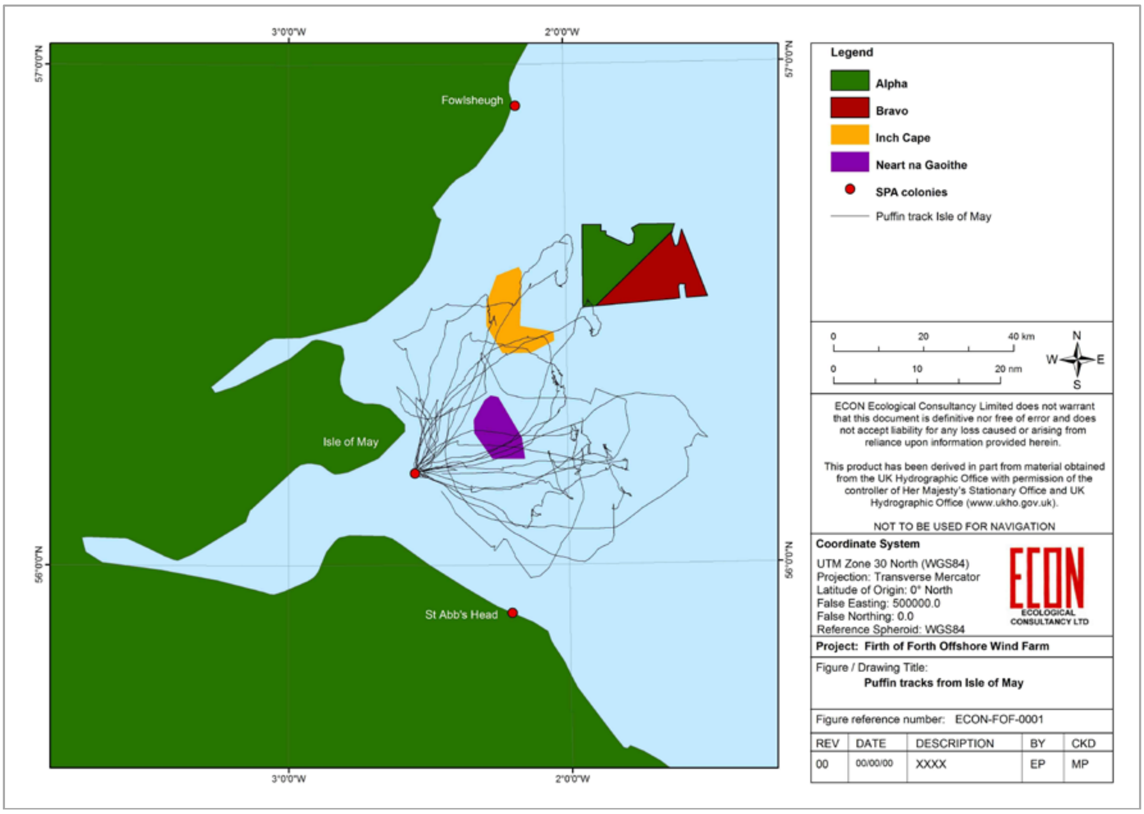


Figure 6.49 Tracklines of breeding Puffins fitted with GPS tags from Isle of May ($n = 7$) in 2010.

Table 6.51. Number and proportion (% in parentheses) of trips obtained by GPS tagged breeding Puffins from the Isle of May crossing the different proposed wind farm sites. Data are expressed for all trips and mean by bird.

Subject	Trips	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	11	1 (9.09)	0	5 (45.45)	5 (45.45)
By bird	2.14	0.14 (7.14)	0	0.71 (33.33)	0.86 (35.71)

6.2.51 Only ~0.5% of the distance travelled by Puffins was in Project Alpha, compared to ~3% and ~4.5% of the distance in Neart na Gaoithe and Inch Cape respectively (Table 6.52). The difference can be explain by the relative remoteness of Alpha in comparison to the STW sites, with the relatively low proportion of distance travelled in the STW sites suggesting that birds were mostly in rapid transit to and from the colony.

Table 6.52 Distance (km) and proportion (% in parentheses) of trips obtained by GPS tagged breeding Puffins from the Isle of May, Fowlsheugh and St Abb's Head within the different proposed wind farm sites. Data are expressed for all trips and mean by bird.

Subject	Total distance (km)	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	1,683.10	9.81 (0.58)	0	83.80 (4.98)	50.49 (3.00)
Mean by bird	240.44	1.40 (0.53)	0	11.97 (4.19)	7.21 (2.78)

6.2.52 The proportion of distance travelled by Puffin in the different sites does appear to be linked to the behaviour of the birds recorded at each GPS fix. Indeed, all fixes in Alpha were of non-flight behaviour with the single bird involved apparently on the water surface and potentially foraging (Table 6.53). In contrast, at Inch Cape the proportion of fixes with flight and non-flight behaviour was similar at 6-7% whereas in Neart na Gaoithe, the proportion of fixes with flight behaviour (~6%) was higher than the proportion of fixes with non-flight behaviour (~0.2%) suggesting commuting flight (Table 6.53).

Table 6.53 Number and proportion (% in parentheses) of total fixes according to different behaviours (combined behaviour = CB, flight = F and non-flight = NF) obtained for GPS tagged breeding Puffins from the Isle of May within the different proposed wind farm sites. Data are expressed for all trips and as a mean by bird.

Subject	Activity	Total fixes	Alpha (%)	Bravo (%)	Inch Cape (%)	Neart na Gaoithe (%)
All	CB	8,398	121 (1.44)	0	607 (7.23)	58 (0.69)
	F	588	0	0	46 (7.82)	37 (6.29)
	NF	7,810	121 (1.55)	0	561 (7.18)	21 (0.27)
By bird	CB	1,679.60	24.20 (1.33)	0	121.40 (6.63)	11.60 (0.59)
	F	117.60	0	0	9.20 (5.92)	7.40 (6.17)
	NF	1,562.00	24.20 (1.42)	0	112.20 (6.60)	4.20 (0.21)

6.2.53 Despite the limitations of the tagging study, it does tend to confirm that adult Puffins from the Forth Islands SPA, and specifically from the large colony on the Isle of May, do reach Alpha in the breeding season at least on occasion. The large relative size of the colony resulting in intraspecific competition for resources by breeding adults coupled with the prospect of interspecific competition for shared resources, most likely with other auk species, may mean that some individuals at least range widely from the colony.

6.2.54 The flight direction of Puffins recorded in Alpha tends to confirm the link with the Forth Islands SPA, with a distinct flight line of potentially returning birds to the southwest, with a smaller reciprocal flight line to the northeast originating from the colony (Table 6.54). The disparity between the two directions may suggest that Alpha does indeed lie towards the outer limit of the range of birds from the colony.

Table 6.54 Number and proportion (%) of flight directions recorded for Puffin during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	14	33	5	18	20	80	21	20	4
	%	6.51	15.35	2.33	8.37	9.30	37.21	9.77	9.30	1.86
Breeding season	Count	10	32	5	17	16	74	18	13	4
	%	5.29	16.93	2.65	8.99	8.47	39.15	9.52	6.88	2.12

6.2.55 There is however no evidence from the tagging studies conducted on 12 Puffins on the Farne Islands that birds from this colony are at all likely to reach Project Alpha in the breeding season or even spend much time at all in the Forth (http://www.bbc.co.uk/news/10528822), with foraging concentrated within about 30 km of the colony.

6.2.56 As well as birds from the Forth Islands, birds from smaller, closer colonies may of course also populate the area of Project Alpha in the breeding season, although the sheer size of the Isle of May population means that the contribution of other colonies is likely to be small.

6.2.57 Harris *et al.* (2010) document the post-breeding and overwinter movements of Puffins from the Isle of May of 14 birds fitted with geolocators recovered in 2008 after attachment to 50 breeding birds in 2007. Immediately after breeding (from August 1st) and up until December 31st, birds mostly remained in an area offshore of Fraserburgh to the Farnes incorporating the outer Forth. Exact locations cannot be provided from geolocators. Nonetheless, the occurrence of Puffins in Alpha in the passage period, persisting into November in some years fits with this known range.

6.2.58 In the early winter period, Puffins become less common in Project Alpha, which again fits with the movement of at least some of the birds Harris *et al*. (2010) fitted with geolocators which moved out of the North Sea entirely into the east Atlantic predominantly between 50̊N and 62˚N and 10˚E and 15˚W. In January and February birds were much less widely dispersed and concentrated in the north-west North Sea. By April, birds had returned to the Isle of May, and concentrated in the Inner Forth around the Isle of May.

6.2.59 There is no evidence as yet, whether birds from the Farne Islands illustrate similar patterns of distribution compared to those from the Isle of May, although it does seem likely that birds from the Farnes will remain in the North Sea and perhaps also disperse into the East Atlantic under particular conditions. Mixing of birds from the Forth Island and the Farne island within the Forth and including within project Alpha outside the breeding season therefore seems to be a possibility.

6.2.60 In relation to other colonies around the UK, it is of note that Puffins fitted with geolocators from Skomer did not venture into the North Sea at all, although ranging to waters off Iceland, Greenland, the Bay of Biscay and even the Mediterranean was all noted. Little is known about the winter distribution of Puffins from colonies further afield, such as Norway. However, an analysis of recoveries of Puffins ringed in Norway, including three from the Firth of Forth, suggests that Scotland is at the southern fringe of the normal wintering grounds of this population (Forrester *et al.* 2007). It would thus appear that birds from outside the UK are not likely to occur in Alpha in anything other than small numbers.

Project Bravo

6.2.61 No tagged birds from the Isle of May were recorded within Project Bravo (Figure 6.49, Table 6.55). However, the sample size of birds was small and the occurrence of relatively large numbers of Puffins later in the breeding season is best explained by an origin from the Isle of May as well as smaller colonies closer to Bravo. The flight direction of birds within Bravo, along a southwest and northeast axis reinforced the idea that birds from the Isle of May were involved. However, the relatively even proportion of flights potentially to and from the colony may indicate that birds are closer to the edge of typical foraging range.

Table 6.55 Number and proportion (%) of flight directions recorded for Puffin during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	9	24	6	13	6	31	10	15	3
	%	7.69	20.51	5.13	11.11	5.13	26.5	8.55	12.82	2.56
Breeding season	Count	9	22	5	13	4	27	9	7	3
	%	9.09	22.22	5.05	13.13	4.04	27.27	9.09	7.07	3.03

6.2.62 Outside the breeding season, the origin of birds present within Project Bravo is likely to be the same as that as suggested for Alpha, with birds from the Forth Islands SPA potentially mixing with birds from the smaller colony on the Farne Islands. Assuming equal mixing, the proportion of birds from the Forth Islands would comprise 63% of individuals from a total population of 198,068 adults and thus a total population incorporating juveniles and immatures in the region of 297,102 individuals (after multiplication by 1.5 according to Wetlands International 2006).

Summary of risks

6.2.63 In their vulnerability index to offshore wind farms for seabirds, Garthe & Hüppop (2004) ranked Puffin 14th of 26 seabirds (i.e. one place below Razorbill). Reduced conservation concern, greater flight manoeuvrability and less potential for disturbance from ship and helicopter traffic were responsible for the slightly lower ranking of Puffin. Dividing the main risks of collision and displacement, Furness & Wade (2012) ranked Puffin 35th from 37 seabirds in terms of collision risk and 17th in terms of potential displacement, the lowest ranks in both categories for the breeding auks.

6.2.64 The lower ranking to collision risk by Furness & Wade (2012) was essentially due to its reduced flight altitude even compared to other auks. The proportion of flights of Puffin at risk height derived from eight study sites, was found to be just 0.02% (Cook *et al*. 2011). The boat-based surveys of Alpha and Bravo produced broadly similar findings with 0.5% of flights >20 m in Alpha but with 0% in Bravo. Coupled with a low proportion of birds in flight (12% and 5% in Alpha and Bravo respectively) the potential for significant ecological impact from collision with turbines at either site thus appears to be virtually non-existent and therefore does not require further examination.

6.2.65 Puffin are less sensitive to disturbance than other auk species (Furness & Wade 2012). Whilst the density and population size of Puffins in Alpha and Bravo was unexceptional in the context of the Firth of Forth during the bulk of the breeding season, there were peaks in what appears to be the chick provisioning period, which introduces the potential for some form of displacement should birds avoid wind farms. The evidence-base for avoidance (or not) is currently very small considering that very few, if any, wind farms fall within the foraging range of breeding Puffins in the UK.

6.2.66 Flight lines across both Alpha and Bravo introduce the potential for barrier effects upon breeding birds, although no birds were actually recorded transporting prey coupled with very few feeding records in the breeding season compared to other times (4% of all birds counted exhibited feeding behaviour in Project Alpha). Puffin is considered for further analysis in regard to displacement.

6.2.67 Puffins have a preference for sandeels over other fish and thus would appear to be far less likely to be affected by construction noise impacting the abundance and distribution of prey resources in indirect effects. However, there is uncertainty over the actual effect on sandeels and Puffins may depend on sensitive clupeids if sandeels are in short supply. Moreover, there is potential for the footprint of construction to extend into more important areas than Alpha or Bravo (e.g. Scalp Bank and especially Wee Bankie and the Marr Bank) that probably support a greater abundance of resources throughout the breeding season. On balance, as for the other breeding auks, the potential for indirect effects to generate a significant ecological effect requires further consideration in EIA (and HRA).

Project Alpha

6.2.68 Given the potential for significant ecological impact on birds resulting from displacement, barrier effects and indirect effects on breeding birds, Puffin is taken forward as a sensitive receptor for Project Alpha in the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

6.2.69 Potential impacts resulting from any displacement, barrier effects and indirect effects upon Puffins originating from the Forth Islands SPA in the breeding season will also have to be considered within HRA.

Project Bravo

6.2.70 The potential for significant ecological impact on Puffin from displacement, barrier effects and indirect effects of construction on prey from Project Bravo require consideration in EIA. Puffin is therefore included as a sensitive receptor in the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

6.2.71 As for Project Alpha, the potential impacts of displacement, barrier effects and indirect effects of construction on prey, upon Puffins originating from the Forth Islands SPA will have to have be considered in HRA.

6.3 Passage/wintering seabirds

Sooty Shearwater

Population ecology

6.3.1 The world population of Sooty Shearwater is thought to number over 20 million individuals, with breeding colonies on islands off New Zealand, Australia, Chile and the Falkland Islands (Birdlife International 2012b). The majority of approximately five million occur at more than 80 colonies in New Zealand. Despite its large population, Sooty Shearwater is listed as Near Threatened on the IUCN Red List as it is believed to have undergone a moderately rapid decline owing to the impact of fisheries, the harvesting of its young and possibly climate change.

6.3.2 During the non-breeding season Sooty Shearwaters occur in more northerly areas, appearing off the Atlantic coast of North America from mid-May (Wernham *et al.* 2002). Birds appear to move into the mid-Atlantic and thence eastwards, occurring in Scottish waters from July to October (Forrester *et al.* 2007). It is very rare outside this period, although there are records from every month. Numbers fluctuate from year to year, but may be in the thousands. For example, about 5,000 were recorded in Scottish territorial waters between the Faeroe Islands and Unst, Shetland in August 1995.

6.3.3 It is likely that Sooty Shearwaters in the north-east Atlantic feed mainly on squid in the relatively productive waters influenced by the Gulf Stream, an arm of which rounds the north of Scotland and flushes into the North Sea (Forrester *et al.* 2007). Following this, they enter the northern North Sea and head southwards, but once they encounter less suitable feeding areas south from Yorkshire, where squid are largely absent, they reverse direction and move north again. Sooty Shearwaters are highly pelagic and distributed far from shore, but especially during strong onshore winds, significant counts are made from land. Highest numbers have consistently been recorded off Orkney, but counts exceeding 500 individuals have been made off the Isle of May in the Firth of Forth in September.

Density distribution and population size

Project Alpha

6.3.4 Sooty Shearwater was only considered to have the potential to be a sensitive receptor to the development of Project Alpha on the basis of regionally important numbers. In fact, Sooty Shearwater was only present within Alpha in 2010, between September and November (Appendix F1 Annex 1, Figure 6.50).

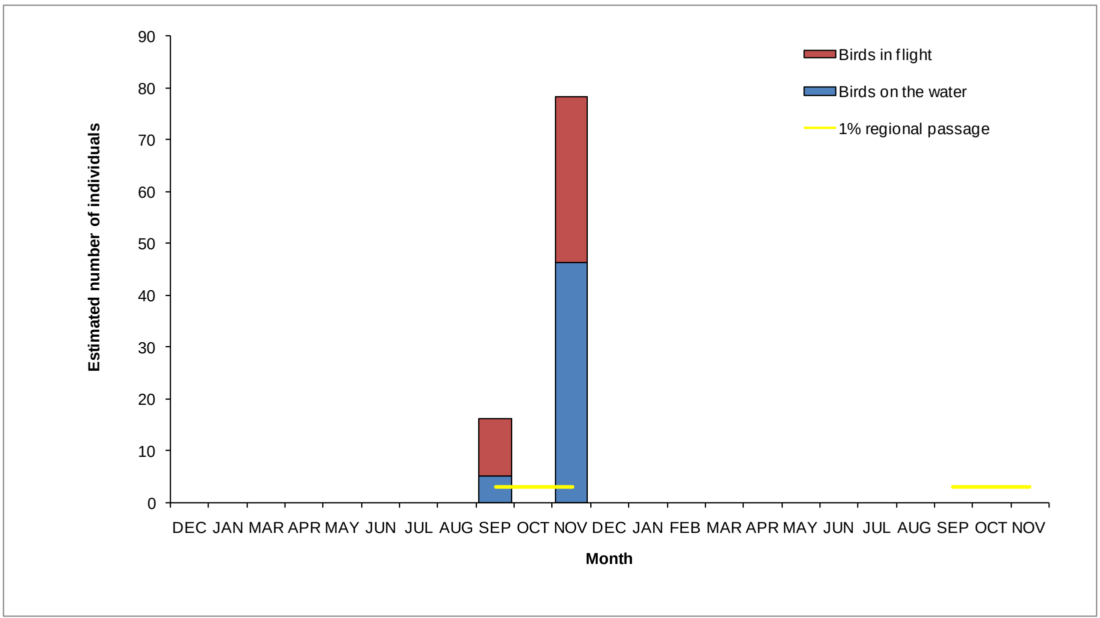


Figure 6.50 Sooty Shearwater population estimates by month over the two years of boat-based surveys of Project Alpha. Estimates are derived from density from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect. The criterion for regional importance in the passage period is shown.

6.3.5 Only two population estimates could be calculated with 36 and 78 individuals, in September and November respectively. The peak estimate was derived from a density of 0.24 ind individuals km^{-2} from standard line transects for birds on the water and 0.2 individuals km^{-2} for flying birds from snapshots (Appendix F1 Annex 1).

Potential origin

6.3.6 Sooty Shearwaters breed in the southern hemisphere and hence all the individuals seen in Alpha and Bravo between mid-September and early November were on passage during their non-breeding season. This highly pelagic passage population, is annual in variable numbers in Scottish waters (Forrester *et al.* 2007).

Project Alpha

6.3.7 Sooty Shearwater were in the main, recorded in the western section of Alpha towards Scalp Bank (Figure 6.51). However, confidence in the distribution pattern is limited as only 19 birds were observed in the site.

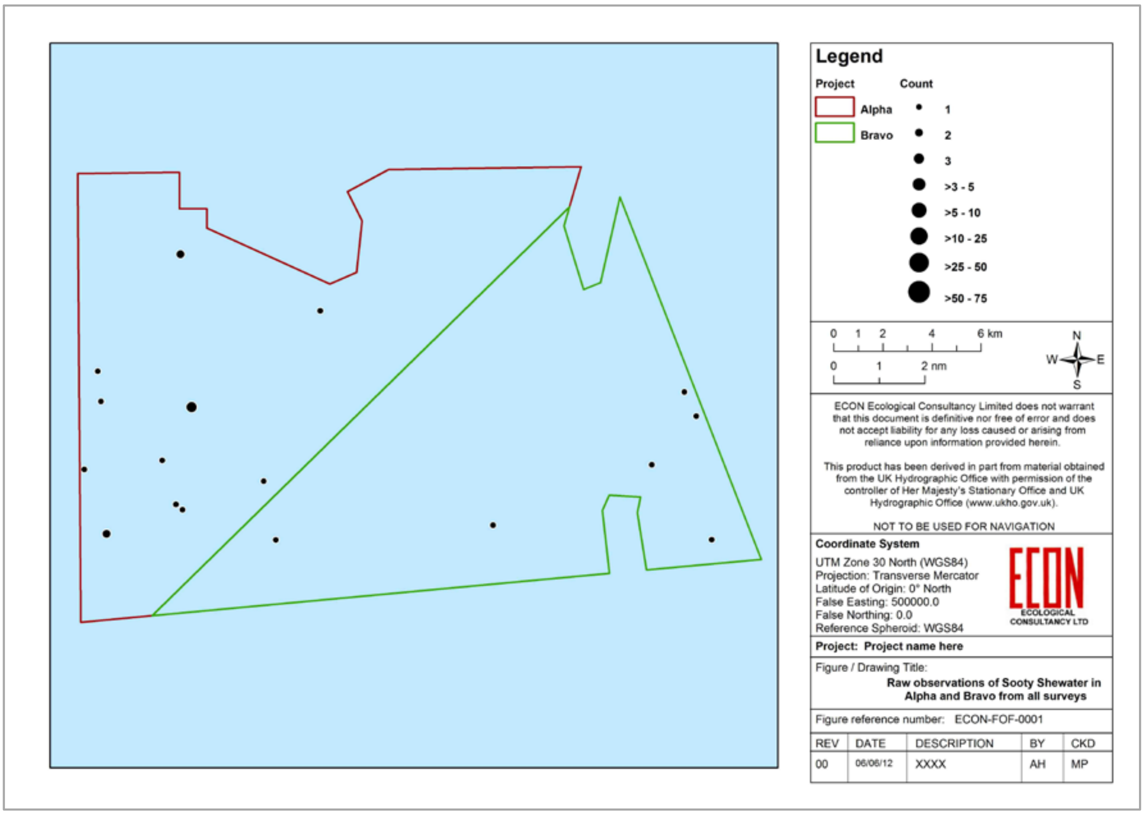


Figure 6.51 Distribution and group size of Sooty Shearwaters recorded in all surveys of Alpha and Bravo in the passage/winter period.

6.3.8 Of the eight Sooty Shearwater observed in flight within the Alpha development boundary, half were flying in a northwest direction and half were recorded as having no specific direction. Six Sooty Shearwaters were observed as part of multi-species foraging associations with Kittiwakes and auks in the September 2010 survey.

Summary of risks

6.3.9 Sooty Shearwater have been considered the least vulnerable of 37 seabirds considered to offshore wind farm development in the context of potential impact from both collision with turbines and displacement (Furness & Wade 2012).

6.3.10 The low risk of collision is supported by the data gathered from boat-based surveys as no birds were recorded flying at > 20 m with the Alpha development although only eight birds were actually recorded in flight.

6.3.11 Sooty Shearwater is considered to be at extremely low risk of displacement as a result of its highly pelagic nature with individuals utilising vast areas of ocean during the course of a year.

6.3.12 Although 32% of records of Sooty Shearwater were part of multi-species foraging associations, this equates to just 6 birds, and does not indicate any specific importance as a foraging ground for the species. Even should the distribution and abundance of prey be affected through construction there is a negligible chance that this has the potential for significant ecological impact on any wide-ranging individual present for only a short-time. With a highly transient population, perhaps making only a few passes through the area, there is also no prospect of significant barrier effects.

Project Alpha

6.3.13 With no prospect of significant ecological impact by any means Sooty Shearwater was not considered for further impact assessment within the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I)

Great Black-backed Gull

Population ecology

6.3.14 Great Black-backed Gull has a world population of 540,000-750,000 mature individuals (Birdlife International 2012e) and a European population of 110,000-180,000 breeding pairs. It is considered to have a Secure conservation status in a global and European context (Birdlife International 2004).

6.3.15 In the UK, Great Black-backed Gull is a relatively uncommon breeding seabird with approximately 16,800 pairs accounting for 9.6% of the global population. It breeds at a number of widely-distributed small colonies, with the majority located in the north and west (Eaton *et al.* 2011, Mitchell *et al.* 2004).

6.3.16 Great Black-backed Gull is Amber listed as a species of conservation concern in the UK due to a moderate (>25% but <50%) decline in the non-breeding population over the past 25 years (Eaton *et al.* 2009). Moreover, the UK breeding population of Great Black-backed Gull declined by 14% between 2000 and 2010 (JNCC 2011). Decline mirrored the fortunes of the two other large gull species (Herring and Lesser Black-backed Gull), but was less severe.

6.3.17 There are no known reasons for decline. Great Black-backed Gulls often nest on well-vegetated rocky seacoast habitats such as stacks and cliffs (Cramp *et al.* 1974) typically in association with other seabirds, which form an important part of the diet of adults and their chicks (Forrester *et al.* 2007). Other foods include a wide range of invertebrates including crabs, vertebrates such as fish and mammals as large as rabbits, as well as human rubbish. The prey taken would tend to buffer Great Black-backed Gulls from any changes at sea.

6.3.18 Outside the breeding season however, Great Black-backed Gull is one of the more pelagic gulls dependent on marine resources such as fish and discards from fishing vessels and changes in the abundance of this resource could impinge on survival.

6.3.19 During the winter months there is an influx of Great Black-backed Gulls to the UK, especially from the stronghold of the species in Norway. Up to 2,000 are recorded on the Isle of May in the Firth of Forth in most winters, peaking in November and December (Forrester *et al.* 2007).

6.3.20 Birds return to breeding colonies and establish territories in February and March (Forrester *et al*. 2007). Three eggs are typically laid in mid-April, with most chicks hatching from mid-June. The chicks fledge after seven to eight weeks in the nest and then leave the colony within a few days (Cramp *et al.* 1974).

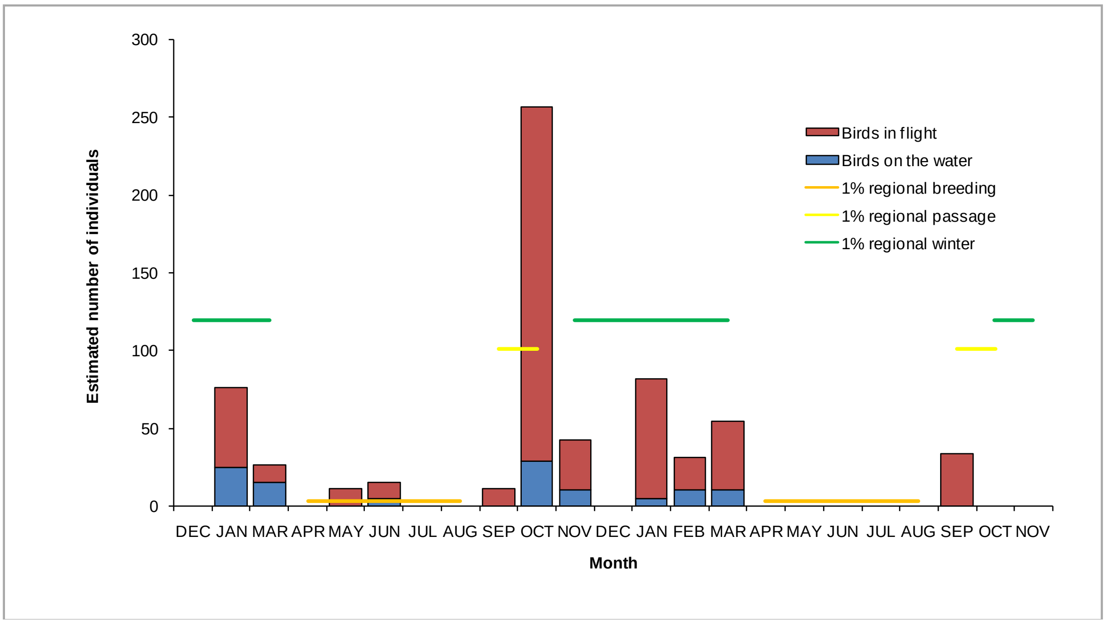
Density distribution and population size

Project Alpha

6.3.21 The boat-based surveys of Alpha indicated that the Great Black-backed Gull was predominantly present in the winter period. In 2010 the species was also present during the spring and early summer, with Great Black-backed Gulls observed up to and including the June survey (Appendix F1 Annex 1). Coupled with a peak population in October 2010, Great Black-backed Gull was generally more abundant in 2010 compared to 2011 (Figure 6.52).

6.3.22 The peak population estimate in October 2010 was 257 individuals which exceeded the 1% regional threshold for the passage period. No other population estimate in the passage or winter period reached regionally important numbers. Numbers in the breeding season did surpass the 1% breeding season estimate on occasion although the threshold is very low.

Project Alpha



Project Bravo

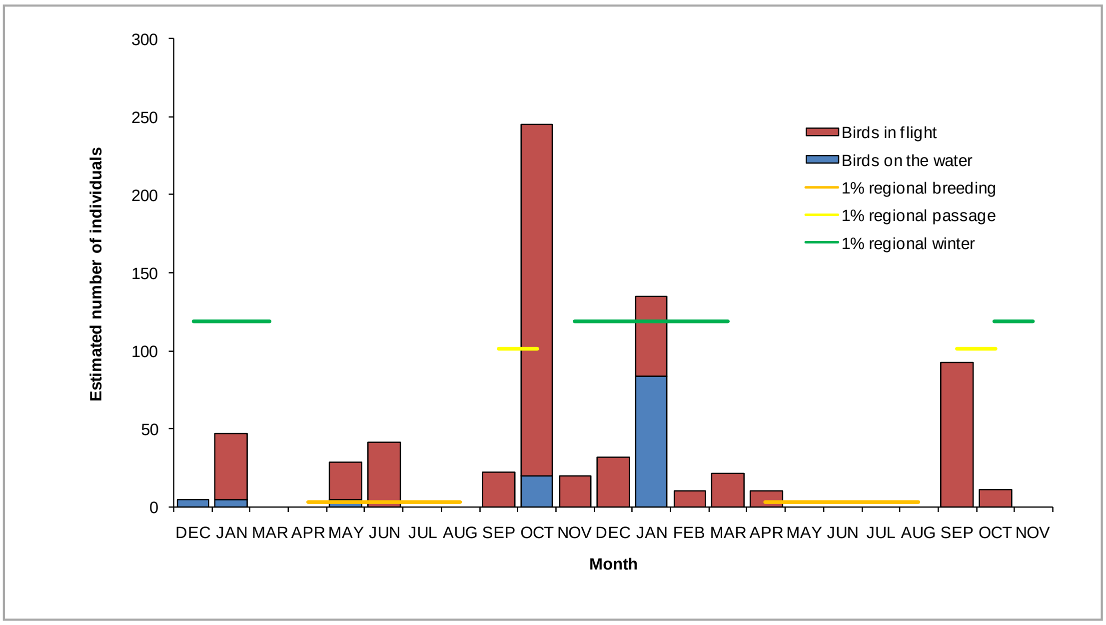


Figure 6.52 Great Black-backed Gull population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from density derived from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect. Criteria for regional importance in the breeding, passage and winter periods are shown.

6.3.23 The mean densities calculated for each month ranged from 0.03 to 0.65 individuals km^{-2} (Table 6.56). Overall, Project Alpha appear to support rather unremarkable densities of Great Black-backed Gull at any time of year. For example, the densities in the breeding season of 0.1 individuals km^{-2} or less just reach the value of 0.1 individuals km^{-2} recorded by Skov *et al*. (1995) for the Forth of Forth. In contrast, the Moray Firth records higher density at 0.53 individuals km^{-2}, in turn lower than important areas in the North Sea in the Baltic supporting over 0.8 to 2 individuals km^{-2}.

Table 6.56 Monthly mean (± 1SD) density of Great Black-backed Gull in Project Alpha and Bravo as 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
Alpha	0.4 ± 0.1	0.2	0.2 ± 0.1	-	<0.1 ± 0.1	<0.1 ± 0.1	-	-	0.1 ± 0.1	0.7 ± 0.9	0.1 ± 0.2	-
Bravo	0.5 ± 0.3	0.1	0.1 ± 0.1	<0.1 ± 0.1	<0.1 ± 0.1	0.1 ± 0.2	-	-	0.3 ± 0.3	0.7 ± 0.9	<0.1 ± 0.1	0.1 ± 0.1

6.3.24 The overall peak in October (0.7 individuals km^{-2}) falls between the values for the two adjacent areas of Aberdeen Bank (0.2 individuals km^{-2}) and Barmade Bank to North East Bank (1.5 individuals km^{-2}) between August and October. The peak densities in the winter between November and February in Alpha are in line with those presented by Skov *et al*. (1995) for Wee Bankie to East Bank of 0.42 individuals km^{-2}, but below the density of 1.1 individuals km^{-2} for the wider Firth of Forth and well below important areas such as the Moray Firth (2.3 individuals km^{-2}), North East Bank (5.2 individuals km^{-2}) and Hills (7.8 individuals km^{-2}) further down the east coast.

6.3.25 The proportion of Great Black-backed Gulls aged within Projects Alpha and Bravo was high with 90.5% of records aged. The proportion of single birds (92.6%) compared to birds in pairs (92.9%) aged was virtually identical. Ageing does show that around half (56%) of birds over the breeding period of April to August inclusive were adults (Appendix F1 Annex 7). In Project Alpha, adults constituted 55.6% of the *n* = 9 birds aged at this time (Table 6.57).

Table 6.57 Number and proportion of adult Great Black-backed Gulls relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	27	0	1	1	2	2	0	0	0	10	4	19
%	61.4	0.0	16.7	50.0	40.0	100	-	-	0.0	21.3	36.4	57.6
Total	44	4	6	2	5	2	0	0	10	47	11	33

6.3.26 The distribution maps derived from the mean abundance of flying birds did not reveal any particular selection of any area of the Alpha site. Indeed, there were large areas of the site in which no Great Black-backed Gulls were observed, especially in the breeding season (Figure 6.53). In the passage and winter periods, some cells recorded densities of 1-5 individuals km^{-2}.

Project Bravo

6.3.27 The same seasonal pattern to that observed in Alpha was recorded in Bravo. Great Black-backed Gulls were present in the initial surveys up to and including June 2010. From September 2010, they were again present until April whereafter they were absent until September (Appendix F1 Annex 1, Figure 6.51). As with Alpha, the peak population estimate, 245 individuals, was recorded in October 2010 and exceeded the 1% threshold for regional numbers during the passage period. A regionally important winter population (>119 individuals) was also recorded in January 2011 with an estimate of 135 individuals (Figure 6.51).

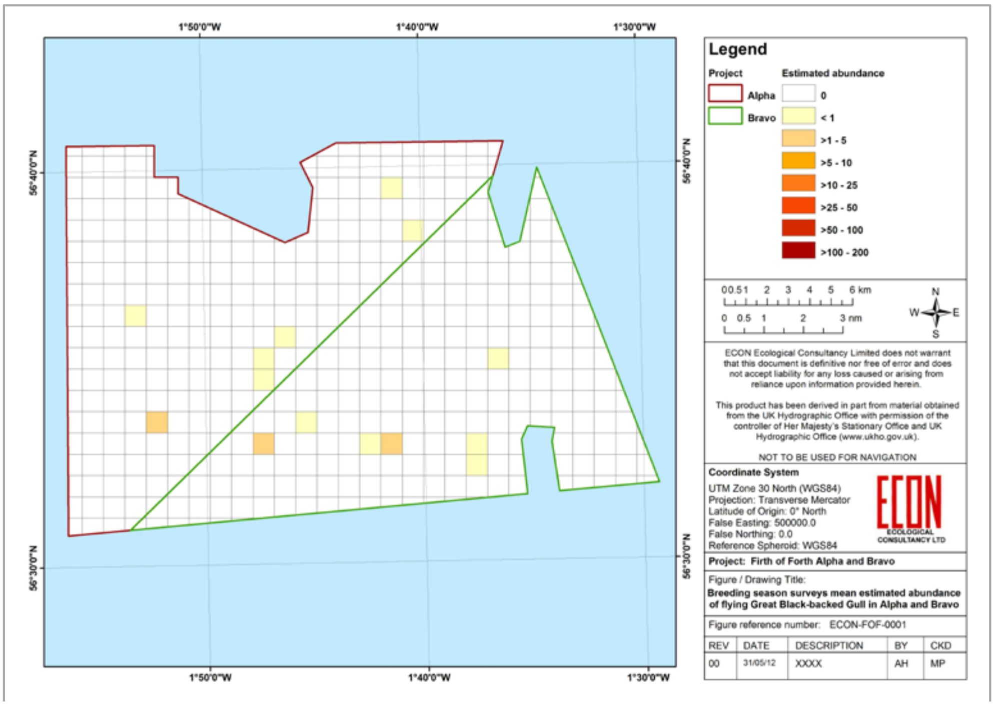
6.3.28 The mean densities per month for Bravo accorded closely with those of Alpha, with values between 0.03 and 0.66 individuals km^{-2} (Table 6.56). The same conclusion that Project Bravo appeared to support rather unremarkable densities of Great Black-backed Gull at any time of year was therefore reached.

6.3.29 In Project Bravo, 54.6% of the n = 11 birds aged in the breeding season of April to August inclusive were adults (Table 6.58), which was very similar to the pattern in Project Alpha (Table 6.57).

Table 6.58 Number and proportion of adult Great Black-backed Gulls relative to the total number of birds aged in each month during boat-based surveys of Project Alpha.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adults	31	1	2	1	2	3	0	0	2	14	2	6
%	63.3	16.7	33.3	33.3	40.0	100	-	-	22.2	31.1	33.3	46.2
Total	49	6	6	3	5	3	0	0	9	45	6	13

6.3.30 With only 175 Great Black-backed Gulls observed in the Bravo development site, no particular distribution pattern was established, apart from some possible tendency to higher density in the southeast part of the area in passage/winter. Otherwise, as with Alpha, birds were not recorded in large areas of the site, especially in the breeding season (Figure 6.53).



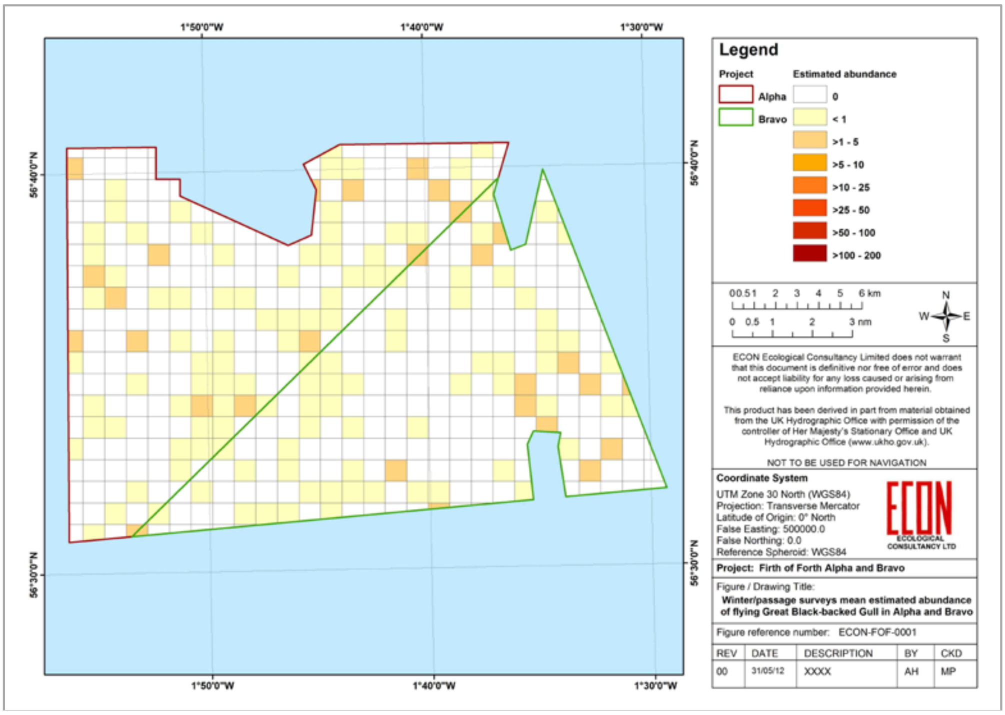


Figure 6.52. Relative abundance of Great Black-backed Gull expressed as birds in flight (individuals recorded km^{-2}) in 1 km^2 grid cells across Alpha and Bravo in the breeding season of April to August (above) compared to the passage/winter period (below).

Foraging range and potential origin

6.3.31 Despite Great Black-backed Gull mainly being a passage/winter species, some breeding birds may reach both Projects as Great Black-backed Gull has a prospective foraging range of ~100 km in the breeding season, including from some protected colonies (Figure 6.54). As a result, information on potential overlap with breeding colonies is included for the sake of completeness.

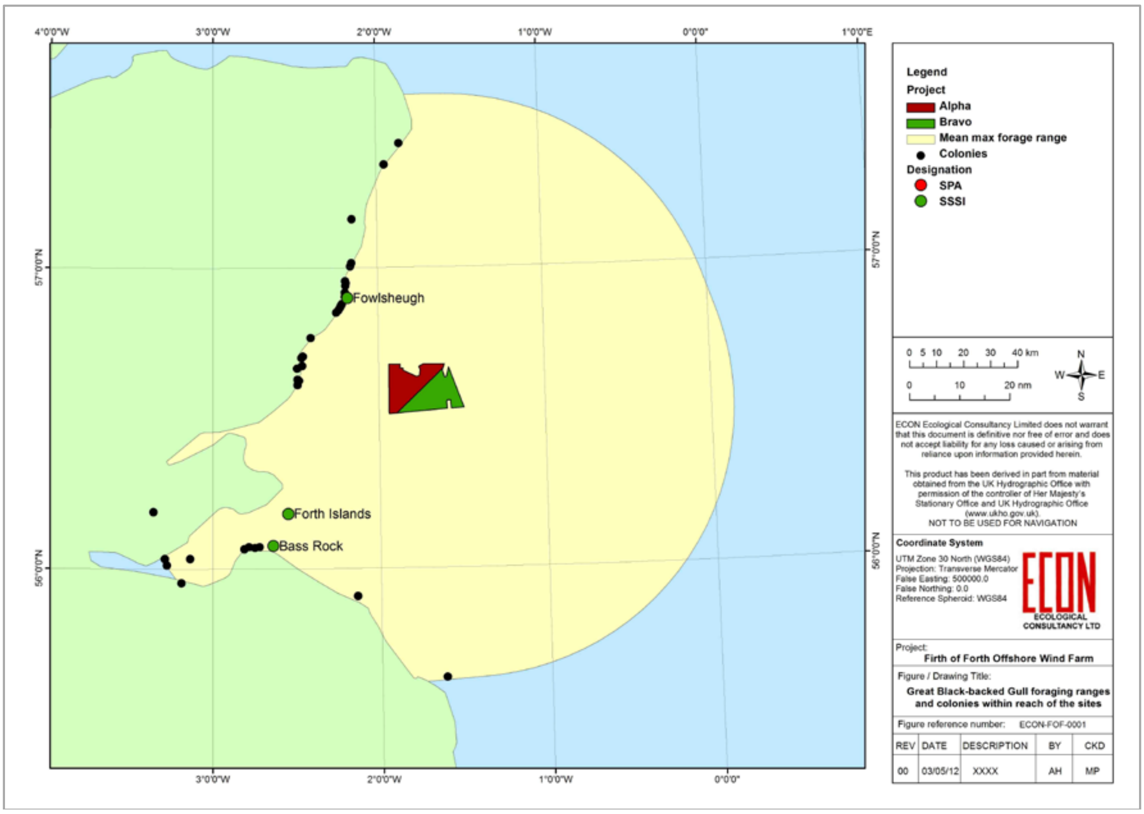


Figure 6.54 Distribution of Great Black-backed Gull breeding colonies including SSSIs contained within the prospective foraging range relative to Projects Alpha and Bravo.

6.3.32 A total of 32 colonies are represented within foraging range in a scattered distribution along the coast from the Farne Islands, Northumberland in the south to Boddam, Aberdeenshire in the north (see Figure 6.54). Only 288 individuals breed within this range that includes three SSSIs for the species. These are the Forth Islands SSSI (comprised of Craigleith, Fidra and the Lamb), Bass Rock SSSI and Fowlsheugh SSSI (Table 6.58). All three of these SSSIs are contained within SPAs for other species.

Table 6.58 Details of all Great Black-backed Gull breeding colonies at increasing distance from Projects Alpha or Bravo within the mean maximum foraging range of 100 km. Numbers of individuals recorded in Seabird 2000 and the latest count from the SMP database in the year specified are shown.

Foraging range	Site and designation	Distance	Seabird 2000	Latest count	
				Number	Year
	Catterline to Inverbervie	27.72	24	24	1999
Mean Max	Fowlsheugh SSSI	30.41	2	4	2009
	Montrose to Lunan Bay	32.64	10	10	2001
	Lunan Bay to Arbroath	33.68	6	6	2001
	Stonehaven to Wine Cove	33.96	8	8	1999
	Newton Hill	39.41	4	4	2002
	Isle of May	52.61	54	82	2011
	Aberdeen City	55.42	18	18	2001
	Bass Rock SSSI	65.15	2	2	2011
	St Abb's to Fast Castle	68.48	2	2	2000
	Forth Islands SSSI	71.06	20	50	2011
	Sands Of Forvie	74.05	10	6	2011
	Boddam to Collieston	81.85	18	28	2007
	Inchkeith	91.25	2	14	2011
	St. Serfs Island, Loch Leven NNR	94.64	4	4	2011
	Inchmickery, Inchgarvie, Forth Rail Bridge	99.71	4	2	2011
	Farne Islands	98.98	4	22	2011
	Forth Islands - Bass Rock to Haystack	98.99	0	2	2011

Project Alpha

6.3.33 All Great Black-backed Gull colonies within mean maximum foraging range are small, with the largest, just over 50 km away on the Isle of May in the Firth of Forth, supporting 82 individuals. Otherwise, Craigleith in the Forth Islands SSSI supports 46 individuals. The status of the closest colonies at Catterline to Inverbervie and from Montrose to Lunan Bay and Arbroath to Lunan Bay is unknown considering that they were last surveyed more than a decade ago. The small size and relative distance of most colonies would explain why relatively few Great Black-backed Gulls were seen during the breeding season.

6.3.34 The small numbers of birds in the breeding season provides little information on prospective flightlines across Alpha, with these distributed across many different directions (Table 6.59). On this basis, the prospective origin of birds can only be assumed to include all colonies within range, with the relatively large size of colonies amongst the Forth Islands assumed to contribute birds in proportion to their abundance.

Table 6.59. Number and proportion (%) of flight directions recorded for Great Black-backed Gull during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	17	16	19	22	6	7	10	32	32
	%	10.56	9.94	11.80	13.66	3.73	4.35	6.21	19.88	19.88
Breeding season	Count	2	0	0	0	2	2	1	2	0
	%	22.22	0.00	0.00	0.00	22.22	22.22	11.11	22.22	0.00

6.3.35 Scottish breeding Great Black-backed Gulls are largely sedentary and are rarely found far from their breeding colonies (Wernham *et al.* 2002). Sub-adults however do disperse in winter, usually southwards, but with a few to the north (Forrester *et al.* 2007). Greater use is made of refuse tips for feeding in winter, although the relative use between these and at-sea sources is unknown (Wernham *et al.* 2002).

6.3.36 The wintering population along the east coast of Scotland is augmented by a large number of Great Black-backed Gulls from Norway, the stronghold of Great Black-backed Gull in Northwestern Europe, and Russia (Wernham *et al.* 2004). These birds begin to arrive in July, with numbers peaking in September with relatively high numbers maintained throughout the winter.

6.3.37 In conclusion, in passage and winter periods the population is swollen by immigrant birds from other countries in more northerly latitudes. Such birds will comprise the majority of individuals present. However, given the sedentary nature of Scottish breeders, it can only be assumed that some of the adults recorded at sea in the passage and wintering periods are the same as those recorded in the breeding season. Using the peak in March when all birds should be back on territory (26 individuals) and comparing this to the peak in the passage period assuming these are represented throughout the passage and wintering period suggests that local breeding birds could comprise 10% of birds in the passage and wintering periods.

Project Bravo

6.3.38 With similar numbers and densities of Great Black-backed Gulls within Project Bravo compared to Project Alpha, the conclusions reached for Project Alpha on the likely origin of birds also hold for Project Alpha, especially since information on flight directions of birds recorded in Bravo also offers no further insight on likely origin (Table 6.60).

Table 6.60 Number and proportion (%) of flight directions recorded for Great Black-backed Gull during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	24	18	7	20	9	5	8	16	44
	%	15.89	11.92	4.64	13.25	5.96	3.31	5.50	10.60	29.14
Breeding season	Count	1	3	3	2	1	0	1	0	3
	%	7.14	21.43	21.43	14.29	7.14	0.00	7.14	0.00	21.43

Summary of risks

6.3.39 Garthe & Hüppop (2004) considered Great Black-backed Gull as the most vulnerable of the gull species to offshore wind farms with a rank of ninth, in part due to the risk of collision stemming from its flight altitude and low manoeuvrability, but also as a result of high adult survival rate and relatively low biogeographical population size. Furness & Wade (2012) take the issue of relative risk further in their consideration of the different risks of wind farms and ranked Great Black-backed Gull as *the* most sensitive seabird to the impact of collision with turbines. The relative risk of displacement is thought to be much lower with a rank of 23rd from the 37 seabirds considered, although it is of note that this is still the highest of any gull species.

6.3.40 The high risk of collision is a consequence of the study by Cook *et al*. (2011) that concluded that Great Black-backed Gull had the highest proportion of flights above 20 m at 35.1%. Very similar proportions were recorded from boat-based surveys of the Alpha and Bravo development sites with 32% and 34% respectively. Both sites also recorded >85% of birds.

6.3.41 Despite Great Black-backed Gull being considered to be the most sensitive gull to displacement by Furness & Wade (2012), this is partly derived from conservation importance and species concern index, rather than actual likelihood of disturbance (by helicopters and ships) and habitat use restrictions. In fact, the risk of collision for Great Black-backed Gull is thought to be mostly determined by the fact that is not likely to be displaced from wind farms in construction or operation. During construction, Great Black-backed Gull may increase abundance and utilise turbine bases as perches (*pers. obs.*). In relation to the two offshore wind turbines at Blyth, UK, Great Black-backed Gull numbers increased after construction (Rothery *et al*. 2009). At this site, Great Black-backed Gull was amongst the most frequent victims of collisions at what was thought to be a low rate (DTI 2005). Otherwise, information is rather scant mainly it seems as a result of occurrence at low density (see Petersen *et al.* 2006).

6.3.42 Despite the occurrence of what may be at least some of the same birds throughout the year, the potential for barrier effects is very low if birds do not avoid wind farms. Moreover, the potential for indirect effects is also considered to be extremely low given that much of the diet may be unaffected by construction if they are terrestrial or coastal in origin or linked to commercial fishing activity. Moreover, Great Black-backed Gull as well as other scavenging species (e.g. other large gulls such as Herring and Lesser Black-backed Gull and Fulmar) may even benefit in the short-term if fish are disoriented or injured as a result of construction noise

Project Alpha

6.3.43 The sensitivity of the species and the prospect of a significant ecological impact resulting from collision particularly in a cumulative context in conjunction with Bravo (and also STW sites), and especially upon the small local populations of breeding birds (some of which are from SSSIs) that may persist throughout the year, all means that Great Black-backed Gull is taken forward as a sensitive receptor in relation to Project Alpha within the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

6.3.44 The potential for significant ecological impact is however, limited to collision, with no evidence for displacement, barrier effects and indirect effects.

Project Bravo

6.3.45 As for Alpha, the potential of significant ecological impact stemming from collision risk particularly in a cumulative context, means that Great Black-backed Gull is taken forward as a sensitive receptor in relation to Project Bravo within the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

6.3.46 As also concluded for Alpha, there is no requirement to consider displacement, barrier effects and indirect effects.

Common Tern

Population ecology

6.3.47 With a global population of some 460,000-620,000 pairs (Mitchell *et al.* 2004) Common Tern is not of conservation concern (Birdlife International 2012f). In turn, the large European population of 270,000-570,000 pairs is regarded as Secure (Birdlife International 2004), although Common Tern is listed under Annex 1 of the EC Birds Directive requiring the designation of SPAs.

6.3.48 In the UK, Common Terns are the most widely distributed breeding tern, although they are far from being the most abundant with around 11,800 pairs, representing 2.2% of the global population (JNCC 2011). Colonies form on offshore islands, sand dunes, shingle spits, coastal lagoons and salt marshes along most of the coast of the UK, with the exception of most of southwest England and mainland Wales. They also nest inland on lakes, reservoirs and gravel pits (Mitchell *et al.* 2004). Common Tern is mostly replaced by Arctic Tern in the Northern and Western Isles.

6.3.49 The generalist nature of Common Tern enables a wide distribution compared to say, Sandwich Tern. The diet of Common Tern is comprised of a wide variety of marine and freshwater fish, aquatic invertebrates and, occasionally, terrestrial invertebrates (Cramp *et al.* 1974). Feeding occurs by surface picking and shallow plunge diving often accompanied by hovering.

6.3.50 Over the last three decades the UK Common Tern population has remained broadly stable (JNCC 2011). Between 2000 and 2010 the UK population increased by 3%, although it fell slightly in Scotland over the same period. Due to at least 50% of the UK breeding population occurring in 10 or fewer breeding colonies, Common Tern has Amber status on the list of birds of conservation concern (Eaton *et al.* 2009).

6.3.51 The majority of Common Terns return to their breeding colonies from early April onwards. A typical clutch of two eggs is laid from mid-May (Cramp *et al.* 1974). Both adults share incubation and the chicks hatch from mid-June. The majority of chicks fledge from mid-July onwards and most colonies are deserted by the end of July.

6.3.52 Few birds are seen in British waters after September. Common Terns mainly overwinter off the west coast of Africa, with a few known to winter off the coast of southern Spain and Portugal (Wernham *et al.* 2002).

Density distribution and population size

Project Alpha

6.3.53 Common Tern was only considered to have the potential to be a sensitive receptor to the development of Project Alpha on the basis of regionally important numbers in the passage period. Common Tern were observed at the end of the breeding season and in the passage period in August and September in 2010, whereas in 2011, they were only observed in what could be described as during the breeding season (May, July and August) (Appendix F1 Annex 1).

6.3.54 Only two population estimates could be calculated from the small number of birds seen (31 individuals). These were populations of 66 and 43 individuals in September 2010 and May 2011 respectively (Figure 6.65). Both estimates suggested regionally important numbers for the breeding season and for the passage period.

6.3.55 The two estimates of density at 0.3 individuals km^{-2} in September 2010 and 0.2 individuals km^{-2} in May 2011 respectively were derived from flying birds recorded in snapshots only. The densities produced are in line with that of 0.4 individuals km^{-2} present around Arbroath between July and September (Skov *et al*. 1995).

Project Alpha

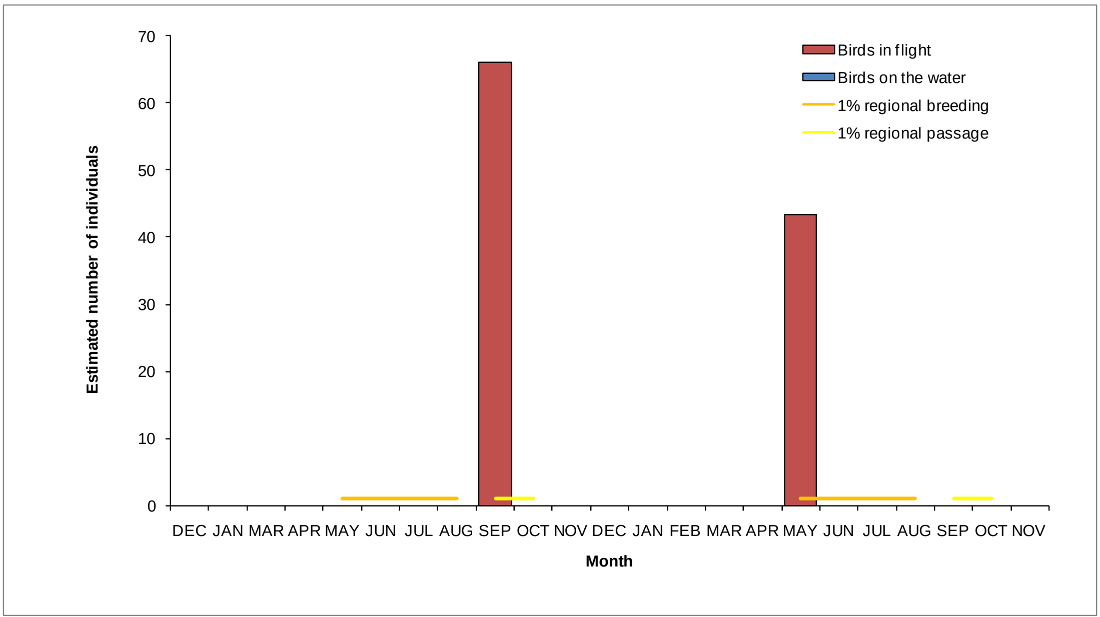


Figure 6.65 Common Tern population estimates by month over the two years of boat-based surveys of Projects Alpha. Estimates are derived from density derived from snapshots of birds in flight. Criteria for regional importance in the breeding and passage periods are shown.

6.3.56 Skov *et al*. (1995) note a similar density is recorded around Flamborough Head (0.2 individuals km^{-2}) although this is likely to have increased considerably in recent times with the presence of up to 40,000 individuals roosting on nearby Spurn Point in recent years (www.spurnbirdobservatory.co.uk/sightings/august09). As this is far higher than the east coast breeding population even accounting for juvenile birds, individuals from elsewhere in the UK and Continental Europe must be involved. The potential for mixing had previously been suggested by ring recoveries (Wernham *et al*. 2002).

6.3.57 Otherwise, density estimates are frequently confounded by the confusion with Arctic Terns leading to classification of 'Commic' Terns, with passage often occurring in inshore waters where there are relatively few surveys. Nevertheless, Stone et al. (1995) present a peak density of 0.23 individuals km^{-2} over the whole of the wider Western North Sea in June. Despite the potential confusion with Arctic Terns, this serves to demonstrate that not only is the density of Common Terns observed in Alpha not particularly unusual in a wider context, but also that the timing of occurrence may not always be entirely consistent with migration patterns.

6.3.58 Whilst only 31 Common Terns observed in the Alpha site, confidence in the pattern of distribution is limited. Nevertheless, the apparent avoidance of the northern half of the site is striking, as is the general occurrence of birds in small groups of 3-10 individuals (Figure 6.66).

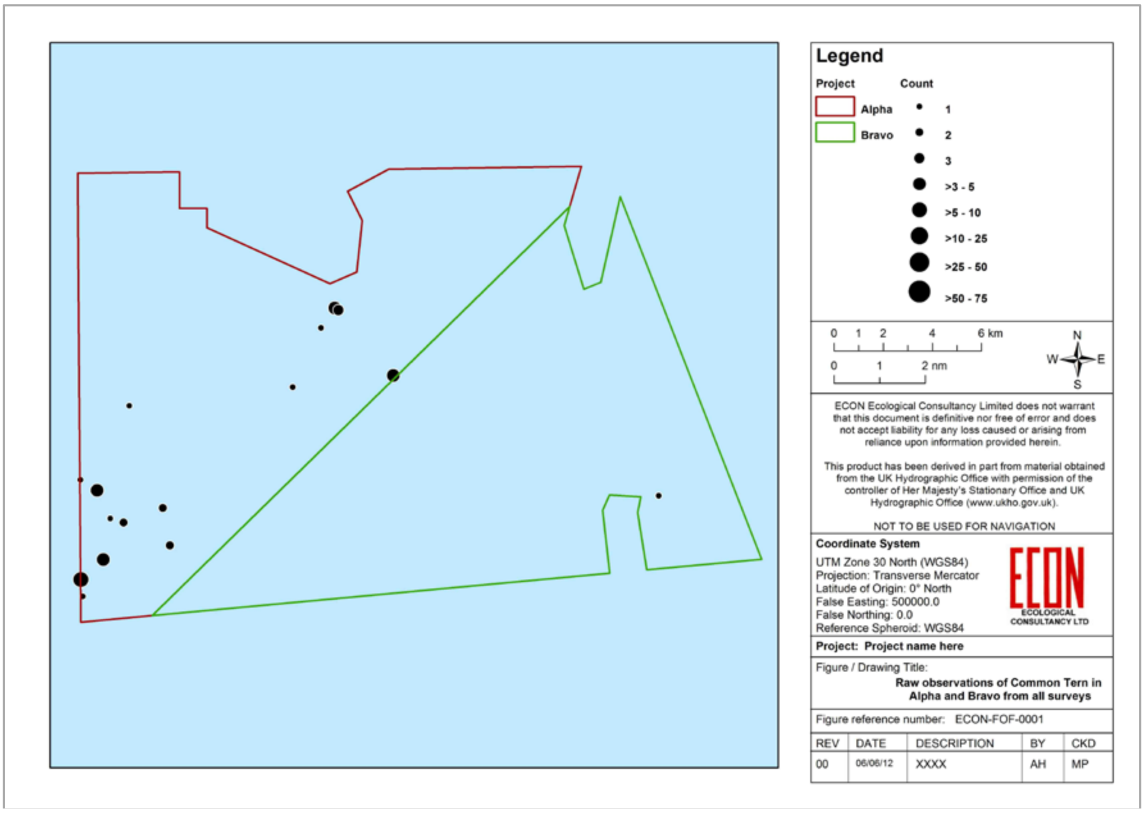


Figure 6.66. Distribution and group size of Common Terns recorded in all surveys of Alpha and Bravo.

Foraging range and potential origin

6.3.59 The occurrence of Common Tern in what appeared to the breeding season prompted consideration of the foraging range of the species in relation to colonies including the large colony at Imperial Dock Lock.

Project Alpha

6.3.60 According to Thaxter *et al*. (2012) Common Tern is thought to have a mean maximum foraging range of 15.2 km and a mean maximum foraging range + 1SD of 26.4 km. No breeding sites lie within mean maximum foraging range with only one within this range + 1SD (Table 6.61, Figure 6.67,). A total of 67 individuals are distributed amongst two non-designated colonies at the site in the Montrose area.

Table 6.61 Details of the single Common Tern breeding site closest to the mean maximum ± 1SD foraging range of 26.4 km from projects Alpha or Bravo. Numbers of individuals recorded in Seabird 2000 and the latest count from the SMP database in the year specified are shown.

Foraging range	Site and designation	Distance	Seabird 2000	Latest count	
				Number	Year
Mean Max + 1 SD	Montrose	33.25	75	67	2008

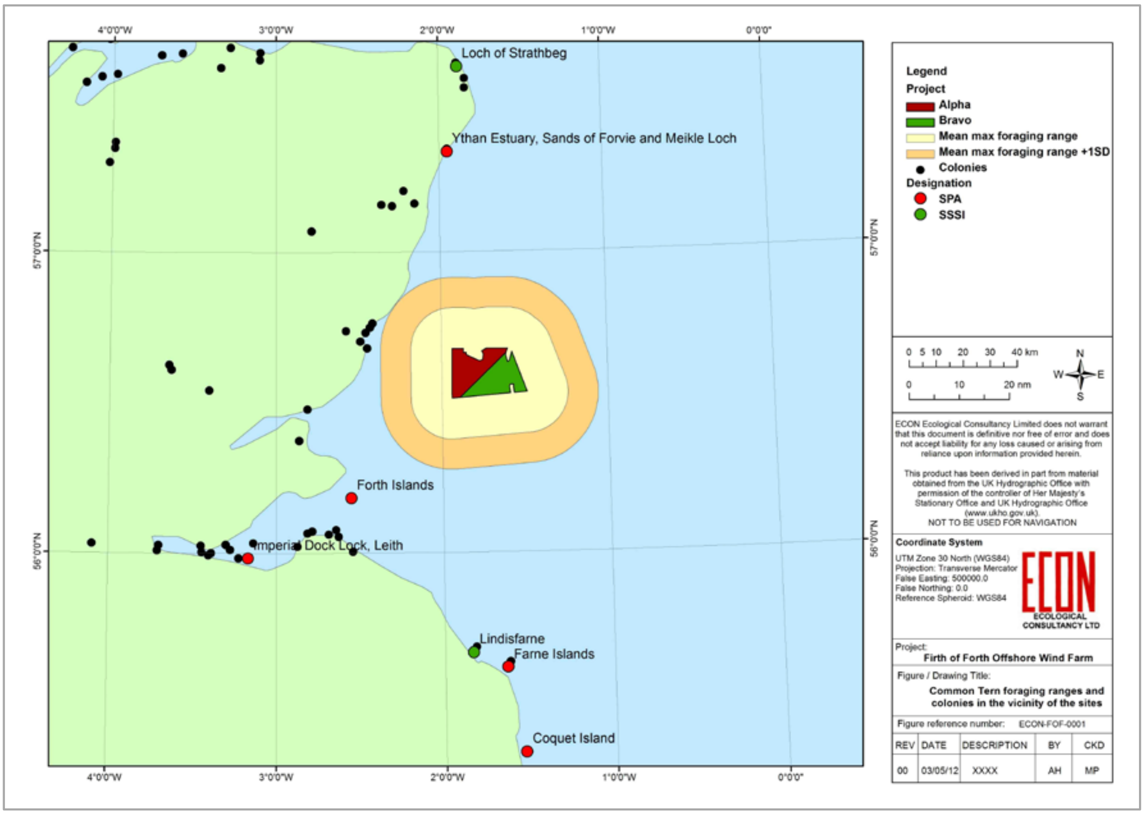


Figure 6.67 Distribution of Common Tern breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

6.3.61 JNCC have undertaken tracking of Common Terns at Imperial Dock Lock according to the methods of Perrow *et al*. (2011b). With similar range to that recorded at other colonies (see Perrow *et al*. 2010), there is no prospect of breeding Common Terns from Imperial Dock Lock SPA reaching Project Alpha in the breeding season.

6.3.62 Analysis of flight direction is inconclusive as a result of small sample size (Table 6.62), although it does demonstrate movement suggestive of northbound passage, with southeast flights indicative of southbound passage away from colonies.

Table 6.62 Number and proportion (%) of flight directions recorded for Common Tern during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	0	4	1	4	0	7	1	9	5
	%	0.00	12.90	3.23	12.90	0.00	22.58	3.23	29.03	16.13
Breeding season	Count	0	4	1	4	0	0	0	5	
	%	0.00	28.57	7.14	28.57	0.00	0.00	0.00	35.71	

6.3.63 In conclusion, whilst there is an outside possibility of a small number of breeders from the Montrose colonies reaching Project Alpha, it would seem more likely that the birds present in what would appear to the breeding season are part of late northbound passage in June or part of early dispersal that Forester *et al*. (2007) state can begin as early in July. Non-breeding individuals may also be represented.

6.3.64 During autumn passage proper it is likely that Common Terns from more northerly colonies, including those on Orkney and Shetland and from further afield in Norway and the Baltic, pass through Alpha on their migration southwards to West Africa. Although this movement can be rapid, some gather at coastal sites before starting or continuing the long journey south. The Firth of Forth is one such site, where birds can linger for a few weeks feeding (Forrester *et al.* 2007). It is possible for birds at such gatherings to be joined by birds from breeding colonies to the south, evidenced by juveniles from Norfolk and Belgium present in Durham in late August and early September (Wernham *et al.* 2002). Hence, predicting the origins of birds seen in Alpha during late summer and early autumn is complex.

6.3.65 Although birds originating from Imperial Dock Lock SPA may well be present during autumn passage their relative contribution appears likely to be small (<4%) considering that up to 40,000 Common Terns have been recorded at Spurn Point alone in UK waters.

Summary of risks

6.3.66 Garthe & Hüppop (2004) ranked Common Tern as 15th in regard to vulnerability to wind farms, with Furness & Wade (2012) ranking the species 13th in the context of collision with turbines and 21st in the context of displacement.

6.3.67 The high proportion of time spent in flight coupled with at least some time at a flight altitude at collision risk was responsible for the relatively high ranking in relation to collision. Data derived from boat-based surveys established a relatively high proportion of flights >20 m (21%), however, this may be a function of small sample size and the modelling by Cook *et al*. (2011) derived a much lower of proportion of flights >20 m of 8.3%. Experience dictates that a low proportion at flight height and low density coupled with intermittent occurrence means there is a very low prospect of a significant ecological impact, especially upon a relatively large passage population.

6.3.68 Previous studies have indicated that Common Tern is not likely to be subject to significant displacement from wind farms (see Dierschke & Garthe 2006, Petersen *et al*. 2006). There thus seems no likelihood of barrier effects especially considering that individuals are only likely to be subject to one or two deviations per annum when on passage. Moreover, of the 31 Common tern observed within Alpha, only one recorded feeding (unusually on a compass jellyfish *Chrysaora hyoscella*). Even if indirect effects were to occur, this seems to be of little consequence for areas immediately around the site.

6.3.69 Although the wider area is thought to be importance to foraging terns on passage, important areas close to the coast are at some distance (>30 km or more) from Alpha, and it would seem unlikely the Project will affect such as large area following mitigation.

Project Alpha

6.3.70 With very low potential for significant ecological impact upon Common Tern populations through collision, displacement, barrier effects or indirect effects, of Common tern is not considered to be a sensitive receptor for Project Alpha and will not feature in the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

Arctic Tern

Population ecology

6.3.71 Europe accounts for less than 25% of the global breeding range of Arctic Tern. The population of >500,000 pairs the Arctic Tern was categorised as Secure and despite recent decline in some parts of its range (BirdLife International 2004). It is however listed under Annex 1 of the EC Birds Directive requiring the designation of SPAs.

6.3.72 Arctic Tern is the commonest breeding tern in the UK with 53,400 pairs comprising 4.7% of the European and 3.1% of the global population. The majority of these birds (84%) breed in Scotland, in particular on Shetland and Orkney (Forrester *et al.* 2007). The population has fluctuated markedly since 1970. Following a peak in the mid-1980s of 78,000 pairs, the population had fallen by over 30% by the time of Seabird 2000 (Mitchell *et al.* 2004). The population fell further to a low in 2004, but rose by 7% over the ten-year period between 2000 and 2010, probably helped by eradication of American Mink *Mustela vison* in the west of Scotland (Eaton *et al.* 2011). Arctic Tern remains of conservation concern in the UK with ‘Amber’ status on account of a moderate (>25% but <50%) long-term decline in the breeding range (Eaton *et al.* 2009).

6.3.73 Rapid changes in population size were largely influenced by a few large colonies in the Northern Isles where most Arctic Terns breed. The diet of Arctic Tern is largely fish, consisting of mostly sandeels, small Herring and Sprat (Cramp *et al.* 1974), although they will also prey on insects blown offshore. The main period of poor productivity between 1988 to 1990 and 2004 was largely attributed to shortages in prey, especially sandeels. Food shortages were exacerbated by poor weather, which not only hampered foraging but also lead to the chilling of eggs and lower rates of chicks survival. Predation by gulls also increased as they searched for alternative food sources (JNCC 2011).

6.3.74 The Arctic Tern has the longest and most extensive migration of any bird, spending the winter months in Antarctic seas approximately 20,000 km from their breeding grounds (Wernham *et al.* 2002). Adults return to their breeding colonies during late April and May. They nest colonially on a variety of habitats, including grassland, dunes, offshore islands and coastal moorlands (Lloyd *et al.* 1991). Clutches of two or three eggs are laid throughout late May and early June and incubation is shared by both parents (Cramp *et al.* 1974). The majority of chicks hatch from mid-June onwards and have fledged by late July. After the colony has been deserted, adults and newly-fledged chicks rapidly move south. Most birds have left British waters by September.

Density distribution and population size

Project Alpha

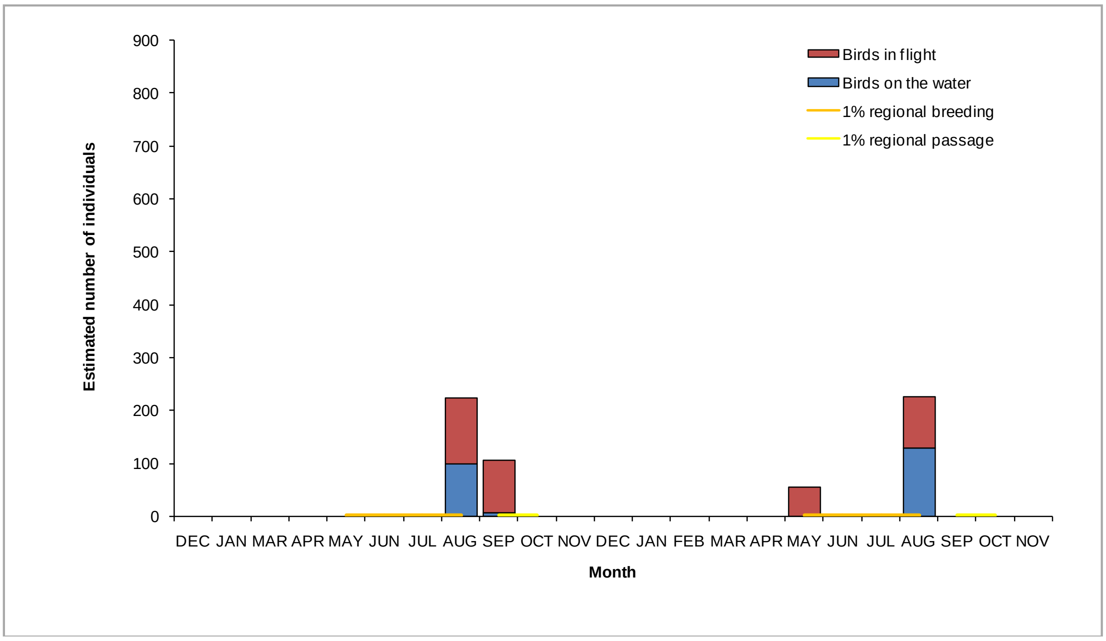
6.3.75 In Project Alpha, the seasonal distribution of Arctic Tern was similar in both years, with a similar peak in abundance in August, with some extension of passage into September in 2010 and with a few birds in July 2011. A little spring passage was recorded in May 2011 (Figure 6.68).

6.3.76 The peak population estimate was 227 individuals in August 2011 with 224 individuals estimated to be present in August 2010. As the regional 1% thresholds was very low, estimates in the passage period invariably exceeded the threshold (Figure 6.68). Nevertheless, as three of the estimates produced >100 individuals, the numbers of birds did appear to be important.

6.3.77 Densities were calculated for both birds on the water and also flying birds from snapshots, with densities for birds on the water up to 0.6 ind. km^{-2} (equivalent to 127 birds) and those in flight from 0.3 to 0.6 individuals km^{-2} (54 and 126 birds). As described in relation to Common Tern, there are few available density estimates of Arctic Tern for comparative purposes. The species is neglected in the analysis of important areas for seabirds in the North Sea by Skov *et al*. (1995) for example.

6.3.78 The tendency for Arctic Terns to occur on the sea surface unlike other species (save occasional feeding of a partner or chick) increases the prospect of accurate density estimation and the occurrence of densities of up to 0.6 individuals km^{-2}, higher than that of ‘Commic Terns’ in any area at any time by Stone *et al.* (1995) reinforces the potential importance of the area and perhaps of the Firth of Forth in general.

Project Alpha



Project Bravo

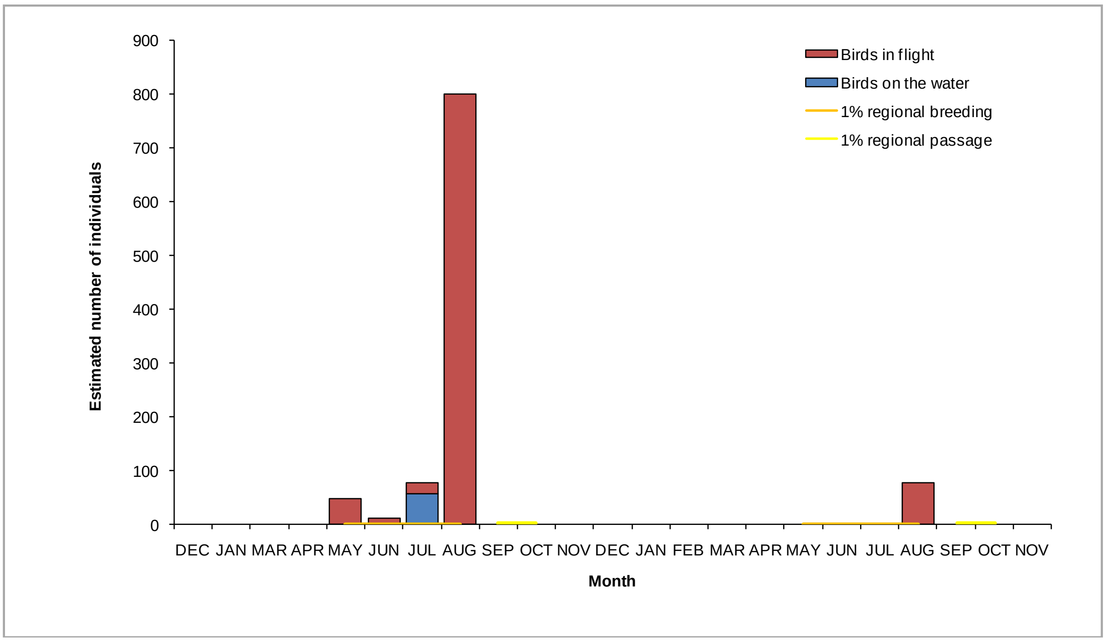


Figure 6.68 Arctic Tern population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from density derived from snapshots of birds in flight combined with uncorrected density of birds on the water from line transect. Criteria for regional importance in the breeding and passage periods are shown.

6.3.79 The distribution of Arctic Terns across Project Alpha was widespread with some clusters of birds in the southwest in groups of >25 individuals (Figure 6.69).

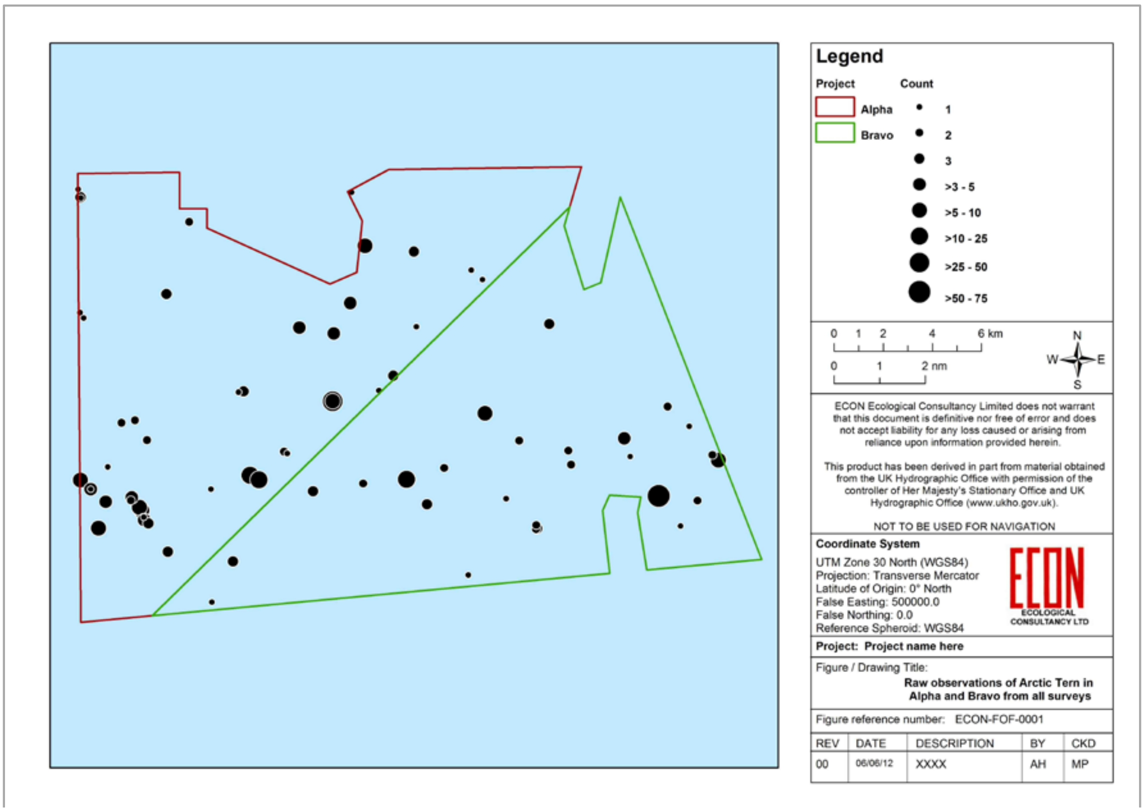


Figure 6.69 Distribution and group size of Arctic Terns recorded in all surveys of Alpha and Bravo.

Project Bravo

6.3.80 The seasonal distribution of Arctic Tern was similar to Alpha in that the peak occurrence was during autumn passage in August although the size of the peaks was very different. Furthermore, whereas in Alpha the small amount of spring passage was in 2011, this was in 2010 in Bravo, with autumn passage beginning in July in 2010 rather than 2011. No birds were recorded in September in Project Bravo.

6.3.81 Population estimates were derived from all surveys in Project Alpha, with the peak recorded in August 2010, with an estimate of 800 individuals (Figure 6.68). The estimate was derived solely from flying birds, with 74 of the 88 birds observed) actively foraging in aggregations containing up to 56 birds (Figure 6.69). As in Alpha Arctic Terns were widely but patchily distributed across much of Project Bravo.

6.3.82 The density acquired from snapshots for the August 2010 survey was 4.1 individuals km^{-2}. Whilst such levels and more must be readily achieved in the vicinity of colonies, there does not appear to be any record of such density on passage in offshore areas in the general literature.

Foraging range and potential origin

6.3.83 Although clearly predominately a passage species, the foraging range of Arctic Tern and distribution of colonies in the general area of projects Alpha and Bravo was considered, especially in relation to the potential origin of birds on site.

Project Alpha

6.3.84 Arctic Tern has a mean maximum foraging range of 24.2 km and a mean maximum foraging range + 1SD of 30.5 km (Figure 6.70). No breeding sites lie within mean maximum foraging range and only two within this range + 1SD (Table 6.63). A total of 58 individuals are distributed amongst three non-designated colonies in the Montrose area (Table 6.63).

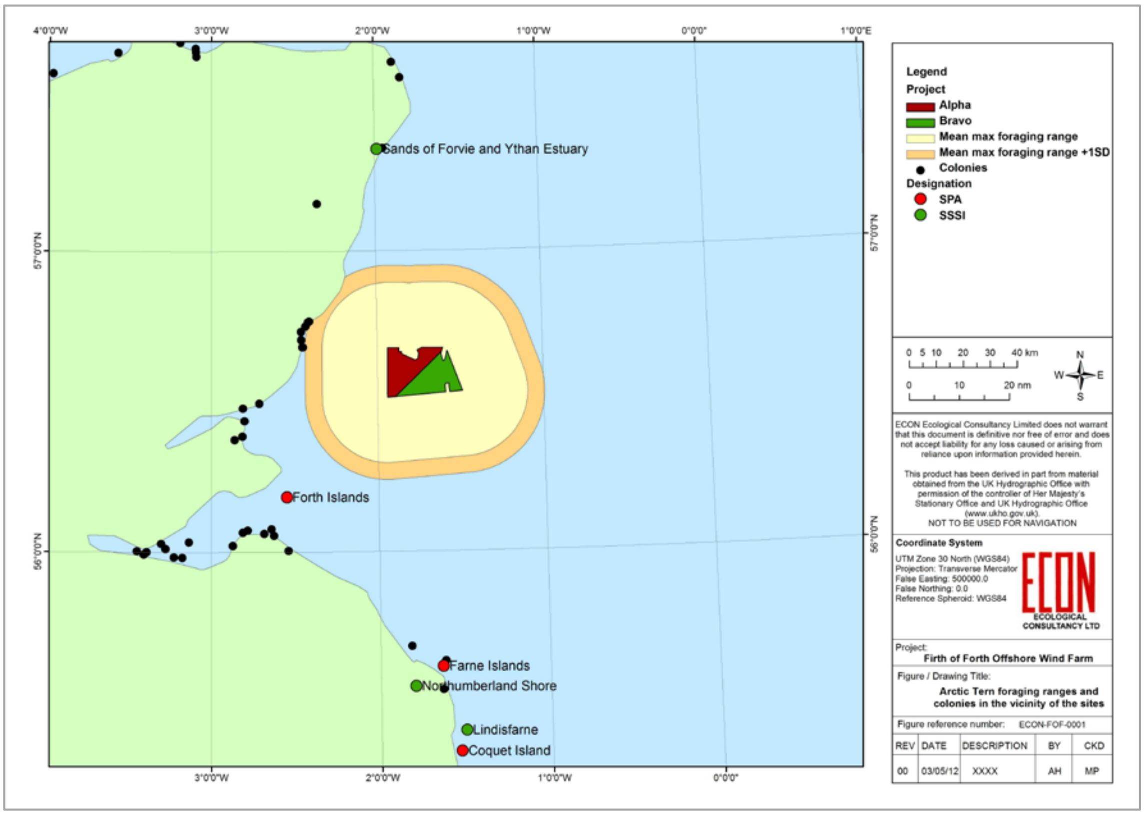


Figure 6.70 Distribution of Arctic Tern breeding colonies including SPAs and SSSIs contained within the mean maximum and mean maximum (+ 1SD) foraging range relative to Projects Alpha and Bravo.

Table 6.63 Details of all Arctic Tern breeding colonies closest to the mean maximum ± 1SD foraging range of 30.5 km from projects Alpha or Bravo. Numbers of individuals recorded in Seabird 2000 and the latest count from the SMP database in the year specified are shown.

Foraging range	Site and designation	Distance	Seabird 2000	Latest count	
				Number	Year
Mean Max + 1 SD	Montrose to Lunan Bay	31.75	16	16	2000
	Montrose	32.50	111	42	2005

6.3.85 It is plausible that a few birds from these colonies at the apparent edge of foraging range could be responsible for the records from May through to July, although the explanation of tardy spring birds or early autumn passage birds is of equal merit, as is the presence of some non-breeding individuals. The flight direction of birds offers no further insight as this mirrors that overall, with a preponderance of flights with no direction indicative of foraging behaviour (Table 6.64).

Table 6.64 Number and proportion (%) of flight directions recorded for Arctic Tern during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	1	5	0	14	35	5	10	17	53
	%	0.71	3.57	0.00	10.00	25.00	3.57	7.14	12.14	37.86
Breeding season	Count	1	5	0	14	35	5	3	4	51
	%	0.85	4.24	0.00	11.86	29.66	4.24	2.54	3.39	43.22

6.3.86 Although few birds breed within the vicinity of Alpha any contribution of these would be swamped by large numbers (>70,000 individuals) breeding to the north on Orkney and Shetland, some of which are known move southwards into the North Sea on autumn passage (Forrester *et al.* 2007). As for Common Tern, the Firth of Forth is a key feeding area for these passage birds, and they may linger for 1-2 weeks before continuing their long southwards migration to Antarctica. Little is known of the movements of birds from colonies in Scandinavia, the Baltic and Siberia, which could also potentially reach Alpha during autumn passage (Wernham *et al.* 2002). Overall, the

Project Bravo

6.3.87 Arctic Terns recorded in Project Bravo showed an even greater proportion of flights with no specific direction indicative of foraging behaviour (Table 6.65). There was thus no evidence of any link of breeding birds in nearby colonies, other than that these may be assimilated into the large passage population of birds from more northerly colonies.

Table 6.65 Number and proportion (%) of flight directions recorded for Arctic Tern during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	4	9	0	3	3	15	0	5	79
	%	3.39	7.63	0.00	2.54	2.54	12.71	0.00	4.24	66.95
Breeding season	Count	4	9	0	3	3	15	0	5	79
	%	3.39	7.63	0.00	2.54	2.54	12.71	0.00	4.24	66.95

Summary of risks

6.3.88 Arctic Tern was considered to be less vulnerable to offshore wind farms than Common Tern by Garthe & Hüppop (2004) with a rank of 17^{th} from 26 species, solely on the basis of the tendency towards lower flight altitude. The same factor was used by Furness & Wade (2012) to rank Arctic Tern below Common Tern in relation to risk of collision (17^{th}).

6.3.89 The proportion of flights >20 m modelled from nine sites was just 4.4% (Cook *et al*. 2011). A similar proportion (5.1%) was established from birds within the Bravo development site, whereas no birds were recorded flying above 20 m in Alpha. A very low proportion at risk height coupled with restricted occurrence means there is a very low prospect of a significant ecological impact of collision especially upon a large passage population.

6.3.90 Furness & Wade (2012) ranked Arctic Tern as 16^{th} in the context of Scottish seabirds sensitivity to displacement, at higher ranking than Common Tern. The difference between the two species is linked to conservation status rather than any behavioural attribute as both species are considered to have a moderate flexibility in relation to habitat use. Arctic tern in particular tends to feed in frontal zones, upwellings and tidal rips where small prey is brought to the surface. The availability of prey may depend to some extent on patterns of tide and current which may limit the availability of prey to birds on passage to some extent.

6.3.91 Whilst only 5% of Arctic Terns recorded within the Alpha boundary exhibited direct feeding behaviours, birds with no specific flight direction was the commonest pattern (Table 6.52). In contrast, 57% of the birds observed within Bravo were recorded as having direct feeding activity mainly as a result of a single feeding aggregation of 56 individuals in August 2010). Moreover, 67% of flights were recorded as having no specific direction. The attractiveness of the Firth of Forth is noted by Forrester *et al*. (2007) although it is difficult to gauge its relative importance in the context of other areas. It is possible that Arctic Terns use a network of particular sites in a similar manner as waterfowl use 'stopover' sites, and it could be that the Firth of Forth is one of them. Whether Arctic Terns continue passage through the North Sea or return north to pass into the Atlantic via the west coast of Scotland or even cross inland is open to question.

6.3.92 Although evidence is limited there is no specific indication that Arctic Terns, like Common Terns will be subject to significant displacement from wind farms (Christensen *et al.,* 2003, 2004). In fact, operational sites may prove attractive to Arctic Terns exploiting the upwellings and currents around turbine bases, part of the wider reef effect (Linley *et al*. 2007). This also suggests that barrier effects are unlikely to operate even if they could be of consequence for a non-breeding species potentially undertaking some repeat movements across the site if individuals do indeed stay in the area for at least some time.

6.3.93 Overall, it is the prospect of indirect effects upon the prey base of Arctic Terns, which is likely to be dominated by young sandeels and clupeids, that provides the source of a potential effect of the Projects. Any effects would most likely be mediated through any impact upon sensitive clupeids, but unfortunately it is not known which prey species are being targeted in the Firth of Forth, and thus there is considerable uncertainty as to the extent of any possible effect, other than it should be short duration, although this may not always be the case (Perrow *et al*. 2011a).

6.3.94 Information on the relative importance of the wider Forth, such as Wee Bankie or the Marr Bank or Scalp Bank itself cannot be considered here, although all of these areas are also thought likely to support Arctic Terns on migration. Extension of the footprint of construction into these areas, thus increased the potential and significance of any impact.

Project Alpha

6.3.95 It is judged that the risks of collision, displacement and barrier effects are highly unlikely to be able to generate a significant ecological impact upon a large passage population of Arctic Terns. However, should the Firth of Forth prove to be an important stopover for foraging birds on migration, there is potential for an indirect effect upon Arctic Terns. This requires further consideration especially in cumulative context using information on the true extent of the footprint of the site. For this reason Arctic Tern is carried forward as a sensitive receptor to the ES Ornithology chapter (Volume 1, Chapter 10).

Project Bravo

6.3.96 As for Alpha, Arctic Tern is to be subject to further consideration as a sensitive receptor for Project Bravo in the ES Ornithology chapter (Volume 1, Chapter 10). The potential for indirect effects of construction upon the prey base of the species is the only aspect to be considered.

Little Auk

Population ecology

6.3.97 Little Auk is the most numerous seabird in the North Atlantic (Grémillet *et al.* 2012). The global population appears to be decreasing, but not rapidly (<30% in 10 years)

(BirdLife International 2012g). Little Auk breeds on high cliffs in Greenland, Svalbard, and on the Russian Islands of the high Arctic. The European breeding population, which accounts for less than a quarter of its global range and 5 - 24% of its global population, is estimated at 11,000,000 – 44,000,000 pairs and is classified as Secure (BirdLife International 2004).

6.3.98 Although Little Auk does not breed in the UK, it winters at sea to the south of the breeding colonies, and the northern North Sea is thought to be a major wintering area, with up to a million birds present. Due to its pelagic habits, only a small proportion of birds are usually seen from land. However, following gales, birds can be forced inshore sometimes resulting in massive 'wrecks' along the British coast. The largest influx occurred during the winter of 1995/96, when 35,000 were recorded off the coast of Scotland (Forrester *et al.* 2007).

6.3.99 Although numbers of Little Auks may be heavily influenced by weather conditions, their movement into the North Sea is probably mainly linked to 'flushing' of their main zooplankton prey, *Calanus* spp., into the North Sea by the Gulf Stream which flows north around Scotland, and by the currents moving south down the Norwegian coast (Forrester *et al.* 2007).

Density distribution and population size

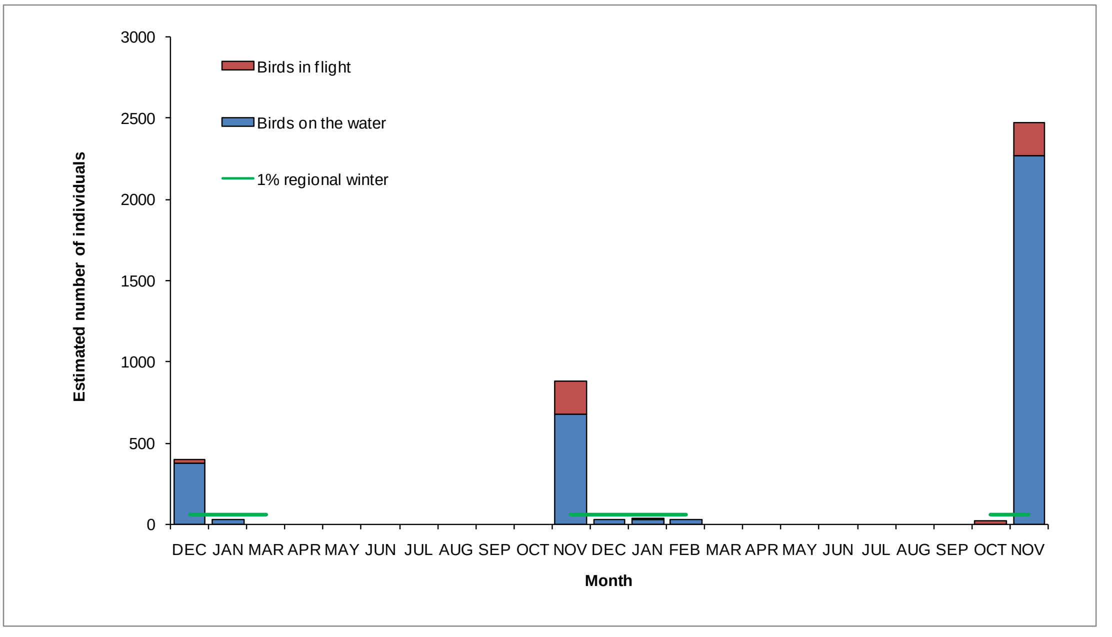
Project Alpha

6.3.100 Little Auk was consistently present within Alpha from October and especially November until February. Peak population estimates were recorded in November, with that of 2011 more than double that in 2010 with respective estimates of 2,471 and 884 individuals (Figure 6.71). The estimates were comparable to what is thought to be the Scottish population (Forrester *et al*. 2007) and thus far exceeded 1% regional threshold. However, it is clear that there are no reliable estimates for a small species occurring offshore in the winter months.

6.3.101 The peak estimate for November 2011 was generated through the DISTANCE corrected density for birds on the water (Figure 6.72). The density of 11.5 individuals km^{-2} with a sizeable UCI at 19.9 individuals km^{-2}, far exceeds the standard line transect density of 2.7 individuals km^{-2}.

6.3.102 The mean densities per month ranged from 0.1 to 8.5 ind. km^{-2} (Table 6.66). Densities described by Skov *et al*. (1995) for the area from the Firth of Forth to Devil's Hole were 0.4 individuals km^{-2} between October and November and 0.3 individuals km^{-2} and between December and February. The peak densities for Alpha are clearly in excess of these estimates, but are far below those for important areas for Little Auk in North Sea including North East Rough southwest of Norway, with densities of 17.2 and 56.8 individuals km^{-2} in the equivalent periods.

Project Alpha



Project Bravo

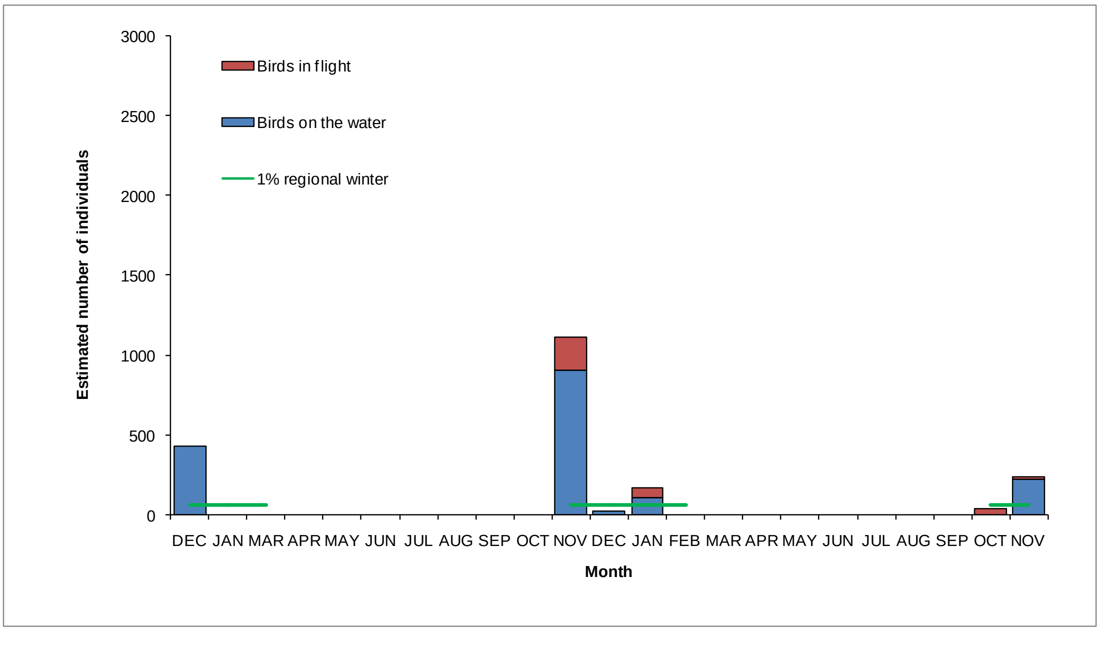


Figure 6.71 Little Auk population estimates by month over the two years of boat-based surveys of Projects Alpha and Bravo. Estimates are derived from DISTANCE-corrected density of birds on the water combined with density derived from snapshots of birds in flight. The criterion for regional importance in the winter period is shown.

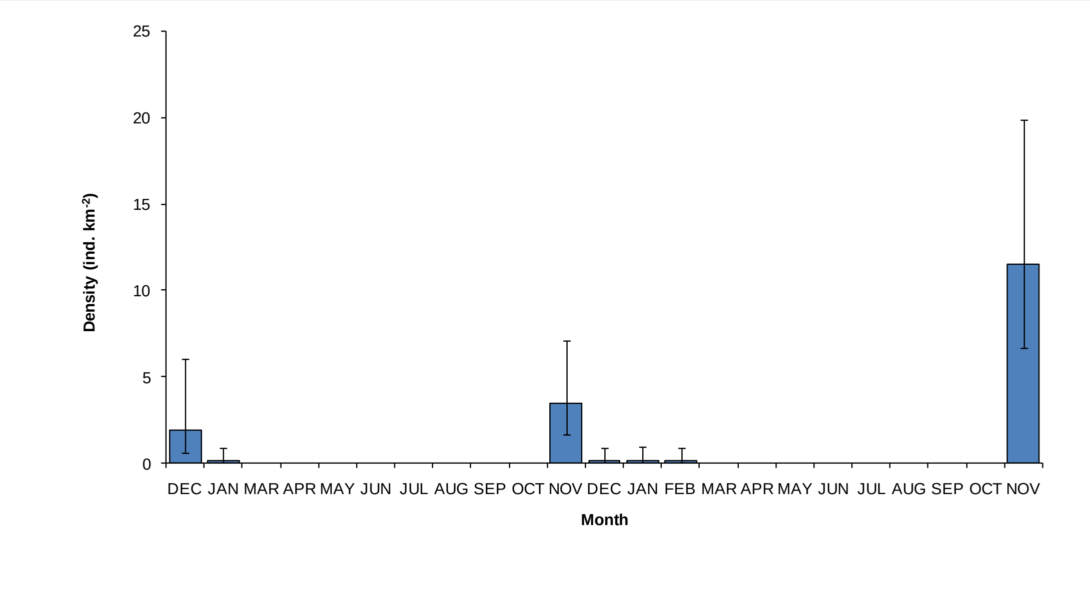


Figure 6.72 Monthly mean (± 95% confidence intervals) density of Little Auk in Project Alpha as derived from DISTANCE correction of birds on the water.

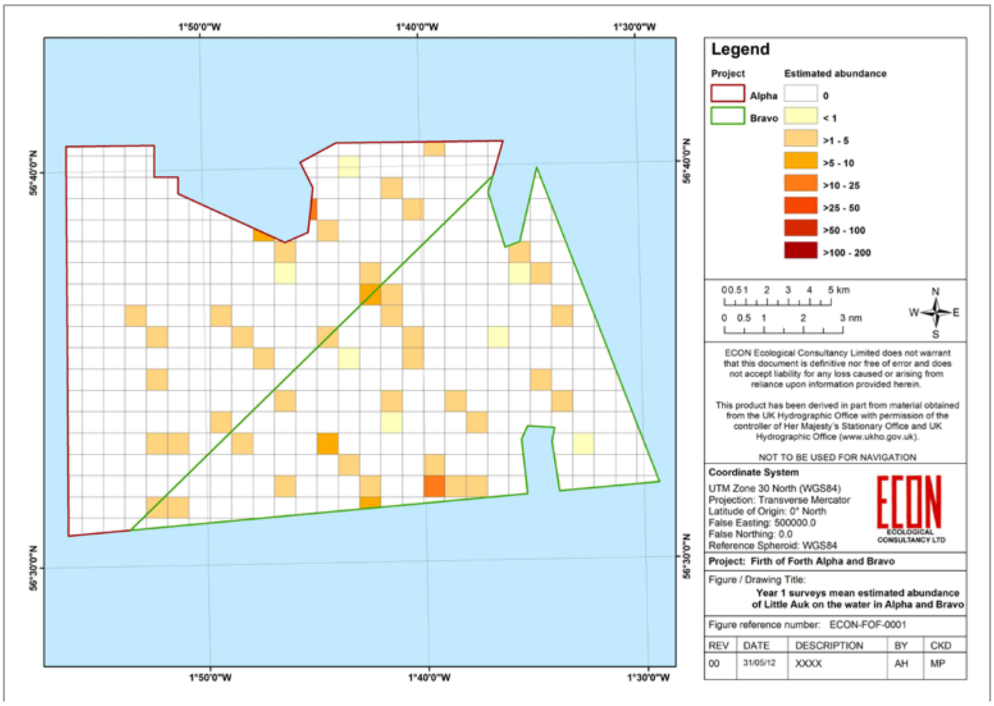
Table 6.66 Monthly mean (± 1SD) density of Little Auk in Project Alpha and Bravo as derived from a combination of DISTANCE-corrected line transect data for birds on the water and snapshot data for flying birds.

Project	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alpha	0.2 ± 0.1	0.2	-	-	-	-	-	-	-	<0.1 ± 0.1	8.5 ± 5.7	1.1 ± 1.3
Bravo	0.4 ± 0.6	-	-	-	-	-	-	-	-	0.1 ± 0.2	3.5 ± 3.2	1.2 ± 1.5

6.3.103 The distribution maps for Little Auks on the water differed between years. In 2010, the western edge and the northwest corner of Alpha contained few birds, with this shifting to the northeast and southwest corners of the site in 2011 (Figure 6.73). Distribution patterns of Little Auk may be determined by their zooplankton prey.

Project Bravo

6.3.104 Little Auk were present within Project Bravo in different months compared to Alpha. Little Auk was not present in January 2010, but was present in the March survey Conversely, the species was recorded in January 2011, but not again until October that year. Little Auk was therefore present for longer in 2009/2010 compared to 2010/2011 (Appendix F1 Annex 1).



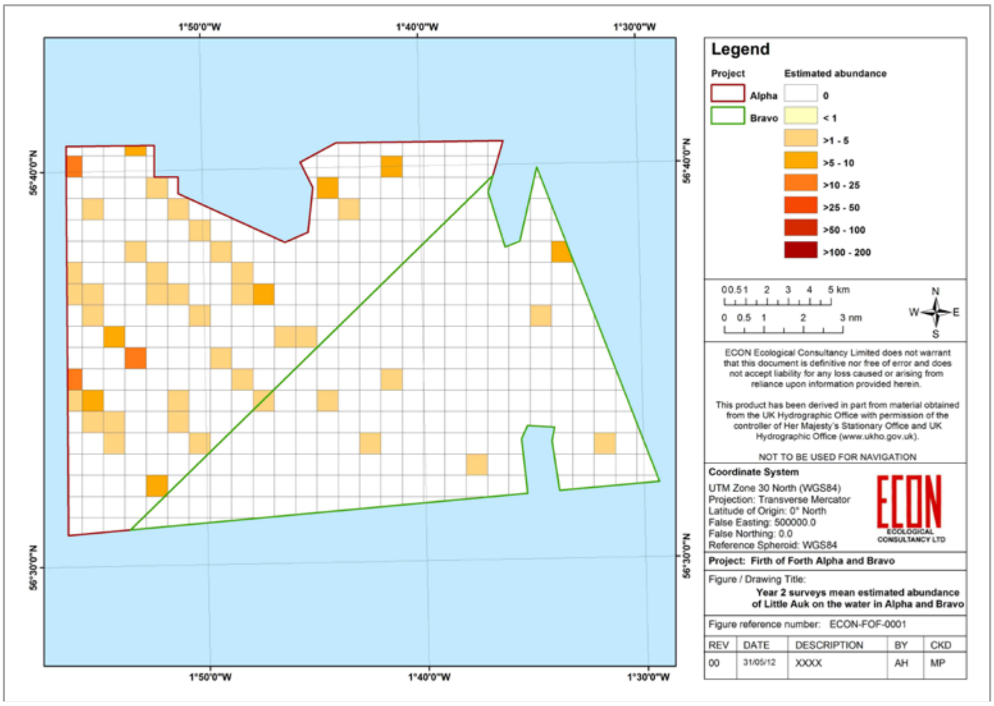


Figure 6.73 Relative abundance of Little Auk expressed as density (individuals km^{-2}) of birds on the water derived from bands A and B in 1 km^2 grid cells across Alpha and Bravo in the passage/winter period from October to February in 2010 (above) compared to 2011 (below).

6.3.105 Mean densities per month were comparable to those of Alpha, although the November peak was not as pronounced in Bravo (Table 6.54) with estimates of 1,113 and 239 individuals, exceeding the regional winter 1% threshold of 62 Little Auks (Figure 6.71). The DISTANCE derived density for birds on the water at 4.7 ind. km^{-2} (Figure 6.74), exceeded that derived from the standard methodology at 1.6 ind. km^{-2}. As noted in Alpha, densities are greater than those presented by Skov *et al*. (1995).

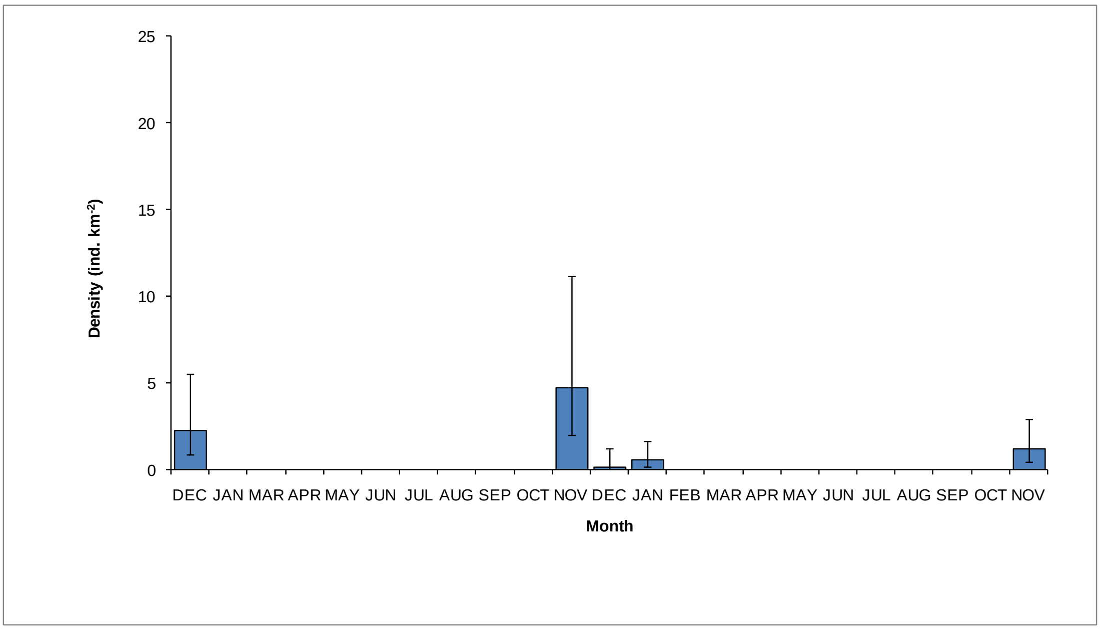


Figure 6.74 Monthly mean (± 95% confidence intervals) density of Little Auk in Project Bravo as derived from DISTANCE correction of birds on the water.

6.3.106 There was considerable inter-annual variation in density distribution within Bravo with large areas of the site containing no Little Auks (at least in bands A and B) in 2011 (Figure 6.73). A lack of zooplankton prey would seem to be the most likely reason for this difference.

Potential origin

6.3.107 About 90% of the world population of Little Auks breeds in Svalbard and in the Thule district of northwest Greenland, therefore it seems logical to conclude that the majority of birds seen in Alpha and Bravo originate from these two areas. There are six accepted records in Scotland of dead birds of the race *polaris*, which breeds on Franz Josef Land to the east of Svalbard, but all were found to the north of Alpha and Bravo.

Project Alpha

6.3.108 Little Auks in flight in Project Alpha showed a range of flight directions indicative of local movements rather than mass reorientation as a result of displacement as is seen after gales (Table 6.67). This points to Project Alpha providing a relatively stable habitat.

Table 6.67 Number and proportion (%) of flight directions recorded for Little Auk during boat-based surveys of Project Alpha.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	19	17	13	10	10	22	21	18	0
	%	14.62	13.08	10.00	7.69	7.69	16.92	16.15	13.85	0.00

Project Bravo

6.3.109 In contrast to Project Alpha, there was rather more directional flight in Bravo with southeast and southwest combined accounting for 41% of flights. This could indicate movement to Wee Bankie and Marr Bank respectively. Some preference for particular areas may account for relative lack of Little Auks in Project Bravo in 2011.

Table 6.68 Number and proportion (%) of flight directions recorded for Little Auk during boat-based surveys of Project Bravo.

Parameters		Compass direction								
		N	NE	E	SE	S	SW	W	NW	None
All records	Count	15	14	3	19	4	26	14	14	0
	%	13.76	12.84	2.75	17.43	3.67	23.85	12.84	12.84	0.00

Summary of risks

6.3.110 Garthe & Hüppop (2004) did not consider the vulnerability of Little Auk to offshore wind farms. However, Furness & Wade (2012) ranked 33rd of 37 species in relation to collision risk and 27th in relation to displacement in their review of the vulnerability of Scottish seabirds

6.3.111 The species was given a low score for the proportion of time in flight as well as a moderate score for flight agility. Of the Little Auk recorded within both Alpha and Bravo from boat-based surveys, 44% and 50% were of birds in flight although this may have been influenced by birds flushing from the survey vessel at close distance. No flying birds were observed at risk height, which is lower than that modelled by Cook *et al*. (2011) at 4%. Even if some birds could reach risk height, the fact that birds are only present for a short part of the year and originate from an extremely large population numbering in the tens of millions means that there is no prospect of an impact from collision.

6.3.112 There was little evidence of feeding within either Project area, with <1% overall engaged in such activity. However, feeding of birds underwater is likely to be have been considerably underestimated. Nevertheless, it would appear that food resources are likely to be naturally patchy in space and time with this perhaps overriding any effects of the presence of wind farms. Even if Little Auks were displaced from the operational wind farm there is no reason to suggest this could be significant. Barrier effects are also unlikely to operate on a non-breeding species that is likely to adjust distribution in time and space in response to patchy prey resources.

6.3.113 Finally, the zooplankton prey of Little Auk is also unlikely to be affected by construction noise even if the birds themselves are temporarily displaced.

Project Alpha

6.3.114 Little Auk is not taken forward into EIA as a sensitive receptor for Project Alpha as a result of the lack of potential for significant ecological impact by whatever mechanism.

Project Bravo

6.3.115 If anything, the prospect of significant ecological impact is even less likely within Bravo as it supported fewer and more variable numbers of Little Auks. The species is therefore not to be considered further in the Impact Assessment of the ES Ornithology chapter (Chapter 10: Ornithology of ES Volume I).

6.4 Migratory waterfowl

Barnacle, Bean and Pink-footed Geese

Population ecology and origin

6.4.1 The Phase 1 HRA Screening Report (Seagreen 2011c) identified Taiga Bean, Pink-footed and Barnacle Geese as at risk of 'likely significant effect (LSE)', which may therefore require further screening for Appropriate Assessment (AA). All three species are characterised by relative longevity, relatively low productivity and extensive migrations from breeding grounds in northern regions to wintering grounds on farmland, coasts, estuaries and saltmarshes in Great Britain. Geese are typically very sensitive to habitat changes and disturbance

6.4.2 Taiga Bean Goose was highlighted by the HRA Screening Report due to the wintering population within the Slamannan Plateau SPA, which lies a short distance inland and south-west of the Firth of Forth. The British wintering population consists of 410 individuals divided into two main flocks (Musgrove *at al.* 2011), and in the winter of 2009/10 the flock on the Slamannan Plateau numbered 260 individuals (Holt *et al.* 2011). These geese migrate to and from their Arctic breeding grounds in Scandinavia and Western Russia. The breeding population of this globally threatened species suffered a recent decline declined of 20% between 1995 and 2005 (WWT / JNCC 2010). Taiga Bean Goose is 'Red' listed as a bird of conservation concern in the UK (Eaton *et al.* 2009).

6.4.3 The British wintering population of Pink-footed Goose numbers some 360,000 individuals, and is thought to comprise the entire breeding population of Greenland and Iceland (Wright *et al.* 2012). Approximately 50% of these winter in Scotland, with this proportion higher in autumn (Forrester *et al.* 2007). Even though wintering numbers have increased steadily in recent years (Musgrove *et al.* 2011), Pink-footed Goose is of 'Amber' conservation concern in the UK as the population is localised and of international importance (Eaton *et al.* 2009).

6.4.4 Pink-footed Geese winter at a series of SPAs inland from the wind farm zone comprising the Firth of Forth, Firth of Tay and Eden Estuary, Montrose Basin and Ythan Estuary SPA. These sites regularly support 12,400, 3,769, 31,622 and 17,213 individuals respectively (Stroud *et al.* 2001). Significant numbers may cross the Zone on their migration to and from these wintering sites.

6.4.5 Almost the entire Svalbard population of Barnacle Goose, numbering some 33,000 birds, winters on the Solway Firth, where it is a qualifying feature of the Upper Solway Flats and Marshes SPA. As a result of this localised wintering population, Barnacle Goose is 'Amber' listed as a bird of conservation concern in the UK (Eaton *et al.* 2009). Satellite tracking has shown that in the autumn these geese migrate via the west coast of Norway coming ashore at various locations along the east coast of Scotland, before moving southwest towards the Solway Firth (Griffin *et al.* 2011). Thus there is strong potential for large numbers of Barnacle Geese to pass through the Zone.

Summary of risks

6.4.6 Research into barrier effects of offshore wind farms upon migrating waterfowl has shown that energetic costs of minor deviations of even a few kilometres were inconsequential compared to the overall distance travelled (Masden *et al.* 2009). There thus seems no prospect of significant barrier effects on any goose species considered.

6.4.7 In relation to collision risk, radar studies at Kalmar Sound, Sweden (Pettersson 2005) showed that migrating waterfowl, including geese, flying towards offshore wind turbines usually deviated at distances of 1–2 kilometres or even further from the turbines to fly around them. Such behaviour means the avoidance rates of geese are usually extremely high at up to 99.9% (Fernley *et al*. 2006). Despite this, a highly precautionary avoidance rate of 98% was used.

6.4.8 The results of the collision risk modelling for Pink-footed, Taiga Bean and Svalbard Barnacle Geese is shown in Table 6.69. The predicted loss per annum for both species is less than 0.01% of the wintering population of Britain and Ireland, implying that the collision risk is negligible.

Table 6.69 Estimates of the number of passages and predicted annual collision risk mortality at an avoidance rate of 98% for migratory goose and wader species at Alpha and Bravo.

Species	Wintering population of GB and Ireland (individuals) from Wright et al. (2012)	Number of annual passages at all heights		Number of annual passages at risk height		Predicted annual number of collisions		Predicted annual number of collisions expressed as percentage of wintering population	
		Alpha	Bravo	Alpha	Bravo	Alpha	Bravo	Alpha	Bravo
(Svalbard) Barnacle Goose	33,000	1,714	1,786	1,286	1,340	0.80	0.76	< 0.01	< 0.01
Taiga Bean Goose	410	0	0	0	0	0.01	0.01	0	0
Pink-footed Goose	360,000	34,660	34,930	25,995	26,198	10.7	11.4	< 0.01	< 0.01
Oystercatcher	387,620	14,562	16,358	10,922	12,269	4.52	5.00	< 0.01	< 0.01
Ringed Plover	48,580 [1]	1,428	1,492	1,071	1,119	0.29	0.29	< 0.001	< 0.001
Golden Plover	566,700 [2]	25,134	26,572	18,851	19,929	6.35	7.16	< 0.01	< 0.01
Grey Plover	49,315	1,570	1,634	1,178	1,226	0.59	0.56	< 0.01	< 0.01
Lapwing	827,700	26,362	27,468	19,772	20,601	10.7	10.2	< 0.01	< 0.01
Knot	338,970	10,238	11,612	7,679	8,709	2.92	2.84	< 0.001	< 0.001
Sanderling	22,680	690	784	518	588	0.20	0.19	< 0.001	< 0.001
Dunlin	438,480 [3]	71,214	70,972	53,411	53,229	17.7	18.9	< 0.01	< 0.01
Black-tailed Godwit	56,880	2,408	2,428	1,806	1,821	0.61	0.66	< 0.01	< 0.01
Bar-tailed Godwit	54,280	1,768	1,788	1,326	1,341	0.69	0.75	< 0.01	< 0.01
Eurasian Curlew	194,650 [4]	13,594	12,866	10,196	9,650	4.81	4.87	< 0.01	< 0.01
Common Redshank	151,090 [5]	13,424	13,348	10,068	10,011	3.41	3.60	< 0.01	< 0.01

Species	Wintering population of GB and Ireland (individuals) from Wright et al. (2012)	Number of annual passages at all heights		Number of annual passages at risk height		Predicted annual number of collisions		Predicted annual number of collisions expressed as percentage of wintering population	
		Alpha	Bravo	Alpha	Bravo	Alpha	Bravo	Alpha	Bravo
Turnstone	59,810	2,026	2,142	1,520	1,607	0.48	0.55	< 0.01	< 0.01

[1] It has been assumed that 50% of the entire international population (36,500 individuals) migrates southwards along the east coast of Britain during the autumn. In spring this population migrates northwards along the west coast of Britain and hence does not cross Alpha and Bravo. [2] In addition it has been assumed that 50% of the British breeding population of 22,600 pairs migrates across a perpendicular front through Alpha and Bravo in the spring and autumn. [3] Of the race *alpina*. In addition it has been assumed that 1,007,500 individuals of the races *schinzii* and *arctica*, that either breed in Britain and Ireland or pass through on migration from Iceland and Greenland, fly across a perpendicular front through Alpha and Bravo in the spring and autumn. [4] In addition it has been assumed that 50% of the British breeding population of 107,000 pairs migrates across a perpendicular front through Alpha and Bravo in the spring and autumn. [5] It has been assumed that 50% of the British breeding population of 38,800 pairs of race *britannica* migrates across a perpendicular front through Alpha and Bravo in the spring and autumn, together with 275,000 individuals of the race *robusta* breeding in Iceland and Faeroes. Furthermore it has been assumed that individuals of the race *totanus* do not occur in Alpha and Bravo.

6.4.9 The SOSS guidance suggests multiplying the number of individuals crossing the wind farm by four to give an upper precautionary collision risk figure to account for the fact that birds are unlikely to be distributed evenly across the migratory front. When four times more Barnacle and Pink-footed Geese cross Alpha and Bravo, the predicted loss per annum for both species is less than 0.1% of the wintering population at each site even with a highly precautionary avoidance rate.

6.4.10 It was possible to model the collision risk for migrating Barnacle Goose more realistically using data from satellite-tracking studies (Griffin *et al.* 2011). Data presented in this report showed that 30.2% of Barnacle Geese flew at risk height while migrating over the sea compared with an assumed value of 75%. The geese also migrated over a narrower front than is presented in the SOSS guidance (281 km perpendicular to the direction of travel measured across the wind farm footprint compared with 587 km). Using this information and re-running the Band model gives 0.67 collisions per annum at an avoidance rate of 98% at Alpha and 0.64 collisions per annum at Bravo, compared with 0.80 and 0.76 collisions respectively using the SOSS methodology (Table 6.69).

6.4.11 The alternative approach for Taiga Bean Goose whereby the entire population of the Slamannan Plateau was simulated to fly through each of Alpha and Bravo twice in any year, predicted a collision rate of 0.22 individuals per annum at Alpha and 0.25 individuals per annum at Bravo. The predicted losses equated to 0.09% and 0.10% of the population at Alpha and Bravo respectively. The results illustrate that when even using a highly precautionary approach, the predicted risk to Taiga Bean Goose is very low.

6.4.12 With no use of Alpha and Bravo and therefore no prospect of either a significant barrier coupled with the demonstrably very low rates of collision that were insignificant at a population scale, Taiga Bean, Pink-footed and Barnacle Geese are not taken forward as sensitive receptors in impact assessment in the ES. With no likely impact upon regional SPA populations, there is also no requirement for these three species to be taken into the HRA process.

Waders

Population ecology

6.4.13 As a group, waders are characterised by relative longevity, relatively low productivity and extensive migrations from breeding grounds in upland, boreal or polar regions to wintering grounds along coasts, estuaries and saltmarshes, productive examples of which are relatively rare in extent and distribution and subject to many threats. Many of the habitats upon which wintering waders depend are protected as SPAs.

6.4.14 The Phase 1 Habitats Regulations Appraisal (HRA) Screening Report (Seagreen 2011) identified 13 species of wader that as a designated feature of one or more SPAs in the region are at risk of ‘likely significant effect (LSE)’ and may therefore require further screening for Appropriate Assessment (AA).

6.4.15 Three estuarine SPAs, important for their wintering wader populations, are situated on the coast inland from Alpha and Bravo. Knot, Curlew and Redshank are also of European conservation concern (Eaton *et al.* 2009). Three of these wader species, Lapwing, Dunlin and Black-tailed Godwit, are both species of European conservation concern and 'Red' listed as a bird of conservation concern in the UK. For Lapwing and Black-tailed Godwit this is due to declines in the breeding populations, whereas for Dunlin this is due to a severe decline in the non-breeding population.

6.4.16 The remaining species are 'Amber' listed, all due, amongst other criteria, to non-breeding populations of international importance, except for Sanderling, which is not of conservation concern, while additionally Lapwing, Black-tailed Godwit and Curlew are listed as priority UK Biodiversity Action Planning (BAP) species.

6.4.1 The importance of the populations of the different species within the region encompassing the various SPAs differs with some currently achieving internationally important status with others of national importance (Table 6.58). Only Golden Plover and Lapwing do not currently occur in at least nationally important numbers in one or other SPA.

Table 6.70 Regional population size of Wader species considered to be at risk in relation to Alpha and Bravo. Nationally important counts are bold with internationally important counts shown in red,

Species	Firth of Forth SPA		Firth of Tay and Eden Estuary SPA		Montrose Basin SPA	
	Natura 2000	Latest WeBS count sourced	Natura 2000	Latest WeBS count sourced	Natura 2000	Latest WeBS count sourced
Oystercatcher	**7,846**	**8,046** [1]			2,368	
Ringed Plover	328	**1,080** [2]		**658** [1,3]		
Golden Plover	2,949	3,436 [4]				
Grey Plover	**724**	425 [5]		173 [2,6]		
Lapwing	4,148	5,465 [7]				
Knot	**9,258**	2,934 [2]			**4,500**	3,182 [4]
Sanderling		**404** [2]		**296** [2]		
Dunlin	**9,514**	**6,565** [1]				
Black-tailed Godwit		**473** [2]				
Bar-tailed Godwit	**1,974**	**1,270** [1]	**2,400**	**1,164** [1]		
Curlew	**1,928**	**2,939** [2]				1,094 [2]
Redshank	**4,341**	**4,244** [2]	**1,800**	**2,084** [1]	**2,259**	**2,770** [2]
Turnstone	**860**	**699** [3]				

[1] 2008/09. [2] 2009/10. [3] Tay Estuary. [4] 2007/08. [5] 2003/04. [6] Eden Estuary. [7] 2006/07.

6.4.2 Unlike some species, individual waders may not stay within a designated area after arriving from their breeding grounds on a 'broad front migration' (Wernham *et al.* 2002). More restricted short distance local movements may occur on a regular basis between locations around the coast. Periods of extreme cold weather may also initiate movements of birds between different localities. Moreover, even when on migration, birds may 'stage' at other sites before continuing their journey. These aspects increase the prospect of connection of birds between various sites along the east coast of Scotland and northern England.

Summary of risks

6.4.3 All 13 species were subject to collision risk modelling irrespective of whether they had been seen within Alpha and / or Bravo. The results of the CRM are shown in Table 6.57. The predicted loss per annum for each species under consideration is less than 0.01% of the wintering population of Britain and Ireland, implying that the collision risk for each is negligible.

6.4.4 The SOSS guidance suggests multiplying the number of individuals crossing the wind farm by four to give an upper precautionary collision risk figure to account for the fact that birds are unlikely to be distributed evenly across the migratory front. For the wader species, the percentage of the wintering population at risk remains less than 0.01 when four times more individuals cross Alpha and Bravo. The exceptions are Curlew and Dunlin, where < 0.1% of their wintering populations are at risk.

6.4.5 If the waders actively avoided Alpha and Bravo when operational, the risk of collision would obviously decrease. This introduces the potential for barrier effects. However, as outlined above, the energetic costs of minor deviations of even a few kilometres have been shown to be inconsequential compared to the overall distance travelled by long-distance migrants (Masden *et al.* 2009).

6.4.6 In conclusion, there was no requirement to take any wader species forward as a sensitive receptor into the ES or into HRA.

7. CONCLUDING SUMMARY

7.1.1 The Firth of Forth is one of the premier areas for breeding seabirds in the UK, with the Outer Forth/Wee Bankie/Marr Bank area recognised as being of international importance and thus potentially qualifying as an offshore Special Protection Area (SPA) for multiple seabird species. The species are breeding Gannet, Guillemot and Puffin and wintering Kittiwake.

7.1.2 A number of SPA seabird breeding colonies fringe the Firth of Forth, which from north to south are Buchan Ness to Collieston Coast SPA, Fowlsheugh SPA, Forth Islands SPA and St Abb's to Fast Castle SPA. The closest of these to Projects Alpha and Bravo is Fowlsheugh SPA at around 30 km to the northwest of Alpha.

7.1.3 Projects Alpha and Bravo are outside the primary area of interest for seabirds. Nonetheless, the estimated number of breeding seabirds that could potentially include Alpha and Bravo within their foraging range (ignoring colonies of Fulmar and Gannet at more than 120 km distant) and then taking the respective foraging range of any seabird into account) is 766,439 individuals (counted between 1998 and 2011, SMP Online Database 2012).

7.1.4 It was thus essential to characterise the ornithological interest of Alpha and Bravo in the most rigorous manner possible. An intensive boat-based survey programme comprised of 24 surveys was undertaken over two years between December 2009 to November 2011 inclusive. Monthly surveys of Alpha and Bravo were undertaken as part of what was thought to the most intensive boat-based survey programme yet undertaken in relation to wind farm development in the UK on a route exceeding 936 km in each month, thus covering >21,000 km. Only the part of the surveys directly concerned with Alpha and Bravo are presented here.

7.1.5 Particular features of the survey programme included the charter of a vessel in excess of 32 m length with specific modification to provide two observation platforms at >5m eye-height, with the primary platform used by bird surveyors with an eye-height of >7 m when standing. The vessel was on permanent charter and mobilised within 24 hours to take advantage of suitable weather conditions in a challenging offshore environment.

7.1.6 Transects were oriented across the main axis of bird flights from the colonies within the Firth of Forth, especially to that of Gannets at Bass Rock. To ensure good coverage transect spacing was 3 km and the transect routes within a phenological period (breeding, dispersal and winter) were randomly rotated between four separate routes. This meant that >80% of the entire area was covered, which was seen to be essential given the high potential for persistent spatial aggregation of seabirds in association with particular habitat features including small (tens of kilometres) dense patches of primary production as shown by previous research.

7.1.7 As well as boat-based surveys, a number of aerial surveys in both summer and winter commissioned by the Crown Estate, provided background context of seabird abundance and distribution across the wider Firth of Forth including the Scottish Territorial Sites of Neart na Gaoithe and Inch Cape.

7.1.8 Seagreen as part of the Forth and Tay Developers Group with Mainstream (Neart na Gaoithe) and Repsol (Inch Cape) commissioned new tracking studies of Kittiwake, Guillemot and Razorbill, and purchased previous data on Puffin, from the Centre for Ecology and Hydrology in Edinburgh. Breeding Kittiwakes were tracked from Isle of May within the Forth Islands SPA, Fowlsheugh SPA and St Abb's Head (within St Abb's Head to Fast Castle SPA), whereas Guillemots Razorbills and Puffins were tracked from the Isle of May. CEH have previously undertaken a considerable body of research on the interactions between seabirds and their prey, particularly on the Isle of May. Previously published research was extensively consulted to further understanding of the results of the survey programme.

7.1.9 Previous research had demonstrated the potential link between seabirds and a commercial fishery for sandeels, one of the mainstays of seabird production in the area. The fishery was subsequently closed, although there has been no clear longer-term benefit for one of the key species, Kittiwake, which continues to decline in the area.

7.1.10 In total, 24,389 and 20,541 birds were observed in Alpha and Bravo respectively. The number of species recorded was slightly greater in Alpha with 54 taxa (including the few that were unidentified to species level) species compared with 49 in Bravo. The seabird assemblage was similar in both sites with general abundance broadly indicated by the numbers of individuals recorded, with Guillemot, Kittiwake and Gannet comprising 68-69% of all birds recorded in Alpha or Bravo. Other auks such as Razorbill and Puffin and unidentified auks were the next most numerous taxa. The relative abundance of these species was weighted more towards Puffin in Bravo perhaps linked to its increased distance from shore (to 59 km)

7.1.11 In total, 13 species of seabird were identified as potentially sensitive to development of either Alpha (13) or Bravo (10). A further 16 species of migratory waterfowl (13 waders and three species of geese) wintering mainly within coastal SPAs and which may not be detected during boat and aerial surveys had previously been identified as sensitive by Habitat Regulations Assessment (HRA). The combined criteria used for seabirds and waterfowl were thus:

- Population size of seabirds where the maximum population size exceeded 1% thresholds for either breeding, passage or winter periods;
- Linkage between designated breeding seabirds at SPAs and Alpha and Bravo and;
- Linkage between migratory species and Alpha and Bravo following consultation with SNCBs.

7.1.12 The waterfowl species were subject to collision risk modelling as a screening exercise of specific relevance to HRA. Modelling concluded that there was no risk of impact at a national population scale and no species was to be considered further in EIA.

7.1.13 Of the 13 seabird species, eight were breeding within the foraging range of Projects Alpha and Bravo, with five species that predominantly or wholly occurred as passage or wintering species. The breeding species were Fulmar, Gannet, Kittiwake, Lesser Black-backed Gull, Herring Gull, Guillemot, Razorbill and Puffin. Passage/wintering species were Sooty Shearwater (Alpha only), Great Black-backed Gull, Common Tern (Alpha only), Arctic Tern and Little Auk.

7.1.14 Despite the occurrence of internationally important breeding populations for many species nearby, only Razorbill occurred in nationally important numbers in the breeding season and then only one site, Alpha. Nationally important numbers of Puffins were achieved on both Projects, but only in the winter months. All other species regarded as sensitive for the relative importance of their peak populations, only achieved the status of regional importance. Overall, it would appear that the area occupied by both Projects is not of particular importance for breeding seabirds compared to other parts of the Forth of Firth.

7.1.15 A detailed discussion of each sensitive species was undertaken including: population ecology; density distribution and population size recorded during surveys; evaluation of foraging range for breeding species; and, potential origin of birds within the boundaries of the two Projects. A concluding summary of risk from the four main impacts from offshore wind farms was provided. Risks include:

- Collision with turbines;
- Displacement;
- Barrier effects and;
- Indirect effects upon the distribution and abundance of prey species.

7.1.16 All risks were assessed in relation to the potential for significant ecological impact as defined by the Institute for Ecology and Environmental Management. A number of factors operated as a guide to the potential significance of the impact in relation to development.

7.1.17 In relation to potential collision risk, the number of the birds flying through the site, the proportion of birds observed at risk height and the general sensitivity of the species were of specific value.

7.1.18 Displacement occurs where seabirds are prevented from utilising the resources within the wind farm site. A significant ecological impact on a species in a particular area or colony is most likely when large numbers or a large proportion are affected. Therefore, the peak population estimate and its relative size in relation to a particular population was used as a guide to the potential impact.

7.1.19 Barrier effects may occur where seabirds are forced to fly around the site to access resources outside of the development. The potential for significant impact is generally restricted to breeding species where individuals undertake multiple movements across a site during the course of the breeding season.

7.1.20 Indirect effects operate through changing abundance or distribution of resources, be it fish prey or foraging habitat that then lead to displacement. The proportion of birds feeding thus provides a guide as to whether indirect effects are likely to be important. A further key factor to consider is that the footprint for indirect effects, for example through construction noise, may be far greater than the area contained within the development. The Firth of Forth is known to have a number of important areas for seabirds and it is the potential effect upon these that was of specific concern.

7.1.21 A total of nine species with the potential to be subject to a significant ecological effect through the development of either Projects Alpha and Bravo were identified. No species was to be considered at a site in isolation. The species in broad order of concern were Gannet, Kittiwake, Guillemot, Puffin, Razorbill, Herring Gull, Great Black-backed Gull and Lesser Black-backed Gull (Table 7.1).

Table 7.1. Species and impacts considered to have the potential of significant ecological impact to be considered in EIA for both Projects Alpha and Bravo.

Species	Potential effects			
	Collision	Displacement	Barrier Effects	Indirect effects
Northern Gannet	•		•	
Black-legged Kittiwake	•	•	•	•
Lesser Black-backed Gull	•			
European Herring Gull	•			
Common Guillemot		•	•	•
Razorbill		•	•	•
Atlantic Puffin		•	•	•
Great Black-backed Gull	•			
Arctic Tern				•

7.1.22 Of the species to be taken forward, all but Arctic Tern were of primary concern as breeding species. This included consideration of impacts upon the small numbers of breeding Herring and Lesser Black-backed Gulls associated with SPAs, and the small number of breeding Great Black-backed Gulls that may persist throughout the year. The larger population of the latter present in the winter was not of specific concern.

7.1.23 Only Kittiwake was to be considered in relation to all four possible effects, with the assessment upon auks to focus on displacement, barrier effects and indirect effects. In contrast, collision was of primary concern for the large gulls and Gannet. The potential for barrier effects upon Gannet was also of secondary concern. The only concern for Arctic Tern was indirect effects upon a migratory population that appears to use the area as a ‘stopover’ foraging area.

8. REFERENCES

Alerstam, T., Rosén, M., Bäckman, J., Ericson, P.G. & Hellgren, O. (2007). Flight Speeds among bird species: allometric and phylogenetic effects. *PLoS Biology, 5*(8), e197.

Baker, H., Stroud, D.A., Aebischer, N.J., Cranswick, P.A., Gregory, R.D., McSorley, C.A., Noble, D. & Rehfisch, M.M. (2006). Population estimates of birds in Great Britain and the United Kingdom. *British Birds*, 99, 25-44.

Band, B. (2011). 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 (2004). *Birds in Europe; population trends and conservation status*.

BirdLife Conservation Series No. 12. Birdlife International, Cambridge, UK; 374pp.

Birdlife International (2012a) Species factsheet *Fulmarus glacialis*. Downloaded from http://www.birdlife.org on 24/01/12.

Birdlife International (2012b) Species factsheet *Puffinus griseus*. Downloaded from http://www.birdlife.org on 08/06/12.

Birdlife International (2012c) Species factsheet *Larus fuscus*. Downloaded from http://www.birdlife.org on 24/01/12.

Birdlife International (2012d) Species factsheet *Larus argentatus*. Downloaded from http://www.birdlife.org on 24/01/12.

Birdlife International (2012e) Species factsheet *Larus marinus*. Downloaded from http://www.birdlife.org on 24/01/12.

Birdlife International (2012f) Species factsheet *Sterna hirundo*. Downloaded from http://www.birdlife.org on 24/01/12.

Birdlife International (2012g) Species factsheet *Alle alle*. Downloaded from http://www.birdlife.org on 08/06/12.

BirdLife International, British Ornithologists' Union, British Trust for Ornithology, Countryside Council for Wales, English Nature, Environment & Heritage Service (Northern Ireland), the Game Conservancy Trust, The Hawk and Owl Trust, Joint Nature Conservation Committee, The National Trust, the Royal Society for the Protection of Birds, Scottish Natural Heritage, the Wildfowl & Wetlands Trust, The Wildlife Trusts (2007). The population status of birds in the UK: Birds of Conservation Concern 2002-2007. 12pp.

Bogdanova, M.I., Daunt, F., Newell, M., Phillips, R.A., Harris, M.P. and Wanless, S. (2011). Seasonal interactions in the black-legged kittiwake, *Rissa tridactyla*: links between breeding performance and winter distribution. *Proceedings of the Royal Society B*, 278, 2412-2418.

Borchers, D.L., Buckland, S.T., Goedhart, P.W., Clarke, E.D. & Hedley, S.L. (1998). Horvitz-Thompson estimators for double-platform line transects surveys. *Biometrics*, 54 1221-1237.

Brown, R.G.B. and Nettleship, D.N. (1981). The Biological significance of polynyas to arctic colonial seabirds. In: Stirling, I., & Cleator, H., eds. Polynyas in the Canadian Arctic. Canadian Wildlife service occasional paper. 45: 59-65.

Brown P & Grice P (2005). *Birds in England*. T&AD Poyser, London, UK: 694pp. ISBN 0 7136 6530 0.

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

Buckland, S.T., Burt, M.L., Rexstad, E.A., Mellor, M., Williams, A.E. & Woodward, R. (2012). Aerial surveys of seabirds: the advent of digital methods. *Journal of Applied Ecology* doi 10.1111/j.1365-2664.2012.02150.x

Burnham, K.P. & Anderson, D.R. (2002). *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*, 2nd edition. Springer-Verlag.

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

Camphuysen, C.J. (1995). Herring gull *Larus argentatus* and lesser black-backed gull *Larus fuscus* feeding at fishing vessels in the breeding season: competitive scavenging versus efficient flying. *Ardea* 83: 365-380.

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: www.offshorewindfarms.co.uk

Christensen TK, Clausager I & Petersen IK (2003). *Base-line investigations of birds in relation to an offshore wind farm at Horns Rev, and results from the year of construction*. NERI Report commissioned by Tech-wise A/S.

Christensen TK, Hounisen JP, Clausager I & Petersen IK (2004). *Visual and radar observations of birds in relation to collision risk at the Horns Rev offshore wind*.

Cook ASCP, Johnston A, Wright LJ & Burton NHK (2011). *Strategic 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.

Coulson, J.C., Duncan, N. & Thomas, C. (1982). Changes in the breeding biology of the Herring Gull *Larus argentatus* induced by reduction in the size and density of the colony. *Journal of Animal Ecology* 51 739-756.

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

Cressie, N.A.C. (1993). *Statistics for spatial data* (*revised edition*). Wiley, New York, 900 p.

Daunt F., Benvenuti, S., Harris, M.P., Dall'Antonia, L., Elston, D.A. & Wanless, S. (2002). Foraging strategies of the black-legged kittiwake *Rissa tridactyla* at a North Sea colony: evidence for a maximum foraging range. *Marine Ecology Progress Series*, 245, 239–247.

Daunt, F., Wanless, S., Greenstreet, S.P.R., Jensen, H., Hamer, K.C. & Harris, M.P. (2008). The impact of the sandeel fishery closure in the northwestern North Sea on seabird food consumption, distribution and productivity. *Canadian Journal of Fisheries and Aquatic Sciences*, 65, 362-381.

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. and 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.

Department of Trade & Industry (dti) (2005). Offshore wind turbines and bird activity at Blyth. Report W/35/00544/REP. Crown Copyright, Department of Trade & Industry, London: 18pp.

Desholm M & Kahlert J (2005). *Avian collision risk at an offshore wind farm*. Royal Society Biology Letters, 1, 296–298.

Dierschke, V. & Garthe, S. (2006). *Literature Review of Offshore Wind Farms with Regard to Seabirds*. In Ecological Research on Offshore Wind Farms: International Exchange of Experiences. Paer B: Literature Review of Ecological Impacts, ed. C. Zucco, W. Wende, T. Merck, I. Köchling & J. Köppel, pp 121-143. Springer Verlag, Berlin.

Eaton, M.A., Brown A.F., Noble, D.G., Musgrove, A.J., Hearn, R., Aebischer, N.J., Gibbons, D.W., Evans, A. & Gregory, R.D. (2009). Birds of Conservation Concern 3: the population status of birds in the United Kingdom, Channel Islands and the Isle of Man. *British Birds* 102: 296–341.

Eaton, M.A., Balmer, D.E., Cuthbert, R., Grice, P.V., Hall, J., Hearn, R.D., Holt, C.A., Musgrove, A.J., Noble, D.G., Parsons, M., Risely, K., Stroud, D.A. and Wotton, S. (2011) The state of the UK's birds 2011. RSPB, BTO, WWT, CCW, JNCC, NE, NIEA and SNH, Sandy, UK: 40pp.

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* doi: 10.1111/j.1365-2664.2012.02114.x

Fernley, J., Lowther, S. & Whitfield, P. (2006). *A review of goose collisions at operating wind farms and estimation of the goose avoidance rate*. A report by Natural Research Ltd., West Coast Energy & Hyder Consultancy.

Ford, R.G., Ainley, D.G., Casey, J.L., Keiper, C.A., Spear, L.B. and 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., Edwards, M., Mavor, R.A. & Wanless, S. (2007). Regional and annual variation in black-legged kittiwake breeding productivity is related to sea surface temperature. *Marine Ecology Progress Series*, 350, 137-143.

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* doi: 10.1111/j.1472-4642.2011.00864.x.

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.

Furness, R.W. & Wade, H. (2012). Vulnerability of Scottish seabirds to offshore wind turbines. Report to Marine Scotland,: 39 pp

Galloper Wind Farm Ltd. (2011) Galloper Wind Farm Project. Habitat Regulations Assessment Report, Document Reference 6.3. Galloper Wind Farm Ltd., Reading, UK: 214pp.

Garthe S & Hüppop O (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. *Journal of Applied Ecology*, **41**, 724-734.

Greenstreet, S.P.R., Armstrong, E., Mosegaard, H., Jensen, H., Gibb, I.M., Fraser, H.M., Scott, B.E., Holland, G.J. & Sharples, J. (2006). Variation in the abundance of sandeels *Ammodytes marinus* off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. *ICES Journal of Marine Science*, 63: 1530-1550.

Greenstreet, S.P.R., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser, H.M., & Gibb, I.M., (2010). Combining hydroacoustic seabed survey and grab sampling techniques to assess "local" sandeel population abundance. *ICES Journal of Marine Science*, 67: 971-984.

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

Grémillet D., Welcker, J., Karnovsky, N.J., Walkusz, W., Hall, M.E., Fort, J., Brown, Z.W., Speakman, J.R. and Harding, A.M.A. (2012). Little auks buffer the impact of current Arctic climate change. *Marine Ecology Progress Series* 454:197-206.

Griffin L, Rees E & Hughes B. (2010). *The Migration of Whooper Swans in Relation to Offshore Wind Farms*. WWT Final Report to COWRIE Ltd, WWT, Slimbridge. 69 pp. ISBN no.: 978-0-9565843-0-4.

Griffin, K. Rees, E. & Hughes, B. (2011). *Migration routes of Whooper Swans and geese in relation to wind farm footprints*. Final report to DECC, WWT Slimbridge. 90 pp.

Guilford, T., Freeman, R., Boyle, D., Dean, B., Kirk, H., Phillips., R. and Perrins, C. (2011). A Dispersive Migration in the Atlantic Puffin and Its Implications for Migratory Navigation. *PLoS ONE* 6(7): e21336. doi:10.1371/journal.pone.0021336.

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., Phillips, R.A., Hill, J.K., Wanless, S. and Wood, A.G. (2001). Contrasting foraging strategies of gannets *Morus bassanus* at two North Atlantic colonies: foraging trip duration and foraging area fidelity. *Marine Ecology Progress Series* 224: 283-290.

Hamer, K.C., Humphreys, E.M., Garthe, S., Hennicke, J., Peters, G., Grémillet, D., Phillips, R.A., Harris, M.P. and 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. and 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. & Wanless, S. (2011). *The Puffin*. T & AD Poyser, London. 256pp.

Harris, M.P. & Wanless, S. (1986). The food of young Razorbills on the Isle of May and a comparison with that of young Guillemots and Puffins. *Ornis Scandinavica*, **17**, 41-46.

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.

Henkel, L.A., Ford, R.G., Tyler, W.B and Davis, J.N. (2007). Comparison of aerial and boat-based survey methods for Marbled Murrelets *Brachyramphus marmoratus* and other marine birds. *Marine Ornithology* 35: 145-151.

Holt, C.A., Austin, G.E., Calbrade, N., Mellan, H.J., Mitchell, C., Stroud, D.A., Wotton, S.R. and Musgrove, A.J. 2011. *Waterbirds in the UK 2009/10: The Wetland Bird Survey.* BTO/WWT/ RSPB/JNCC, Thetford: 185pp.

Hyrenbach, K.D. (2001) Albatross response to survey vessels: implications for studies of the distribution, abundance and prey consumption of seabird populations. Marine Ecology Progress Series 221: 283-295.

Joint Nature Conservation Committee (JNCC) (2010). Seabird population trends and causes of Change: 2010 report. Joint Nature Conservation Committee. Updated July 2010. Downloaded from http://www.jncc.gov.uk/page-3201 on 24/01/12.

Joint Nature Conservation Committee (JNCC) (2011). Seabird population trends and causes of change: 2011 report. Joint Nature Conservation Committee. Updated April 2011. Downloaded from http://www.jncc.gov.uk/page-3201 accessed on 09/07/12.

Kahlert, J., Petersen, I.K., Fox, A.D., Desholm, M. & Clausager, I. (2004). *Investigations of birds during construction and operation of Nysted offshore wind farm at Rødsand*. Annual status report 2003. NERI Report commissioned by Energi E2 A/S.

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.

Krijgsveld, K.L., Fijn, R.C., Japink, M., van Horssen, P.W., Heunks, C., Collier, M.P., Poot, M.J.M., Beukers, D. & Dirksen, S. (2011). *Effect studies Offshore Wind Farm Egmond aan Zee. Flux, flight altitude and behaviour of flying birds*. Bureau Waardenburg report 10-219. Bureau Waardenburg, Culemborg: 334pp.

Kubetzki, U., Garthe, S., Fifield, D., Mendel, B., Furness, R.W. (2009). Individual migratory schedules and wintering areas of northern gannets. *Marine Ecology Progress Series*, 391, 257-265.

Langston, R.H.W. & Boggio, S. (2011). Foraging ranges of northern gannets *Morus bassanus* in relation to the proposed offshore wind farms in the North Sea. RSPB report to Hartley Anderson/Department of Energy & Climate Change (DECC), Royal Society for the Protection of Birds, Sandy, UK: 19pp.

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.

Lewis, S., Hamer, K.C., Money, L., Griffiths, R., Wanless, S. & Sherratt, T.N. (2004). Brood neglect and contingent foraging behaviour in a pelagic seabird. *Behavioural Ecology and Sociobiology* 56, 81-88.

Linley, E.A.S., Wilding, T.A., Black, K., Hawkins, A.J.S. & Mangi, S. (2007). *Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation*. Report from PML Applications Ltd. and the Scottish Association for marine science to the Department for Business, Enterprise and Regulatory Reform (BERR). Contract No. RF CA/005/0029p: 132pp.

Lloyd, C., Tasker, M.L. & Partridge, K. (1991) The status of Seabirds in Britain and Ireland. T & A 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.

Mainstream Renewable Power (2012). Neart na Gaoithe Offshore Wind Farm Environmental Statement. Chapter 5: Project Description. Mainstream Renewable Power, Glasgow, 37pp.

Masden, E.A., Haydon, D.T., Fox, A.D., Furness, R.W., Bullman, R. & Desholm, M. (2009). Barriers to movement: impacts of wind farms on migrating birds. *ICES Journal of Marine Science* 66: 746-753.

Masden, E.A., Haydon, D.T., Fox. A.D and Furness, R.W. (2010). Barriers to movement: Modelling energetic costs of avoiding marine windfarms amongst breeding seabirds. *Marine Pollution Bulletin* 60: 1085-1091.

Mason, J.W., McChesney, G.J., McIver, W.R., Carter, H.R., Takekawa, J.Y., Golightly, R.T., Ackerman, J.T., Orthmeyer, D.L., Perry, W.M., Yee, J.L., Pierson, M.O. & McCrary, M.D. (2007). At-sea distribution and abundance of seabirds off southern California: a 20-year comparison. *Studies in Avian Biology* 33: 1−110.

McDonald, C., Searle, K., Wanless, S. & Daunt, F. (2012). Effects of displacement from marine renewable development on seabirds breeding at SPAs: a proof of concept model of common guillemots breeding on the Isle of May. Final report to Marine Scotland, Centre for Ecology & Hydrology, Edinburgh, UK: 48pp.

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.

McSorley, C.A., Webb, A., Dean, B.J. & Reid, J.B. (2005). UK inshore Special Protection Areas: a methodological evaluation of site selection and definition of the extent of an interest feature using line transect data. JNCC Report, No. 344. 54pp.

McDonald C, Searl K, Wanless S & Daunt F (2012). *Effects of displacement from marine renewable developments on seabirds on seabirds breeding as SPAs: a proof of concept model of common guillemots breeding on the Isle of May*. Centre for Ecology & Hydrology Final report to Marine Scotland Science. 48pp.

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

Musgrove, A.J., Austin, G.E., Hearn, R.D., Holt, C.A., Stroud, D.A. & Wotton, S.R. (2011). Overwinter population estimates of British waterbirds. *British Birds*, 104: 364-397.

Ojowski, U., Eidtmann, C., Furness, R.W. & Garthe, S. (2001). Diet and nest attendance of incubating and chick-rearing Northern Fulmars (*Fulmarus glacialis*) in Shetland. *Marine Biology* 139: 1193-1200.

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.

Parkin, D.T. & Knox, A.G. (2010). *The status of birds in Britain and Ireland*. Christopher Helm, London: 440pp.

Pennycuick CJ (1997). Actual and 'optimum' flight speed: field data reassessed. *Journal of Experimental Biology* 200: 2355-2361.

Perrow, M.R., Gilroy, J.J., Skeate, E.R. & Mackenzie, A (2010). *Quantifying the relative use of coastal waters by breeding terns: towards effective tools for planning and assessing the ornithological impacts of offshore wind farms*. ECON Ecological Consultancy Ltd. Final report to COWRIE Ltd. ISBN: 978-0-9565843-3-5.

Perrow, M.R., Gilroy, J.J., Skeate, E.R. & Tomlinson, M.L. (2011a). Effects of the construction of Scroby Sands offshore wind farm on the prey base of Little tern *Sternula albifrons* at its most important UK colony. *Marine Pollution Bulletin* 62: 1661-1670.

Perrow, M.R., Skeate, E.R. & Gilroy, J.J. (2011b). Novel use of visual tracking from a rigid-hulled inflatable boat (RIB) to determine foraging movements of breeding terns. *Journal of Field Ornithology* 82: 68-79.

Petersen, I.K. (2004). *Investigation of birds during the operational phase of the Nysted offshore wind farm. Preliminary notes on the issue of potential habitat loss*. National Environmental Research Institute.

Petersen, I.K., Christensen, T.K., Kahlert, J., Desholm, M. & Fox, A.D. (2006). *Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark*. NERI Report, commissioned by DONG Energy and Vattenfall A/S, DK. 166pp.

Pettersson, J. (2005). The impact of offshore wind farms on bird life in Southern Kalmar Sound, Sweden. Report to Swedish Energy Agency.

Pollock, C. & Barton, C. (2006). *An analysis of ESAS seabird surveys in UK waters to highlight gaps in coverage*. Report to the Department of Trade and Industry (Dti), London: 63pp.

Rexstad, E. & Buckland, S.T. (2012). Displacement analysis boat surveys Kentish Flats. Draft report for Project SOSS-1A, British Trust for Ornithology, Thetford, UK: 18pp.

Riddle, J.D., Mordecai, R.S., Pollock, K.H. & Simons, T.R. (2010). Effects of prior detections on estimates of detection probability, abundance, and occupancy. *Auk* 127, 94-99.

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

Rothery, P., Newton, I. & Little, B. (2009). Observations of seabirds at offshore wind turbines near Blyth in northeast England. *Bird Study* 56: 1-14.

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.

Scott, B.E., Sharples, J., Wanless, S., Ross, O., Frederiksen, M. & Daunt, F. (2006). The use of biologically meaningful oceanographic indices to separate the effects of climate and fisheries on seabird breeding success. In: *Top predators in marine ecosystems: their role in monitoring and management*, I.L. Boyd, S. Wanless & C.J. Camphuysen (eds), pp. 46-62. Cambridge University Press, Cambridge, UK.

Seabird Monitoring Programme Online Database (2011). http://www.jncc.gov.uk/smp/. [Accessed 3 March 2011].

Seagreen Wind Energy (2010). Zone appraisal and planning: Firth of Forth Zone characterisation. Seagreen Document No. A6SW/SEAG-Z-DEV260-SWR-017-A3, Glasgow: 121pp.

Seagreen Wind Energy (2011a). Seagreen Year 1 Round 3 Zone Ornithology Survey: December 2009 - December 2010. Seagreen Document No. A4MR/SEAG-Z-DEV210-CRP-080, Glasgow: 191pp.

Seagreen Wind Energy (2011b). 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 Wind Energy Ltd. (2011c). *Offshore Phase 1 Habitats Regulations Appraisal (HRA) Screening Report.* Document No. A4MR/SEAG-Z-DEV200-SRP-094, Glasgow: 58pp.

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. Durinck, J. Leopold, M.F. & Tasker, M.L. (2007). A quantitative method for evaluating the importance of marine areas for conservation of birds. *Biological Conservation* 136: 362-371.

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.

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.

Taylor, M and Marchant, J H. (2011). *The Norfolk Bird Atlas: summer and winter distributions 1999-2007*. British Trust for Ornithology, Thetford: 528pp. ISBN 978 1 906204 82 2.

Thaxter, C.B. & Burton, N.H.K. (2009). High definition imagery for surveying seabirds and marine mammals: a review of recent trials and development of protocols. British Trust for Ornithology Report commissioned by COWRIE Ltd., BTO, Thetford. ISBN 978-0-9561404-5-6.

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* doi:10.1016/j.biocon.2011.12.009

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.
Thomsen F, Lüdemann K, Kafemann, R. & Piper, W. (2006). *Effects of offshore wind farm noise on marine mammals and fish*. Biola, Hamburg, Germany on behalf of COWRIE Ltd. 66pp. (www.offshorewind.co.uk).
van Franeker, J.A. (1994). A comparison of methods for counting seabirds at sea in the southern ocean. *Journal of Field Ornithology*, 65, 96-108.
van der Meer, J. & Leopold, M.F. (1995). Assessing the population-size of the European storm-petrel (*Hydrobates pelagicus*) using spatial autocorrelation between counts from segments of crisscross ship transects. *ICES Journal of Marine Science* 52: 809-818.
Votier, S.C., Bearhop, S., Witt, M.J., Inger, R, Thompson, D. & Newton, J. (2010) Individual responses of seabirds to commercial fisheries revealed using GPS tracking, stable isotopes and vessel monitoring systems. *Journal of Applied Ecology* 47: 487-497.
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., Harris, M.P. & Morris, J.A. (1990). A comparison of feeding areas used by individual common murres (*Uria aalge*), razorbills (*Alca torda*) and Atlantic puffin (*Fratercula arctica*) during the breeding season. *Colonial Waterbirds* 13: 16-24.
Wanless, S., Murray, S. & Harris, M.P. (2005a). The status of Northern Gannet in Britain & Ireland in 2003/04. *British Birds* 98, 280-294.
Wanless, S., Harris, M.P., Redman, P. & Speakman, J.R. (2005**b**). Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. *Marine Ecology Progress Series*, 294, 1-8.
Webb, A. & Durinck, J. (1992). *Counting birds from ship*. In: *Manual for aeroplane and ship surveys of waterfowl and seabirds* Eds. J. Komdeur, J. Bertelsen and G. Cracknell. IWRB Special Publication No. 19, Natural Environmental Research Institute, Kalø, Denmark, pp. 24-35.
Weimerskirch, H., Chastel, O., Henden, J.A. & Tveraa, T. (2007). Nest attendance and foraging movements of Northern Fulmars rearing chicks at Bjornoya Barents Sea. *Polar Biology* 24: 83-88.
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 (2006). Waterbird population estimates – fourth edition. Wetlands International, Wageningen, The Netherlands, ISBN 90 5882 031 9: 239pp.
Wright, L.J., Ross-Smith, V.H., Massimino, D., Dadam, D., Cook, A.S.C.P. & Burton, N.H.K. (2012). Strategic Ornithological Support Services Project SOSS-05: Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and other Annex 1 species). BTO Research Report No. 592, British Trust for Ornithology, Thetford, UK: 192pp.
WWT / JNCC 2010. *GooseNews*. The newsletter of the Goose & Swan Monitoring Programme. Issue No. 9, Autumn 2010. Slimbridge, UK. Available at http://monitoring.wwt.org.uk/pdf/GooseNews9.pdf.