APPENDIX 16B: APPORTIONING IMPACTS ON HRA SPECIES AT THE OPTIMISED SEAGREEN PROJECT TO SPAS

16.1 This Appendix supports the Habitats Regulations Appraisal (HRA) for the optimised Seagreen Project. The HRA assesses the possible effect that the Project will have on breeding seabird populations in protected areas i.e. Special Protection Areas (SPAs).

16.2 This Appendix outlines the methodology and results for calculating apportioning values to be used within the HRA to apportion impacts arising on seabirds from the optimised Seagreen Project to breeding populations of relevant species at SPAs with potential connectivity to the Project sites (Project Alpha and Project Bravo). Connectivity refers to the known or likely occurrence of bird features originating from SPAs at the Project Alpha and Project Bravo sites or buffer. For features of the SPAs for which potential connectivity has been identified in the breeding season, the proportion of adult and immature birds present at the optimised Seagreen Project has been identified from age class data, where available from site-specific surveys. For each of the features of the SPAs, the approach used to apportion impacts between adults and juveniles is outlined. Of those adults, a proportion will be taking a sabbatical (adults which are not breeding in any one year) and the impacts assigned to this cohort can be removed, as population size estimates of breeding colonies do not include sabbatical birds. How sabbaticals have been apportioned to adults is considered elsewhere within the HRA.

16.3 In the non-breeding season, population data from Furness (2015) has been used to determine the proportion of adult birds from the SPAs with connectivity present in the relevant Biologically Defined Minimum Population Scale (BDMPS) population. This approach is considered against an alternative approach to identifying a non-breeding season population for the Forth and Tay region and the contribution to it from regional SPA populations. An outline of the methodology used and the results, concludes this Appendix.

CONNECTIVITY BETWEEN SPA SEABIRD FEATURES AND THE OPTIMISED SEAGREEN PROJECT IN THE BREEDING SEASON

Overview

16.4 During the breeding season foraging seabirds may travel some distance from their breeding colonies. The information available on the distances that breeding birds will forage depends on the individual species. Typically, the mean-maximum foraging range (i.e. the mean of the maximum foraging trips recorded across multiple sites) as reported by Thaxter *et al.* (2012), has been applied in Habitats Regulation Appraisal (HRA) as a criterion for establishing whether there is likely to be connectivity (and hence risk of an impact) between a SPA breeding colony and a proposed wind farm development. Where the foraging ranges presented in Thaxter *et al.* (2012) are used in the assessment of the optimised Seagreen Project, the mean-maximum range with one standard deviation has been applied to the HRA in order to add considerable further precaution.

16.5 Table 15.1 presents the breeding season mean maximum foraging range for the qualifying features of the SPAs (Forth Islands SPA, Fowlsheugh SPA, Buchan Ness to Collieston Coast SPA, St Abb's Head to Fast Castle SPA) that Marine Scotland advised must be included in the assessment for the optimised Seagreen Project (Marine Scotland 2017).

Table 16.1 Breeding season mean-maximum foraging ranges

Species	Mean-maximum foraging range (km) +/- one standard deviation (Thaxter *et al* 2012)
Gannet	229.4 ± 124.3
Kittiwake	60 +/- 23.3
Herring gull	61.1 +/- 44
Guillemot	84.2 +/- 50.1
Razorbill	48.5 +/- 35
Puffin	105.4 +/- 46

16.6 Whilst at-sea surveys can provide valuable information on where important aggregations of seabirds occur, such surveys cannot establish the provenance of individuals and therefore establish connectivity between the impacts of the optimised Seagreen Project and an SPA breeding colony. Information from seabird tracking studies may be used to establish the likely colony origins of at-sea concentrations of seabirds. In some cases, targeted species-specific information is available from GPS/satellite tracking studies, such as, for example, the tracking by FAME (Future of the Atlantic Marine Environment, fameproject.eu) of breeding kittiwake and guillemot colonies associated with Fowlsheugh SPA. This information is initially qualitatively reviewed below, to establish the likely connectivity of a breeding seabird species from an SPA with the optimised Seagreen Project. The key SPA seabird qualifying features and SPAs against which impacts are likely from the optimised Seagreen Project are then finally considered in this section.

Tracking studies

GPS tracking by FAME

16.7 FAME (RSPB unpublished) GPS-tracked a sample of three seabird species that included 55 kittiwake and 18 guillemots at colonies in the SPAs/pSPA where these two species are qualifying features and which Marine Scotland advised must be included in the assessment for the optimised Seagreen Project. The colonies sampled were within Buchan Ness to Collieston Coast SPA, Fowlsheugh SPA and St Abbs Head SPA. The GPS tracking was carried out during May-July 2012, when the study species were either approaching the end of the incubation period or raising small chicks. The birds were recaught 1-7 days later to retrieve data.

16.8 Single tracks of two of the 15 kittiwakes and none of the tracks of the one guillemot tagged at St Abb's Head SPA interacted with the optimised Seagreen Project sites (Project Alpha and Project Bravo). The species connectivity reversed at Fowlsheugh SPA from where two guillemots (n = 10) and none of the kittiwake (15) tagged interacted with the Project sites. No kittiwakes (n = 25) or guillemots (n = 7) tracked from Buchan Ness to Collieston Coast SPA interacted with the Project sites.

GPS tracking study on the Isle of May (2012-2014)

16.9 The Centre for Ecology & Hydrology (CEH) GPS-tracked a sample of four seabird species that included 50 kittiwake, 28 razorbills, 51 guillemots on the Isle of May, one of the islands within the Forth Islands SPA (BirdLife International Seabird Tracking Database http://www.seabirdtracking.org/ accessed 26th March 2018). The GPS tracking was carried out during May-July, 2012 – 2014, when it is presumed given the limitations of current technology and bird welfare, that the study species were either approaching the end of the incubation period, or raising small chicks. Small numbers of tagged kittiwake were recorded commuting through the optimised Seagreen Project. No overlap was however recorded by the GPS tracking between foraging ranges of tagged guillemot and razorbill and the Project sites.

GPS tracking study by CEH (2010-2011)

16.10 CEH GPS-tracked a sample of kittiwake, razorbills, guillemots and puffins from three SPA colonies around the Firth of Forth in 2010 and 2011 (Daunt *et al.* 2011a, cited in Seagreen Wind Energy 2017). Tracks of breeding kittiwake from the Isle of May (n =36) in 2010, and Fowlsheugh (n = 35) and St Abb's Head (n = 25) in 2011, suggested the latter colony to have more limited connectivity with the optimised Seagreen Project site than the other two colonies. The three auk species were only tracked in 2010 and from the Isle of May. Whereas tracks of breeding guillemots (n = 33) did not insect with the proposed optimised Seagreen Project, a low level of connectivity was recorded amongst the breeding razorbills and puffins tracked (n = 18 and n = 7) with 1.8% and 1% of trips respectively reaching the Project sites.

Relevance of the findings of Wakefield et al. (2017)

16.11 Wakefield *et al.* (2017) GPS-tracked a sample of four seabird species that included 464 kittiwake, 281 razorbills, 178 guillemots from respectively 20, 14 and 12 colonies in the UK. The sample of colonies were drawn from throughout the geographical, environmental and colony size range of the study species in Britain and Ireland. The sample of colonies included Buchan Ness to Collieston Coast SPA, Fowlsheugh SPA and St Abbs Head SPA for kittiwake and guillemot, and the Forth Islands SPA (Isle of May) for kittiwake, guillemot and razorbill. Fowlsheugh SPA, Forth Islands SPA and St Abbs Head SPA together with Buchan Ness to Collieston Coast SPA were the SPAs Marine Scotland advised in their project-specific advice to Seagreen considered by the HRA with the species included being kittiwake, guillemot and razorbill (Marine Scotland 2017a). The GPS tracking was carried out during May-July, 2010 – 2014, when the study species were either approaching the end of the incubation period or raising small chicks. Data from all of the previously described tracking studies were included in the analysis by Wakefield *et al.* (2017).

16.12 Using Poisson point process habitat use models, Wakefield *et al.* (2017) showed that distribution at sea is dependent on: (i) density-dependent competition among sympatric conspecifics[1] (all species) and parapatric conspecifics[2] (Guillemots); (ii) habitat accessibility and coastal geometry, such that birds travel further from colonies with limited access to the sea; and (iii) regional habitat availability. Using these models, Wakefield *et al.* (2017) predicted space use by birds from unobserved colonies e.g. Fowlsheugh SPA and St Abbs Head SPA for razorbill, and thereby mapped the distribution at sea of each species at both the colony and regional level. This is presented in the form of percentage utilisation distributions (UD), defined as a population's spatial probability distribution (Fieberg and Kochanny 2005).

16.13 Poisson point process habitat use models in Wakefield *et al.* (2017) suggested that the optimised Seagreen Project is located in an area delineating 5-10%, 75% and 75% at-sea utilisation distribution of breeding kittiwake, guillemot and razorbill respectively within Britain and Ireland during late incubation/early chick-rearing estimated as functions of colony distance, coast geometry and intra-specific competition. On the basis of these

[1] Density dependent competition among seabirds breeding in the same colony (sympatric competition)

[2] Density-dependent competition between colonies (parapatric competition)

findings alone, it is considered a robust assumption that the optimised Seagreen Project lies within the maximum foraging range of breeding kittiwake, guillemot and razorbill from one of the four above mentioned SPAs (Buchan Ness to Collieston Coast SPA, Fowlsheugh SPA, Forth Islands SPA and St Abbs Head SPA) when successfully breeding i.e. a distance compatible with a two parent family able to bring enough food back to keep a chick alive.

The key SPA seabird features and SPAs against which impacts are likely

16.14 Marine Scotland (2017a) suggested the most applicable foraging range criterion for use in assessment was the mean maximum foraging range as derived by Thaxter *et al.* (2012). For the purposes of this assessment, the mean-maximum range with one standard deviation has been applied to the HRA in order to add considerable precaution (Table 15.1). The proposed optimised Seagreen Project lies within the mean maximum foraging range plus one standard deviation of the qualifying features of the four SPAs which support breeding seabirds colonies that Marine Scotland advise must be included in the assessment.

16.15 For one of the four SPAs for which assessment is required with respect to kittiwake, namely Buchan Ness to Collieston Coast, the project lies outwith the boundary of the mean maximum foraging range, plus one standard deviation. This holds true whether the measured distance is between the geometric centre of the development and the geometric centre of the colony, or nearest count sector (at 83.8 km). No connectivity was established by tracking studies by FAME at Buchan Ness to Collieston Coast SPA, however the shortest distance between the site and the SPA is within mean-max foraging range plus one standard deviation, therefore it is included, in line with Marine Scotland scoping requirements (Marine Scotland 2017).

METHODS: APPORTIONING ESTIMATED EFFECTS FROM THE BREEDING SEASON

Introduction

16.16 For apportioning impacts associated with an offshore wind farm that may occur in the breeding season to seabirds from those SPAs within a species' foraging range of the proposed development, Scottish Ministers have advised the project to follow the two-step approach advised by SNH (Marine Scotland 2017a). This is the approach that has been followed in the assessment of impacts on seabirds from the optimised Seagreen Project.

16.17 The recommended two stage process is:

- (i) To apportion impacts between SPA and non-SPA breeding colonies within foraging range of the wind farm. This is done using Seabird 2000[3] data as this provides a common reference point and many of the non-SPA breeding colonies have not been counted since this time.
- (ii) The impacts assigned to the SPA component are further apportioned between the individual SPAs within foraging range. In this regard, the most recent counts are used, as provided by SNH (2017) and the subsequent revisions made in SNH Advice to Seagreen in May 2018.

[3] Seabird 2000 was the third complete census of the entire breeding seabird population of Britain and Ireland. It took place during 1998 – 2002, being co-ordinated by JNCC in partnership with other organisations (http://jncc.defra.gov.uk/seabird2000).

16.18 This second stage of the process is described within the HRA assessing each respective breeding season impact on seabirds of the optimised Seagreen Project. The remainder of this section describes the methodology used to perform the first stage of the process.

Apportioning impacts between SPA and non-SPA breeding colonies within foraging range of the optimised Seagreen Project

16.19 The current method for apportioning impacts between breeding colonies (SPA and other) within foraging range of the optimised Seagreen Project is SNH (2016) "*Interim Guidance on Apportioning Impacts from Marine Renewable Developments to Breeding Seabird Populations in Special Protection Areas*". This is an update to the guidance recommended to recent projects by Marine Scotland (2017b; c). As discussed in 16.4, connectivity to SPAs is largely based on determining seabird foraging ranges. The use of an empirically derived approach requires the use of robust site-specific field-derived data on foraging ranges and locations. This necessitates acquiring an adequate sample size of tagged birds from a colony selected from a random sample of breeding locations within the site. The tracking period should be representative of the breeding season and comparable for all sites. Moreover, it requires information from each tag and the length of each foraging day including the proportion of each day spent within the Project area. Such tagging data of the required level of spatial and temporal information, for one or more SPA colonies with connectivity to the optimised Seagreen Project does not exist. Therefore, the theoretical approach of SNH (2016) is followed with this using published seabird foraging range information and generalised models.

16.20 The method is based on foraging range and three colony-specific weighting factors:

- (i) Colony size (with consistent count unit used between colonies for a species e.g. individuals, breeding pairs or apparently occupied sites);
- (ii) Distance of colony from the Project area (using the geometric centre of both); and
- (iii) Sea area (the areal extent of the open sea within the foraging range of the relevant species).

16.21 To identify those breeding colonies (SPA and other) for which there may be connectivity between breeding birds and the Seagreen Offshore Wind Farm, the mean-maximum foraging range as published by Thaxter *et al.* (2012), has been applied. In order to add further precaution, the mean-maximum range with one standard deviation has been used.

16.22 Large colonies will contribute more individuals to the number of seabirds found within the optimised Seagreen Project, all other factors being equal. To account for this, a weighting factor based on colony size is derived. For all colonies considered, colony size has been calculated from Seabird 2000 data with this providing a common reference point as all count data is contemporaneous. Seabird 2000 data is comprised of separate count sections with long stretches of coastline e.g. Fowlsheugh, made up of several count sections. For the purposes of this analysis each count section is treated as a separate colony. If a single SPA is made up of several count sections the combined SPA impact is reconstructed after the weighting for each count section is completed.

16.23 Weighting by distance from the colony is calculated using the measured distance between the geometric centre of the development to the geometric centre of the colony. As birds radiate out from a colony density will decrease by a factor proportional to $1/\text{distance}^2$ as area increases proportionally by πr^2. For the purposes of this assessment, a weighting factor based on $1/distance^2$ is used as advised by SNH (2016)[4].

16.24 The available sea area for foraging is measured by plotting a circle defined by the species-specific foraging range around the colony in ArcGIS and calculating the area of sea available to each seabird species. The fraction of the disc centred on the colony that is occupied by sea surface is then expressed as a decimal. As the density of birds will increase as the area of available foraging area decreases this is used in the formula as 1-estimated area.

16.25 The three weighting factors (weightings by colony size, distance from the colony and sea area) are combined to produce an overall weighting for each colony. Each factor is given equal weight in the combined weighting. The calculation is made as follows:

$$\text{Colony Weight} = \frac{\text{Colony Population}}{\text{Sum of Populations}} \times \frac{\text{Sum of Distance}^2}{\text{Colony Distance}^2} \times \frac{{}^{1}/_{\text{Colony Sea Proportion}}}{\text{Sum of }({}^{1}/_{\text{Colony Sea Proportions}})}$$

16.26 The weighting is then used to calculate the proportion of birds attributed to each colony ("proportional weight of colony") by calculating colony weight divided by sum of all colony weights. As noted in paragraph 16.22, if a single SPA is made up of several count sections the combined weight for the SPA is reconstructed after the combined weighting for each count section is completed by summation of the colony weights.

Calculation of the number of birds allocated to each SPA at the Seagreen Offshore Wind Farm

16.27 To estimate the contribution of each SPA to the population of birds at the optimised Seagreen Project, the total number of breeding birds at the latter site is multiplied by proportion allocated to the SPA ("proportional weight of colony"). This requires the optimised Seagreen Project area count to be adjusted to account for the presence of birds aged as sub-adult or immatures. The approaches used for defining the age composition of a species population at the optimised Seagreen Project is described in the section "Age composition during the breeding season" (from paragraph 16.37).

METHODS: CALCULATION OF APPORTIONING VALUES FOR NON-BREEDING SEASONS

16.28 When apportioning non-breeding season effects from the optimised Seagreen Project between relevant SPAs for gannet and kittiwake, the contribution of adult birds from an individual SPA, as estimated by Furness (2015), as a proportion of the BDMPS population is used. The same approach is considered for herring gull against an alternative approach to identifying a non-breeding season population for the Forth and Tay and the contribution to it from regional SPA populations. For auks, the Scottish Ministers advise no assessment is required for puffin in the non-breeding season (Marine Scotland 2017a). For the remaining auk species being considered (guillemot and razorbill), the non-breeding season effects of the optimised Seagreen Project will be assigned to relevant SPAs within a species' foraging range when breeding. This, a highly precautionary approach due to the non-breeding season dispersal of the species, will as when apportioning breeding season effects, follow the two-step approach promoted by SNH (Marine Scotland 2017a), as Scottish Ministers have advised the project.

[4] Correction to the formula of the SNH (2016) guidance notified by email to Seagreen Wind Energy Ltd. (N. Brockie) from Marine Scotland (S. Humphries) on 18th July 2018.

16.29 An outline of the methodology used when apportioning non-breeding season effects from the optimised Seagreen Project, between relevant SPAs, are described below for each species.

Gannets and kittiwake

Methodology

16.30 The calculation of apportioning values for non-breeding seasons (post-breeding, non-breeding and pre-breeding) follows the approach used previously in the application and examination documentation for multiple offshore wind farms (e.g. East Anglia THREE Ltd. 2015, Forewind 2013, SMart Wind 2015a). The contribution of adult birds from an individual SPA, as estimated by Furness (2015), to the relevant BDMPS population for each species/season combination is divided by the total BDMPS population to calculate the proportion of the BDMPS population represented by adult birds from the SPA considered. An example of the computation involved is given in the following paragraph. It should be noted that no updates have been made to the population data presented in Furness (2015) as any updates will not be contemporaneous with those data not updated.

Worked example

16.31 The following calculations are an example, in this case for kittiwake, of the approach used to assess the contribution of the focal colony to the BDMPS population (i.e. what proportion of the adults in the BDMPS region consist of birds from the focal colony). In this example the focal colony is the Fowlsheugh SPA. Furness (2015) defines the kittiwake non-breeding season as two periods, autumn migration (August to December) and spring migration (January to April). In this example the autumn migration period is considered. The population of kittiwake in the relevant BDMPS region for the optimised Seagreen Project, i.e. 'UK North Sea waters', is estimated in the autumn migration season to be 829,937 birds (Furness 2015, p348, table 47). The Fowlsheugh SPA adult population in the BDMPS region is 18,674. The proportion of Fowlsheugh SPA adult population present in the non-breeding season in the BDMPS region is 0.6 (Furness 2015, p348, table 47). Therefore:

- The number of Fowlsheugh SPA adult birds in the BDMPS =

  (Fowlsheugh SPA adult population in the BDMPS region) * (proportion of Fowlsheugh SPA adult population present in the autumn migration season in the BDMPS region) = 18,674 * 0.6 = 11,204

- The proportion adults of the autumn migration season BDMPS comprising Fowlsheugh SPA birds =

  (No. of Fowlsheugh SPA adult birds in the BDMPS) / (Total no. of birds in the BDMPS) = 11,204 / 829,937 = 0.01 (to two significant figures)

Herring gull

16.32 The calculation of apportioning values for non-breeding season follows the approach used previously in the application documentation for Beatrice Offshore Wind Farm and as advised by Marine Scotland in their project-specific advice to the optimised Seagreen Project (Marine Scotland 2017a). It involves identifying a suitable regional population of relevance of to the project site by considering the SPA summer population and any other non-SPA colonies, use of this to inform the non-breeding season population of relevance to the project and its size and finally an estimate is made of the percentage population of the non-breeding season population derived from the regional SPA population. It is then advised by Marine Scotland in their project-specific guidance to the optimised Seagreen Project (Marine Scotland 2017a) that the merits of proceeding with this approach is considered against using a summation of the contribution of adult birds from individual

SPAs, as estimated by Furness (2015), as a proportion of the BDMPS population (for adults only) as defined by Furness (2015). The latter approach is as described above for gannet and kittiwake, other than its last step which expresses the proportion of adults of the non-breeding BDMPS for adults only and not the BDMPS for all ages classes.

16.33 Large numbers of the Scandinavian herring gull subspecies *argentatus* from northern Russia and Fennoscandia are present on the east coast of Scotland during the winter (Forrester and Andrews 2007, Wernham *et al.* 2002). They form up to about 30% of the wintering herring gull, in places along the eastern side of northern Britain. (Coulson *et al.* 1984). British breeding herring gulls are generally dispersive during the non-breeding, moving in all directions, but with a marked tendency for southward autumn movements from the colony (Wernham *et al.* 2002). An analysis of British and Irish ringing recoveries, found the distance moved by adults between breeding and winter areas in the UK was a median of 45.5 km. Informed by these observations of a dispersive species for which adults can be present at their breeding colonies all year, except for just a few weeks through the winter (Coulson & Butterfield 1986), the non-breeding season population of relevance to the optimised Seagreen Project (i.e. Forth and Tay non-breeding season population) is defined as:

- The breeding populations of herring gull along the Scottish east coast between Banff and Buchan and Berwickshire, an estimated 28,876 pairs at the time of the last census (Mitchell et al. 2004; sites include Banff and Buchan, Gordan, City of Aberdeen, Kincardine and Deeside, Angus, Perth and Kinross, City of Dundee, Northeast Fife, Kirkcaldy, Dumfemline, Clackmannan, Falkirk, City of Edinburgh, East Lothian and Berwickshire)
- An additional 30%to the preceding breeding population, to account for the influx of Scandinavian herring gull i.e. 30% added to 28,876 pairs equates to 37,539 pairs or 75,078 adult birds.

16.34 The regional SPA (reference) population assessed for effects during the breeding season would represent approximately 42% of the Forth and Tay non-breeding season population of adults of relevance to the Seagreen Offshore Wind Farm (15,674 pairs; the Seabirds Count Census, 2014 – 2017; Buchan Ness to Collieston Coast SPA 3,115 pairs, Forth Islands SPA 125 pairs, Fowlsheugh SPA 9,655 pairs, St. Abb's Head to Fast Castle 2,779 pairs).

16.35 Summation of the contribution of adult birds from individual SPAs, as estimated by Furness (2015), as a proportion of the BDMPS population (for adults only) as defined by Furness (2015), results in an apportioning value for the non-breeding season for adult herring gull of 6.1%. Furness (2015) attributes 24% of adult birds in the UK North Sea & Channel waters non-breeding season BDMPS to non-UK breeders. Regardless of the difference in value assigned to the proportion of overseas breeders in the population, a marked difference exists in the results between the two methods used for calculating the apportioning values for non-breeding season. As previously discussed, the UK breeding population of herring gull is a dispersive species with the distance moved by adults between breeding and winter areas recorded as a median of 45.5 km. This would support the use of the higher apportioning value of 42% of the Forth and Tay non-breeding season population of adults in the current assessment to represent the regional SPA (reference) population assessed for effects during the breeding season.

Guillemot and razorbill

16.36 For guillemot and razorbill the non-breeding season effects will be assigned to relevant SPAs using the same method and data as described for the breeding season (see 16.16). This is likely to be highly precautionary due to the non-breeding season dispersal of the species, in particular during the period of parental guarding of fledged chicks and wing moult. However, using the BDMPS reference population is likely to underestimate the effects on the Forth and Tay breeding population during the non-breeding season due to e.g. guillemots returning to their colony during this period by early October following wing moult (Harris & Wanless 1990). Therefore for guillemot and razorbill the breeding season reference populations will be used whilst discussion will be provided around why the estimated effects are likely to be overestimates and reference to the BDMPS made. This approach is in accordance with the recommendations on assigning for the auks non-breeding season effects to relevant SPAs as advised by Marine Scotland in their project-specific advice to the optimised Seagreen Project (Marine Scotland 2017a).

METHODS: AGE COMPOSITION

Age composition during the breeding season

16.37 When assigning impacts from the optimised Seagreen Project between age classes[5], for gannet, herring gull and kittiwake, impacts are apportioned to age classes using proportions derived from site survey data gathered at an area encompassing the optimised Seagreen Project area (Seagreen Wind Energy 2017). The optimised Seagreen Project area contains the revised Project area for the originally consented project as well as Scalp Bank and a 2 km buffer area. For species where age composition survey data is not available e.g. the auk species (puffin, razorbill and guillemot), the numbers of birds in each age class estimated by Furness (2015) using a stable (equilibrium) model population for the relevant species will be applied. These approaches follow recommendations on assigning impacts between age classes as advised by Marine Scotland in their project-specific advice to the optimised Seagreen Project (Marine Scotland 2017a).

16.38 The following species-specific sections provide further discussion on the approaches used in determination of the numbers of birds in each age class. The species considered are those six key species for which there is likely to be connectivity (and hence risk of an impact) between a key SPA breeding colony against which impacts from the optimised Seagreen Project need consideration, as determined from the Marine Scotland (2017a) project-specific advice.

Gannet

16.39 To calculate the apportioning of birds to age classes for gannet, site-specific data collected as part of boat-based surveys of the optimised Seagreen Project study area have been analysed. The boat-based surveys were conducted across a series of strip transects spaced 3 km apart, covering the optimised Seagreen Project study area and were undertaken between May and September 2017. The analysis used data from the four surveys undertaken during the months May to July. Use of this subset of the breeding season (April to August) avoids any error arising from the age code used for newly fledged juveniles from late July. Whilst it was anticipated that one survey would be completed each month between April and September 2017 inclusive, survey logistics and weather constraints meant the intended April survey was delayed into early May. Birds were classified as either adult, one of four immature plumage categories, juvenile .

16.40 Table 16.2 presents the proportion of adult and immature gannet recorded during boat-based surveys of the optimised Seagreen Project area for April to July. These proportion are used in further analysis as the estimated breeding season contribution of adult birds to

[5] classified as either adult, not adult, immature, juvenile or aged in years.

total predicted to be present at the Optimised Seagreen Project. (and hence risk of an impact) between a SPA.

Table 16.2 The proportion of adult and immature gannet calculated using the optimised Seagreen Project area boat-based survey data collected in the breeding season (April to July)

Data	Sample size	Adult proportion (%)	Immature proportion (%)
P1 study area boat-based survey	• 2,942	• 97.3	• 2.7

Kittiwake

16.41 The ageing of birds in boat-based surveys can prove problematic for certain species. Immature kittiwake beyond their first year are essentially indistinguishable from adult birds during surveys (Coulson 2011, Malling Olsen and Larsson 2003), but they do not breed until their fourth year. This means that using the age proportions from site-specific data would represent a considerable over-estimate of the proportion of adult birds present within the optimised Seagreen Project area. In order to address this limitation during the breeding season, an approach was developed during the examination for Hornsea Offshore Wind Farm Project Two (SMart Wind 2015b). This approach utilises age-specific survival rates (Horswill and Robinson 2015) to calculate the proportion of different age classes likely to be present within the optimised Seagreen Project area.

16.42 The approach used for Hornsea Project Two (SMart Wind 2015b) and adopted in the current assessment is considered to be precautionary. The main area of precaution is the affinity exhibited by different immature age classes to natal waters during the breeding season. First year birds show considerably less affinity for natal waters than do older immatures with the many birds remaining thousands of kilometres away (Coulson 2011). Applying the approach used at Hornsea Project Two (SMart Wind 2015b) assumes that the proportion of older immatures in natal waters is consistent with the proportion of first year immatures. This under-estimates the proportion of older immature age classes present within the optimised Seagreen Project area, as these birds show a much greater affinity for natal waters, with much higher proportions of these age classes present in natal waters. This, and other sources of uncertainty and precaution related to the calculated apportioning values is discussed in the species-specific sections below.

16.43 It is certain that an unknown proportion of the cohort of unaged 'adult type' kittiwakes within the optimised Seagreen Project area will include two and three-year-old birds. Coulson (2011) provides evidence that shows that immature kittiwakes visit natal waters with increasing numbers of older immatures visiting breeding colonies. This therefore supports the conclusion that the approach proposed to calculate an apportioning value for the breeding season will under-estimate the proportion of second and third year immatures which will show a much greater affinity for natal waters than first year birds.

16.44 Further to this, it is not possible to separate non-breeding adult birds from those that are breeding at SPAs with connectivity to the optimised Seagreen Project area. A minimum of 4% of adult male birds missed a breeding season at North Shields, Tyneside, whereas females did so about half as frequently with a recorded maximum of approximately 13% (Coulson 2011). In the absence of evidence to the contrary, it is reasonable to assume that immature birds that cannot be distinguished from breeding adult birds, based on plumage, are present within the optimised Seagreen Project area.

16.45 Whilst maintaining the proportion represented of each year class of immatures within the optimised Seagreen project area, mortality reduces the absolute number of birds present from each successive year class of kittiwake. In calculating the number of two and three-year-old kittiwakes within the optimised Seagreen Project area, the analysis uses survival rates of each immature year class of kittiwake that follows Model KI1 in SMart Wind (2015c) (i.e. 0.79 for juveniles, 0.85 for one-year olds and 0.87 for two year olds).

16.46 The analysis used data from the four boat-based surveys in 2017 undertaken during the months May to July that covered the optimised Seagreen Project area. Table 16.3 presents the proportion of adult and immature kittiwake recorded during the boat-based surveys of the optimised Seagreen Project area for the months April to July.

Table 16.3 The proportion of adult and immature kittiwakes calculated using the optimised Seagreen Project area boat-based survey data collected in the breeding season (April to July)

Data	Sample size	Adult proportion (%)	Immature proportion (%)
P1 study area boat-based survey	• 2,624	• 97.9	• 2.1

16.47 The datasets are used in Table 16.4 to calculate the likely proportion of adult birds at the optimised Seagreen Project, taking into account the presence of older immatures which are indistinguishable from adult birds using plumage characteristics.

Table 16.4 Estimated breeding season contribution of adult birds to the total predicted to be present at the optimised Seagreen Project using immature proportions as calculated from survival rates and numbers of one-year old birds recorded on digital boat-based survey transects covering the optimised Seagreen Project area

Analysis step	Formula (using the parameters identified as part of each analysis step	Value
(a) Survival rate of juvenile birds		0.79
(b) Survival rate of one year old birds		0.85
(c) Survival rate of two year old birds		0.87
(d) % of kittiwake at the P1 study area assigned to one year old birds		2.10%
% of kittiwake at the P1 study area assigned to other immature age classes (e) two years old (f) three years old	$e = \frac{a \times b}{a} \times \frac{d}{100} \times 100$ $f = \frac{(a \times b) \times c}{a} \times \frac{d}{100} \times 100$	1.78% 1.96%
(g) % of kittiwake at the P1 study area assigned to adults	$g = 100\% - (d + e + f)$	94.16%

16.48 Based on the proportion of first year birds observed from boat-based survey, and the likely age structure of the kittiwake population it is considered that adults will comprise 94.2% of the individuals observed at the optimised Seagreen Project. However, this is considered to be precautionary due to the following:

- The value accounts for adults in the population not breeding in a given year – this could account for a further reduction of c5-10% (Coulson 2011, Marine Scotland 2017b, c);
- A smaller proportion of first year birds are likely to be present in natal waters with a much greater proportion of older age classes of immature birds showing affinity with natal waters; and
- Immature birds are not likely to be evenly distributed within the North Sea and will show aggregations near to foraging resources. If the area within which the optimised Seagreen Project lies is seen to be notable for kittiwake foraging, immatures may be present in larger proportions.

16.49 The evidence reviewed here, therefore suggests the proportion of adult kittiwakes at the optimised Seagreen Project will be lower than the 94.2% values obtained through boat-based surveys. In addition, the use of survival rates in the apportioning approach presented in Table 16.4 is considered to be appropriately precautionary. Older immature year classes are known to show a greater affinity for natal waters with the proportion of older immature year classes returning to natal waters during the breeding season therefore higher than the proportion of first year birds returning to natal waters. The approach applied in Table 16.4 assumes that a consistent proportion of each year group will be present at the optimised Seagreen Project and therefore likely under-estimates the proportions of older immature year classes present at the optimised Seagreen Project. The apportioning value calculated using boat-based survey data is considered to be appropriately precautionary for use in further analyses.

Herring Gull

16.50 To calculate the apportioning of birds to age classes for herring gull, site-specific data collected as part of boat-based surveys of the optimised Seagreen Project area have been analysed. The analysis used data from the four surveys undertaken during the months April to July 2017. Use of a subset of the breeding season (April to August) reduces any error arising from the age code used for newly fledged juveniles. Birds were classified as either adult, not adult, immature, juvenile or aged using a number representing the year of life (i.e. 2 = second year).

16.51 In the data presented below only those birds identified as adults, non-adults, immatures and those aged using a number are included. No juvenile birds were recorded in surveys during the breeding season sampled (April – July; 4 boat-based surveys).

16.52 Table 16.5 presents the proportion of adult and immature herring gull recorded during boat-based surveys of the optimised Seagreen Project area for April to July. These proportion are used in further analysis as the estimated breeding season contribution of adult birds to total predicted to be present at the Seagreen Offshore Wind Farm. (and hence risk of an impact) between a SPA.

Table 16.5 The proportion of adult and immature herring gulls calculated using the optimised Seagreen Project area boat-based survey data collected in the breeding season (April to July)

Data	Sample size	Adult proportion (%)	Immature proportion (%)
P1 study area boat-based survey	98	28.6	71.4

Auk species

16.53 For the three auk species (puffin, razorbill and guillemot) where the ageing of birds is not possible from boat-based surveys, a theoretical approach is necessary, to estimate the breeding season contribution of adult birds, predicted to be present at the optimised Seagreen Project. Furness (2015) uses a stable (equilibrium) model population (i.e. a Leslie Matrix model using a stable age distribution and immature survival rates adjusted to give a zero net rate of population change) to derive an estimate of the number of immatures per breeding adult in a typical population of individual seabird species in UK waters, including the three auk species. In the absence of a more robust approach, the current assessment uses the Furness (2015) estimate of the number of immatures per breeding adult in a typical population to estimate the breeding season contribution of adult birds to the total predicted to be present at the optimised Seagreen Project (Table 16.6). The above approach follows recommendations on assigning effects between age classes for breeding auks as advised by Marine Scotland in their project-specific advice to the optimised Seagreen Project (Marine Scotland 2017a).

Table 16.6 The derived estimate of the proportion of immatures per breeding adult in a typical population of each of the three auk species

Species	Estimated immatures per breeding adult in a typical population	Adult proportion (%)	Immature proportion (%)
Puffin	1.04	49.0%	51.0%
Razorbill	0.75	57.1%	42.9%
Guillemot	0.74	57.5%	42.5%

Age composition during the non-breeding season

16.54 For all species with the exception of herring gull, the age class composition of a seabird species present at the optimised Seagreen Project during non-breeding seasons will be derived using proportions from PVA stable age structure. The approach taken in applying the PVA stable age structure differs however between species as is described in the following section. When apportioning non-breeding season effects from the optimised Seagreen Project between relevant SPAs for herring gull (see 16.32), it solely dealt with adult breeding birds. The age class composition of herring gull present at the optimised Seagreen Project during non-breeding seasons will be derived from site survey data gathered at an area encompassing the optimised Seagreen Project area (Seagreen Wind Energy 2017).

Gannet and kittiwake

16.55 For gannet and kittiwake, the age class composition of a seabird species present at the optimised Seagreen Project during non-breeding seasons, including all the breeding interest features of individual SPAs in the UK, were derived using population data from Furness (2015).

16.56 Furness (2015) presented breeding adult and immature populations associated with colonies, with predicted connectivity with the BDMPS population relevant to the optimised Seagreen Project during the non-breeding seasons (i.e. UK North Sea waters and, for some species, with Channel waters). Also presented is the proportion of each breeding colony designated as a SPA in the UK predicted to be present in the BDMPS during the non-breeding seasons together with the proportion of birds that exhibit connectivity with the BDMPS from foreign and non-SPA UK colonies (Furness 2015). For each colony with connectivity to the optimised Seagreen Project, the proportion of an age group (i.e. breeding adults or immatures) at the project site present from a colony will equate to the species age group population estimate for the colony divided by the species BDMPS population during the non-breeding seasons, for all age classes, as derived by Furness (2015). This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England (East Anglia THREE Ltd. 2015, SMart Wind 2015a). Moreover it apportions impacts across all age classes based on PVA stable age structure of gannet and kittiwake as advised by Marine Scotland in their project-specific advice to the optimised Seagreen Project (Marine Scotland 2017a).

Herring Gull

16.57 To calculate the apportioning of birds to age classes for herring gull, site-specific data collected as part of boat-based surveys of the optimised Seagreen Project area have been analysed. The analysis used data from the surveys undertaken during the months September to March. Birds were classified as either adult, not adult, immature, juvenile or aged using a number representing the year of life (i.e. 2 = second year).

16.58 In the data presented below only those birds identified as adults, non-adults, immatures and those aged using a number are included.

16.59 Table 16.7 presents the proportion of adult and immature herring gull recorded during boat-based surveys of the optimised Seagreen Project area for September to March. These proportion are used in further analysis as the estimated breeding season contribution of adult birds to total predicted to be present at the Seagreen Offshore Wind Farm. (and hence risk of an impact) between a SPA.

Table 16.7 The proportion of adult and immature herring gulls calculated using the optimised Seagreen Project area boat-based survey data collected in the breeding season (September to March)

Data	Sample size	Adult proportion (%)	Immature proportion (%)
P1 study area boat-based survey	148	50	50

Auk species

16.60 For the two auk species (razorbill and guillemot), the same theoretical approach as for the breeding season, is taken to estimate the non-breeding season contribution of adult birds predicted to be present at the optimised Seagreen Project. Furness (2015) uses a stable (equilibrium) model population (i.e. a Leslie Matrix model using a stable age distribution and immature survival rates adjusted to give a zero net rate of population change) to derive an estimate of the number of immatures per breeding adult in a typical population of individual seabird species in UK waters, including the two auk species. In the absence of a more robust approach, the current assessment uses the Furness (2015) estimate of the number of immatures per breeding adult in a typical population to estimate the non-breeding season contribution of adult birds to the total predicted to be present at the optimised Seagreen Project (Table 16.8). The above approach follows recommendations on assigning effects between age classes for non-breeding auks as advised by Marine Scotland in their project-specific advice to the optimised Seagreen Project (Marine Scotland 2017a).

Table 16.8 The derived estimate of the proportion of immatures per adult in a typical population of each of the two auk species

Species	Estimated immatures per adult in a typical population	Adult proportion (%)	Immature proportion (%)
Razorbill	0.75	57.1%	42.9%
Guillemot	0.74	57.5%	42.5%

METHODS: SABBATICALS

16.61 Every breeding season a proportion of adults skip breeding and take a sabbatical. To include any impacts occurring on any sabbatical birds would seem likely to overestimate the effects to these species/populations (Marine Scotland 2017b, c), as breeding colony population size estimates do not include these sabbatical birds. Marine Scotland have in their project-specific guidance to the optimised Seagreen Project (Marine Scotland 2017a) recommended using the proportion of adults taking sabbaticals from a breeding in a given year presented in Table 16.9. This guidance was based on the advice of SNH following an initial review of the literature. The application of these sabbatical rates within the current assessment will be considered in the HRA and its other technical appendices.

Table 16.9 The proportion of adults taking sabbaticals from breeding in a given year

Species	% sabbatical
Gannet	10%
Kittiwake	10%
Herring gull	35%
Puffin	7%
Razorbill	7%
Guillemot	7%

16.62 While there is uncertainty around appropriate rates to use, SNH were content to advise in 2017, Inch Cape and Moray East Offshore Wind Farms to adopt the above tabulated '% sabbaticals' (Marine Scotland 2017b, c). These are considered likely to be underestimates and therefore remain precautionary.

RESULTS: APPORTIONING OF BREEDING SEABIRDS AT THE SEAGREEN OFFSHORE WIND FARM ACROSS MULTIPLE SPAS WITHIN FORAGING RANGE

16.63 Table 16.10–Table 16.15 present the apportioning values to be used to apportion impacts from the optimised Seagreen Project, to breeding populations of relevant species at SPAs for which connectivity has been identified. The species and SPAs presented are those that Marine Scotland advised must be included in the assessment for the optimised Seagreen Project (Marine Scotland 2017a).

Table 16.10 The proportion of breeding gannets at the optimised Seagreen Project apportioned to SPAs and sites outside of SPAs within foraging range

SPA name	Count of occupied nests on SPA	Distance from SPA to the Seagreen Offshore Wind Farm (km)	1/Proportion of foraging range at sea	Resulting weight for SPA	Proportional weight of SPA
Forth Islands	44,110	79.6	1.61	1.89	0.99
All other colonies (Troup)	1,085	127.0	1.33	0.02	0.01

Table 16.11 The proportion of breeding kittiwakes at the optimised Seagreen Project apportioned to SPAs and sites outside of SPAs within foraging range

SPA name	Count of occupied nests/territories on SPA	Distance from SPA to the Seagreen Offshore Wind Farm (km)	1/Proportion of foraging range at sea	Resulting weight for SPA	Proportional weight of SPA
Fowlsheugh	28,447	46.0	1.90	0.71	0.61
Forth Islands	5,457	76.8	2.52	0.07	0.06
St. Abb's Head to Fast Castle	15,501	80.0	1.88	0.12	0.10
All other colonies	13,779	55.6	1.96	0.27	0.23

Table 16.12 The proportion of breeding herring gulls at the optimised Seagreen Project apportioned to SPAs and sites outside of SPAs within foraging range

SPA name	Count of adult birds on SPA	Distance from SPA to the Seagreen Offshore Wind Farm (km)	1/Proportion of foraging range at sea	Resulting weight for SPA	Proportional weight of SPA[6]
Buchan Ness to Collieston Coast	3,482	91.3	1.42	0.07	0.06
Fowlsheugh	1,194	45.9	1.78	0.13	0.10
Forth Islands	6,352	82.2	2.94	0.37	0.29
St. Abb's Head to Fast Castle	621	79.9	2.00	0.02	0.02
All other colonies	9,102	65.8	2.06	0.66	0.53

[6] The summation of the values in the column of the proportional weight of SPA does not add to 1.0 due to rounding of the individual values.

Table 16.13 The proportion of breeding guillemots at the optimised Seagreen Project apportioned to SPAs and sites outside of SPAs within foraging range

SPA name	Count of adult birds on SPA	Distance from SPA to the Seagreen Offshore Wind Farm (km)	1/Proportion of foraging range at sea	Resulting weight for SPA	Proportional weight of SPA[7]
Buchan Ness to Collieston Coast	29,362	91.9	1.37	0.07	0.04
Fowlsheugh	69,095	46.1	1.71	0.80	0.52
Forth Islands	36,369	80.5	2.85	0.28	0.18
St. Abb's Head to Fast Castle	43,138	79.9	2.13	0.20	0.13
All other colonies	85,522	82.2	1.85	0.20	0.13

Table 16.14 The proportion of breeding razorbills at the optimised Seagreen Project apportioned to SPAs and sites outside of SPAs within foraging range

SPA name	Count of adult birds on SPA	Distance from SPA to the Seagreen Offshore Wind Farm (km)	1/Proportion of foraging range at sea	Resulting weight for SPA	Proportional weight of SPA[8]
Fowlsheugh	7,334	46.0	1.90	0.60	0.52
Forth Islands	4,416	76.8	2.52	0.19	0.17
St. Abb's Head to Fast Castle	2,918	80.0	1.88	0.08	0.07
All other colonies	3,478	51.3	1.92	0.27	0.24

Table 16.15 The proportion of breeding puffins at the optimised Seagreen Project to SPAs and sites outside of SPAs within foraging range

SPA name	Count of adult birds on SPA	Distance from SPA to the Seagreen Offshore Wind Farm (km)	1/Proportion of foraging range at sea	Resulting weight for SPA	Proportional weight of SPA
Forth Islands	70,434	87.5	2.95	0.79	0.75
All other colonies	77,262	71.8	1.78	0.27	0.25

[7] The summation of the values in the column of the proportional weight of SPA does not add to 1.0 due to rounding of the individual values.

[8] The summation of the values in the column of the proportional weight of SPA does not add to 1.0 due to rounding of the individual values.

RESULTS: CALCULATION OF APPORTIONING VALUES FOR NON-BREEDING SEASONS

16.64 For gannet and kittiwake, Tables 16.16 and Table 16.17 present the calculated proportion of the relevant BDMPS population represented by adult birds of the SPAs for which connectivity has been identified in the breeding season with the optimised Seagreen Project. The equivalent apportioning values to be used for guillemot and razorbill for the non-breeding season, are those already presented for the breeding season in Table 16.13 and Table 16.14.

16.65 For herring gull, the apportioning value calculated represents the contribution of adult birds for an SPA as the proportion of the Forth and Tay non-breeding season population of adults only, and not all age classes as for the previous four species. Table 16.18 presents the contribution of adult herring gulls from individual SPAs to the Forth and Tay non-breeding season population of adults.

16.66 The five species and SPAs presented are those that Marine Scotland advised must be included in the non-breeding season assessment for optimised Seagreen Project (Marine Scotland 2017a).

Table 16.16 The contribution of breeding gannets from SPAs to the UK North Sea and Channel Waters BDMPS population

SPA	Post-breeding (September – November)	Pre-breeding (December - March)
Forth Islands	0.24	0.31

Table 16.17 The contribution of breeding kittiwakes from SPAs to the UK North Sea and Channel Waters BDMPS population

SPA name	Post-breeding (August – December)	Non-breeding (January - April)
Fowlsheugh	0.01	0.02
Forth Islands	0.00	0.01
St. Abb's Head to Fast Castle	0.00	0.01

Table 16.18 The contribution of breeding herring gulls from SPAs to the Forth and Tay non-breeding season population of adult birds.

SPA name	Non-breeding season
Buchan Ness to Collieston Coast	0.08
Fowlsheugh	0.00
Forth Islands	0.26
St. Abb's Head to Fast Castle	0.07

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