Seabird Monitoring for Forth and Tay Offshore Wind Farms – Discussion Document, March 2016

1. Introduction

1.1 This Discussion Document

The purpose of this document is to promote discussions regarding future monitoring for the currently consented Forth and Tay offshore wind farm projects (Neart na Gaoithe, Inch Cape, Seagreen Alpha and Seagreen Bravo).

The document sets out key species of interest, potential effects of specific concern in the region, key questions regarding future monitoring and potential monitoring methods. This document does not constitute a proposal and the methods highlighted are not expected to be definitive. It is intended that it will help to gain consensus on the aims of future monitoring and the most appropriate methods.

The intended audience are members of the Forth and Tay Regional Advisory Group Ornithology Sub-Group (FTRAG-O)[1].

1.2 Background

The October 2014 Marine Scotland consent decision documents outlined the key questions arising for the Forth and Tay OWF projects and these are listed below:

- the impacts on breeding seabirds arising from collision with turbines, particularly gannet and kittiwake;
- flight height distributions of seabirds at wind farm sites;
- displacement of kittiwake, puffin, guillemot and razorbill from wind farm sites;
- effects on survival and productivity at relevant breeding colonies; and
- effects on species not covered under HRA also require consideration (i.e. individuals breeding outwith SPAs and non-breeding individuals).

These points should be borne in mind when considering the monitoring options listed below.

[1]Scottish Natural Heritage (SNH), Joint Nature Conservation Committee (JNCC), Marine Scotland, the Royal Society for the Protection of Birds (RSPB), Seagreen Wind Energy Ltd (SWEL), Inch Cape Offshore Wind Ltd (ICOL) and Neart na Gaoithe Offshore Wind Ltd (NnGOWL).

2. Key Species, SPAs and Potential Effects

The information on species, SPAs and potential impacts described below is taken from the Marine Scotland Appropriate Assessment.

The impact tables in this document take the conservative approach of describing a 'potential' impact at an individual site as one where an effect (displacement or collision at 98% avoidance rate) was estimated to be greater than 0.01% even when it was deemed not significant in the Appropriate Assessment. A 'negligible' impact is one which does not exceed 0.01% at any individual site or where cumulative effects are <0.05%. 'No effect' is used where effects were predicted to be zero.

Sites and species where effects are predicted to be greatest are likely to be those where monitoring will be focused.

Gannet

High priority species in terms of collision risk.

Advice from the SCNBs submitted to Marine Scotland highlighted that maintaining breeding populations of the qualifying species as a viable component of the designated conservation site was the key conservation objective.

Potential collision and displacement impacts on the population of gannets at the key SPAs arising from the Forth and Tay offshore wind projects are summarised in Table 1 below, based on information presented in Marine Scotland Appropriate Assessment.

Table 1 Potential impacts on key SPAs from collision and / or displacement

SPA	Neart na Gaoithe	Inch Cape	Seagreen Alpha	Seagreen Bravo
Forth Islands SPA (breeding)	Potential impact on SPA population due to collision effect Negligible impact predicted from displacement effects	Potential impact on SPA population due to collision effect Negligible impact predicted from displacement effects	Potential impact on SPA population due to collision effect Negligible impact predicted from displacement effects	Potential impact on SPA population due to collision effect Negligible impact predicted from displacement effects

Kittiwake

High priority species in terms of collision risk and displacement. Marine Scotland Appropriate Assessment also considered barrier effects for Neart na Gaoithe and Inch Cape projects for Forth Islands SPA.

Potential collision and displacement impacts on the breeding population of kittiwakes at the key SPAs arising from the Forth and Tay offshore wind projects are summarised in Table 2 below, based on information presented in Marine Scotland Appropriate Assessment. A precautionary approach means that any potential effects greater than zero are included.

Table 2 Potential impacts on key SPAs from collision and or displacement

SPA	Neart na Gaoithe	Inch Cape	Seagreen Alpha	Seagreen Bravo
Forth Islands SPA (breeding)	Potential impact on SPA population due to collision and displacement/ barrier effects	Potential impact on SPA population due to collision and displacement/ barrier effects	Potential impact on SPA population due to collision and displacement effects	Potential impact on SPA population due to collision and displacement effects
Fowlsheugh SPA (breeding)	No displacement or collision effects predicted	No displacement effect predicted Potential impact on SPA population due to collision effects	Potential impact on SPA population due to collision and displacement effects	Potential impact on SPA population due to collision and displacement effects
St Abb's Head to Fast Castle SPA (breeding)	Potential impact on SPA population due to collision and displacement effects	No displacement effect predicted Potential impact on SPA population due to collision effects	No displacement effect predicted Potential impact on SPA population due to collision effects	Potential impact on SPA population due to collision and displacement effects
Buchan Ness to Collieston Coast SPA (breeding)	No displacement or collision effects predicted	No displacement effect predicted Potential impact on SPA population due to collision effects	No displacement effect predicted Potential impact on SPA population due to collision effects	No displacement effect predicted Potential impact on SPA population due to collision effects

Razorbill

High priority species in terms of displacement only. Razorbills are not considered to be at risk of collision due to their low flight heights. No razorbills were recorded at collision risk height during any of the Forth and Tay boat surveys carried out by the developers.

Potential displacement impacts on the breeding population of razorbills at the key SPAs arising from the Forth and Tay offshore wind projects are summarised in Table 3 below, based on information presented in Marine Scotland Appropriate Assessment.

Table 3 Potential impacts on key SPAs from displacement

SPA	Neart na Gaoithe	Inch Cape	Seagreen Alpha	Seagreen Bravo
Forth Islands SPA (breeding)	Potential cumulative impact from Forth & Tay projects on SPA population due to displacement effects			
Fowlsheugh SPA (breeding)	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted
St Abb's Head to Fast Castle SPA (breeding)	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted

Puffin

High priority species in terms of displacement. Puffins are not considered to be at risk of collision due to their low flight heights.

Potential displacement impacts on the breeding population of puffins at the key SPAs arising from the Forth and Tay offshore wind projects are summarised in Table 4 below, based on information presented in Marine Scotland Appropriate Assessment.

Table 4 Potential impacts on key SPAs from displacement

SPA	Neart na Gaoithe	Inch Cape	Seagreen Alpha	Seagreen Bravo
Forth Islands SPA (breeding)	Potential impact on SPA population due to displacement/ barrier effects	Potential impact on SPA population due to displacement/ barrier effects	Potential impact on SPA population due to displacement/ barrier effects	Potential impact on SPA population due to displacement/ barrier effects

Guillemot

Lower priority species for displacement only. Guillemots are not considered to be at risk of collision due to their low flight heights. No guillemots were recorded at collision risk height during any of the Forth and Tay boat surveys carried out by the developers.

Potential displacement impacts on the breeding population of guillemots at the key SPAs arising from the Forth and Tay offshore wind projects are summarised in Table 5 below, based on information presented in Marine Scotland Appropriate Assessment.

Table 5   Potential impacts on key SPAs from displacement

SPA	Neart na Gaoithe	Inch Cape	Seagreen Alpha	Seagreen Bravo
Forth Islands SPA (breeding)	Potential impact on SPA population due to displacement effects	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted
Fowlsheugh SPA (breeding)	No displacement impacts predicted	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted
St Abb's Head to Fast Castle SPA (breeding)	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted
Buchan Ness to Collieston Coast SPA (breeding)	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted	No displacement effects predicted

3. Potential Monitoring and Research Questions

The initial discussion document circulated by Marine Scotland prior to the first FTRAG-O meeting in June 2015 highlighted several detailed questions regarding collision/avoidance, flight height, displacement, barrier and population impacts. Some of these questions have been discussed at least in part at the FTRAG-O meetings to date, however, it has been highlighted that in order to progress discussions further, a list of key questions needs to be agreed. Methods to address these key questions can then be considered. The original list of questions is included in Appendix A, together with the corresponding Key Question addressing this question.

Before setting out these questions, it is first important to consider the extent to which the monitoring programme should focus solely on the breeding populations or seek to address these questions for both breeding and non-breeding populations. Given that the key predicted impacts from the Appropriate Assessment are all concerned with breeding populations, it is considered that this should be reflected by the monitoring programme, such that determining the effects on breeding individuals and impacts on breeding populations are the clear priority. Such a focus will increase the chances of producing answers to the key questions that arise from the Appropriate Assessment by ensuring that maximum resources are devoted to addressing those issues, as opposed to diluting effort across a broader range of issues (which increases the risks of failing to address any issues adequately – e.g. by reducing survey sampling intensity). Thus, it is proposed that the questions to be addressed by the developers will be focussed on the breeding populations. As indicated previously (see Section 1.1), it is acknowledged that the effects and impacts on populations breeding outwith the SPAs considered by the Appropriate Assessment and on non-breeding populations require consideration. However, for the reasons outlined above, together with the larger scale at which impacts on non-breeding populations may need to be addressed, it is proposed that these should be regarded as issues to be considered by SPORRAN.

Following from discussions around the MS paper, the following text provides a summary of key questions which monitoring and future research could seek to address. Some questions may be appropriate for developers to address in post-construction monitoring, whereas others may be more appropriate to be addressed through strategic research projects.

Collision, Avoidance and Flight Height

It was noted at the September FTRAG-O meeting in relation to **gannet** and **kittiwake**, that if the total number of collisions could be measured, together with the number of birds passing through the wind farm, then a collision rate could be determined. It was suggested that this would be very challenging and that if monitoring collision rate is considered to be unfeasible, it may be more appropriate to consider avoidance behaviour instead.

Whilst initial MS questions focused on a comparison of avoidance rates with the BTO Avoidance rate report, these could be simplified to:

1. *Does collision occur and are there empirical methods to record seabird collisions at offshore wind farms?*
2. *What are the collision rates?*

   or

3. *What are the micro, meso and macro avoidance rates?*

Previous questions regarding flight height can be simplified to:

4. *Do flight height distributions differ inside and outside the wind farm?*
5. *Do flight height distributions differ significantly in different weather conditions?*
6. *Do flight height distributions change over time as birds habituate to the presence of WTGs?*

Displacement and Barrier

Key questions in relation to displacement of **kittiwake, puffin, razorbill** and **guillemot** are as follows:

7. *Can a significant change in densities of KI, PU, RA and GU in the wind farms be identified?*
8. *Can a significant change in densities of KI, PU, RA and GU be attributed to the wind farms?*
9. *Is there a significant difference in foraging activity inside and outside the wind farms, and can this be associated with the presence of the wind farms ? [N.B. this may be very challenging to measure and methodologies able to tease apart wind farm from other drivers remain uncertain]*
10. *Do densities of KI, PU, RA and GU inside the wind farm change with time from construction (i.e. due to habituation)?*
11. *Is there evidence of connectivity between breeding birds from specific colonies and the wind farm footprints*

Questions on barrier effects have been simplified to:

12. *What percentage of birds avoid the wind farm boundary?*

Other initial MS questions considered differences between displacement rates and barrier effects at wind farms with different turbine spacings and at different distances from colonies. If the key questions of whether displacement/barrier occurs can be answered, then it may be possible for subsequent strategic projects to consider differences between projects such as:

13. *Are the densities of KI, PU, RA and GU different between wind farms with different turbine densities?*

Population impacts

The MS paper included questions considering the potential for population-level impacts due to any identified collision, displacement and barrier effects. These included questions regarding adult survival, productivity and population numbers.

Identifying changes in adult productivity and population numbers may be possible through existing government SPA monitoring, which could cover all of the key species. Linking changes to wind farm effects will be difficult, so may require the study of control sites that do not have connectivity with the wind farms. Monitoring of adult survival would require long term monitoring using Capture-Mark-Recapture modelling of marked birds, however, since the Isle of May colony already includes large numbers of marked birds this may be possible for this colony. Any such studies would have to be able to disentangle WF effects from other, potentially larger scale, environmental effects on seabird demography. A potentially useful method may be to examine differences in demographics along a distance gradient from the wind farms.

14. *Does adult productivity and survival of species experiencing displacement/barrier effects vary between colonies with differing levels of connectivity to the wind farms?*
15. *Does adult survival of species experiencing collision mortality vary between colonies with differing levels of connectivity to the wind farms?*
16. *Do the population trends of species experiencing possible impacts vary between colonies with differing levels of connectivity to the windfarm?*

At the January 2016 FTRAG-O meeting, it was suggested that the above questions were too complex to allow suitable methods to be brought forward to address them. These questions were subsequently reworded as follows:

14. *What is the rate of adult productivity for each of the relevant key species at the key SPAs for those species?*
15. *What is the rate of adult survival for each of the key species at the key SPAs for those species?*
16. *Where it is possible to compare between SPAs, are there differences in the rates of adult productivity and survival for the key species at these SPAs?*

It is recognised that, in many ways, determining the population-level impacts is ultimately the most critical issue to be addressed. However, it is also recognised that linking changes in the demographics of seabird colony populations to wind farm mediated effects with a reasonable degree of confidence is highly challenging and could prove intractable, even with substantial resource investment. Given that there is likely to be a need to also identify and monitor colonies that are unaffected by wind farms for comparison with 'affected' colonies or to monitor colonies across a wind farm 'connectivity gradient', it is likely that the required monitoring would have to be undertaken at a multi-regional (or perhaps national) scale. Substantial tracking work may also be required to complement the monitoring of colony demographics. Attempting to undertake work of this type on the basis of an inadequate study-design is likely to lead to substantial wasted resource investment (due to the very low power to detect impacts), and potentially give rise to a high risk of detecting spurious wind farm impacts.

Therefore, whilst the importance of these issues is recognised, it is suggested that the scale over which such work would be required means that it goes beyond the direct remit of the Forth and Tay developers, and would be more appropriately considered at a SPORRAN level. If following such consideration an appropriate and feasible study-design emerges, the Forth and Tay developers would be prepared to engage in discussions on how such work could be facilitated and funded, and on the role that they could play in that process.

Other factors

One aspect that has yet to be discussed is the distribution and abundance of prey species e.g. sandeels, and how this may be affected by the wind farms. In addition, consideration is required on how the current CEH displacement model would be affected by the use of real prey distribution data, as the prey parameters used in the displacement model are all currently based on bird distribution.

Another aspect for consideration concerns the demographic & energetics parameters used to model population impacts and if they are appropriate for the Firth of Forth? Could CEH identify factors that can relatively easily be verified?

17. *How will the distribution and abundance of prey species e.g. sandeels, be affected by the wind farms?*
18. *How will this in turn affect seabird distribution and foraging in the area?*
19. *How would the CEH displacement model be affected by the use of real prey distribution data?*
20. *Is there any relevant prey distribution data for the area? Is the work done by Simon Greenstreet in a useable format?*
21. *Are the demographic & energetics parameters used to model population impacts appropriate for the Firth of Forth?*
22. *Could CEH identify factors that can relatively easily be verified?*

We have indicated in the summary table below which of the questions we consider to be most appropriate for the developers to address, and which we consider to be of a more strategic nature that should be addressed by SPORRAN. This is on the basis of identifying the highest priorities amongst those questions that relate to direct wind farm effects and are considered to be practical for the developers to address.

Table 1. FTRAG-O Discussion Document Summary Table

Collision

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
1. Does collision occur and are there empirical methods to record seabird collisions at offshore wind farms?	Developer	Gannet	Forth Islands (Bass Rock)	Turbine mounted cameras Turbine mounted sensors/ microphones Record bird behaviour from a static platform	Turbine mounted cameras Other technologies to be reviewed
		Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
2. What are the collision rates?	Developer/ Strategic	Gannet	Forth Islands (Bass Rock)	Record bird behaviour from a static platform Turbine mounted cameras Turbine mounted sensors/ microphones Radar	Turbine mounted cameras
		Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
3. What are the micro, meso and macro avoidance rates?	Developer	Gannet	Forth Islands (Bass Rock)	Record bird behaviour from a static platform Turbine mounted cameras Digital Aerial surveys Radar Tagging studies (Indirectly)	Input required from ORJIP studies
		Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
4. Do flight height distributions differ inside and outside the wind farm?	Developer	Gannet	Forth Islands (Bass Rock)	Radar Tagging studies Boat-based surveys Digital aerial surveys	Survey based techniques (digital aerial/boat-based surveys)
		Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
5. Do flight height distributions change significantly in different weather conditions?	Strategic	Gannet	Forth Islands (Bass Rock)	Turbine mounted cameras Tagging studies Boat-based surveys Digital aerial surveys LiDAR	Tagging studies
		Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
	Developer	Gannet	Forth Islands (Bass Rock)	Radar	

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
6. Do flight height distributions change over time as birds habituate to the presence of WTGs?		Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Tagging studies Boat-based surveys Digital aerial surveys	Survey based techniques (digital aerial/boat-based surveys)

Displacement

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
7. Is there a significant difference in densities of birds inside and outside the wind farm	Developer	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Digital aerial surveys Boat-based surveys	Survey based techniques (digital aerial/boat-based surveys)
8. Can a significant change in species densities be attributed to the wind farms?	Developer	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Digital aerial surveys Boat-based surveys Tagging studies	Survey based techniques (digital aerial/boat-based surveys)
9. Is there a significant difference in foraging activity inside and outside the wind farm, and can this be associated with the presence of the WF?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Tagging studies Record bird behaviour from a static platform Boat-based surveys	Tagging studies

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
10. Do densities inside the wind farm change with time from construction (i.e. due to habituation)?	Developer	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Digital aerial surveys Boat-based surveys Tagging studies	Survey based techniques (digital aerial/boat-based surveys)
11. Is there evidence of connectivity between breeding birds from specific colonies and the wind farm footprints	Developer	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Tagging studies	Tagging studies

Barrier effect

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
12. What percentage of birds avoid the wind farm boundary?	Developer	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Boat-based surveys Digital aerial surveys Tagging studies Radar	Tagging studies or radar

Secondary questions

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
13. Are the densities of birds different between wind farms with different turbine densities?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Boat-based surveys Digital aerial surveys Tagging studies META-ANALYSIS	Survey based techniques (digital aerial/boat-based surveys)

Population impacts

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
14. What is the rate of productivity for each of the relevant key species at the key SPAs for those species?	Developer	Kittiwake	Forth Islands, Fowlsheugh, St Abb's Head To Fast Castle	Colony monitoring plots	Colony monitoring plots
		Puffin, Razorbill	Forth Islands	Colony monitoring plots	Colony monitoring plots
15. What is the rate of adult survival for each of the key species at the key SPAs for those species?	Developer	Kittiwake	Forth Islands, Fowlsheugh, St Abb's Head To Fast Castle	Colony monitoring plots Colour-ringing programme (mark-recapture)	
		Puffin, Razorbill	Forth Islands	Colony monitoring plots Colour-ringing programme (mark-recapture)	

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
		Gannet	Forth Islands	Colour-ringing programme (mark-recapture)	
16. Where it is possible to compare between SPAs, are there differences in the rates of adult productivity and survival for the key species at these SPAs?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle	Compare rates of adult productivity & survival for the key species from the different SPAs	

Other factors

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
17. How will the distribution and abundance of prey species e.g. sandeels, be affected by the wind farms?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
18. How will this in turn affect seabird distribution and foraging in the area?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		

Question	Developer or Strategic?	Species	Relevant SPAs	Potential methods	Preferred Method (tbc)
19. How would the CEH displacement model be affected by the use of real prey distribution data?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
20. Is there any relevant prey distribution data for the area? Is the work done by Simon Greenstreet in a useable format?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
21. Are the demographic & energetics parameters used to model population impacts appropriate for the Firth of Forth?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		
22. Could CEH identify factors that can relatively easily be verified?	Strategic	Gannet, Puffin Razorbill, Guillemot Kittiwake	Forth Islands Fowlsheugh St Abb's Head To Fast Castle		

4. Discussion of monitoring methods

Boat/Digital aerial surveys

Both boat and/or digital aerial surveys could be used to undertake monitoring surveys of seabirds in and around the Forth and Tay OWF projects.

European Seabirds At Sea (ESAS) boat-based surveys have been widely used to record the offshore distribution and abundance of seabirds since 1980. ESAS boat-based surveys have been used in the majority of post-construction monitoring projects in the UK and at other European projects e.g. Blighbank and Thorntonbank OWFs in Belgium (Vanerman *et al.* 2013).

ESAS Survey methods are very repeatable, therefore any post-construction data collected at Forth and Tay OWF sites would be directly comparable with existing years of boat-based pre-construction survey data, assuming similar collection methods were used.

An added advantage of using boat-based surveys is that it potentially allows for simultaneous deployment of a towed hydrophone array recording underwater harbour porpoise presence or absence.

Boat-based surveys also have the advantage of being connected to the sea and therefore offer opportunities to collect additional environmental variables (e.g. sea surface temperature, chlorophyll-a concentrations, water depth, and presence/absence of key prey species (i.e. fish finders).

The ability to record accurate flight heights using any method (boat-based observers, laser rangefinders, digital aerial calculations, altimeter tags, GPS tags) remains a point of much debate. A suitable method for post-construction monitoring may need to wait until the ability of different methods to accurately estimate flight heights is resolved. Evidence of the accuracy of flight height data recorded by digital aerial survey techniques from system operators would be very useful. It would also be useful to know if the accuracy of flight height data collected in the Moray Firth has been examined.

Digital aerial surveys are able to survey larger areas over shorter periods of time so may be better suited to large scale surveys than boat-based surveys. In addition, digital data images are collected/stored and therefore can be re-examined later, if required, allowing the source material to be audited.

There may still be issues determining identification of similar species e.g. guillemot/razorbill with digital aerial surveys although this aspect of the technology has apparently been improved. Further evidence of this from system operators would be useful.

Digital aerial surveys also have to correct for availability bias (birds being underwater when the area of sea they are using is sampled) of diving birds (e.g. guillemot, razorbill, puffin) due to the very high speeds of aeroplanes compared with typical dive times for these species. It has been estimated that availability bias is not sufficiently high to require a correction for boat-based survey data as dive times are short in relation to vessel speed. A further problem may exist with availability bias correction for aerial survey data; the bias correction is applied evenly across the survey area despite knowledge that diving behaviour will not be homogenous across the survey area. Therefore, the bias correction will reduce the difference in abundance between areas of sea that are more heavily used and those areas less heavily used. Since the main purpose of the surveys is to determine whether the abundance of birds within the wind farm is reduced in comparison to areas outside the wind farm, the application of availability bias correction will reduce the statistical power to detect an effect. It is currently unknown whether this will result in an important loss of statistical power, though this can be modelled using simulated data.

The possibility of focussing survey effort on the periods of key interest, as determined by the work in the Appropriate Assessment and the fact that the relevant SPAs are for breeding populations has been raised. This would involve concentrating effort in the breeding, and potentially, post-breeding season months. The statistical implications of any changes in survey effort on any subsequent post-construction analyses in relation to the baseline survey effort would need to be analysed using a statistical power analysis.

There are operating limitations in relation to weather conditions for both boat-based and digital aerial survey methods, as outlined in e.g. Camphuysen et al (2004).

In a recent teleconference on 1st December 2015, MSS, SNH and JNCC agreed that developers would need to provide appropriate justification if they are considering the use of boat-based surveys rather than digital aerial for post-consent monitoring (MSS, SNH & JNCC, 2015). It is not clear from the circulated teleconference notes why digital aerial appears to be the preferred survey method, and on what basis this has been decided.

The teleconference also concluded that digital aerial survey should be used as the primary data collection method to investigate whether there a significant difference in densities of birds inside and outside the wind farms. There was no further explanation in the circulated teleconference notes as to why digital aerial studies were considered to be "of more use" than boat-based studies for this question (Question 7 in Table 1).

Discussion points:

- *Do boat & digital aerial surveys typically show changes in distribution rather than actual displacement?*
- *Could boat or digital aerial surveys be used to demonstrate displacement without additional studies using e.g. tagging?*
- *If using boat/aerial, would targeted survey effort using boats or digital aerial techniques be a better approach compared to regular monthly monitoring?*
- *As the key period is the breeding season, would it be more useful to conduct more detailed surveys over this period, with less/no survey effort in winter months? Would this result in any issues for a DISTANCE-type analysis?*
- *Is there any evidence that aerial surveys are better suited than boat-based surveys to detect changes in seabird densities?*

Potential differences between boat-based and digital aerial surveys

There are advantages and disadvantages to each survey platform and these would need to be carefully considered against each monitoring question to determine which approach provides the most suitable trade off.

Should a decision be made to use aerial surveys, consideration would need to be given to the implications this would have for any expectations that the baseline (boat-based) surveys could still be used to provide (or contribute) to pre-construction comparisons.

This is not to say that it make the baseline survey data redundant, but only that this issue would need to be carefully considered and discussed.

Colony counts

The last national seabird colony census (excluding gannet) was conducted as part of Seabird 2000 between 1998 and 2002 (Mitchell *et al.,* 2004). Data from this census and more recent counts for some colonies are available from the JNCC Seabird Monitoring Programme online database (SMP 2015).

Gannet colonies around Britain and Ireland are currently undertaken every ten years e.g. Wanless et al., (2005). Aerial photographs are taken of each colony and the number of "apparently occupied sites" are then counted.

The count of breeding gannets for the Bass Rock utilised in the AA was conducted in 2009 (Murray, 2011). However, a subsequent count was conducted in 2014 (Murray et al., 2014).

The next national UK seabird census is in the early stages of planning, with the aim of having up to date population estimates of the UK's breeding seabirds by 2019 (RSPB 2015). Regular updates on the progress of planning and timing of this national census from JNCC would be useful.

Of the four SPAs considered here, the major guillemot, razorbill and kittiwake colonies in the Forth Islands SPA are counted most years, with recent data for 2014 available on the SMP database. The most recent counts of these species for Fowlsheugh SPA on the SMP database are from 2012. More recent data from Fowlsheugh, together with

Although the kittiwake colony at St Abb's Head NNR is counted annually (most recent online data 2014), the remainder of this SPA was last covered during Seabird 2000. For guillemot and razorbill, the most recent counts at St Abb's Head NNR on the SMP database are from 2013. For Buchan Ness to Collieston Coast SPA, the most recent counts of these three species on the SMP database are from 2007 (SMP 2015).

The last national puffin colony census was conducted as part of Seabird 2000 between 1998 and 2002 (Mitchell *et al.,* 2004). The most recent count of breeding puffins on the Isle of May was in 2013, while counts of puffin colonies on Craigleith, Fidra, Inchmickery and The Lamb in the Firth of Forth are available on the SMP database for 2014 (SMP 2015).

Discussion points:

- *Is the next national UK seabird census likely to be conducted by 2019?*
- *Are current levels of monitoring at the main seabird breeding colonies likely to continue for the foreseeable future?*

GPS Data loggers and Satellite Tags

GPS data loggers are ideal for obtaining data on individual seabirds during the breeding season, as they provide very detailed information over a short period (c. 2 days) on flight paths and location). The equipment is relatively inexpensive, although remote-downloading GPS tags are more costly. Overall, there is a high chance of obtaining useful tracking data.

There are a few disadvantages to their use, such as generally tagged birds need to be re-captured to retrieve data from GPS data loggers, although it is possible to retrieve data via a mast located within a breeding colony. In addition, tags may fall off or stop working. Overall, existing datasets are generally quite small and currently restricted to two or three seasons. There is likely to be considerable variation between breeding seasons as a result of differences in prey availability. The small sample size may limit the robustness of any statistical analysis on the data, particularly if the species is prone to device effects, as has been recorded with puffins.

Combined Satellite/GPS tags and geolocators are suitable for longer-term studies such as investigating where seabirds travel to in the non-breeding season. Generally, tags record less detailed information, typically a location every few days over a long period e.g. several months/years. Tag batteries are solar powered so can recharge and transmit data to satellites at regular intervals. Such tagging equipment is relatively inexpensive and there is a high chance of obtaining good tracking data. There are similar disadvantages to using satellite tags as there are for GPS data loggers.

Tags can also be fitted that record altitude and acceleration (although accuracy may be an issue).

Such tags are suitable for several species e.g. kittiwake, gannet, guillemot and razorbill, gulls and terns, although there have been some issues with tagging puffins, due to tag size. Smaller tags for puffins are now available, and may prove more suitable (F. Daunt pers. comm.). Tag technology is constantly improving and this should be taken into account for any further tagging studies.

A brief summary of tagging studies for the key species considered here is presented below.

Gannet

Between 1998 and 2003, satellite telemetry was used to examine the foraging ranges, feeding locations and travel speeds of 53 chick-rearing gannets from the Bass Rock (Hamer *et al.*, 2007). In addition, GPS loggers were fitted to 13 chick-rearing gannets from the Bass Rock in July and August 2003 to record location, temperature and pressure. This data was used to analyse foraging tracks, as well as timing, dive duration and maximum dive depth (Hamer *et al.,* 2009).

Between 2010 and 2012, gannets at Bempton Cliffs on the north-east coast of England were fitted with satellite tags to investigate their foraging ranges during chick-rearing and early post-breeding periods (Langston et al., 2013). Overall, sample sizes were small, with 14 birds tagged in 2010, 13 birds in 2011 and 15 birds in 2012. Similar research on Bass Rock over the same period using GPS loggers and time-depth recorders concluded that there were sex-specific differences in foraging habitat, range and behaviour of gannets in the Forth region (Cleasby et al., 2015a).

More recent tagging studies on the Bass Rock have used altimeter tags on gannets, combining data from GPS tracks of gannets collected between 2010 and 2012, with data from bird-borne pressure loggers in 2011 and 2012 to estimate the foraging ranges and densities of birds at sea, their flight heights during different activities, and spatial variation in flight height and potential collision risk during foraging trips (Cleasby et al., 2015b). There have been questions raised as to the accuracy of the flight height estimates calculated from pressure logger data. Further papers based on data from pressure loggers in 2015 on Bass Rock & Ailsa Craig are due to be published soon.

Current research by the University of Leeds during the 2013-2015 breeding seasons on the Bass Rock is investigating gannet flight in 3D, looking at where birds are going and flight height during foraging trips (Lane, 2015). In addition, a GPS tagging study on gannets on the Channel Islands was also conducted in 2015.

Kittiwake

CEH conducted GPS tracking for FTOWDG[2] on breeding adult kittiwakes from the Isle of May in June 2010, (36 birds, 91 foraging trips) (Daunt *et al.,* 2011a). Similar tracking studies were repeated in May and June 2011 at Fowlsheugh (35 birds, 93 trips) and St Abb's Head (25 birds, 70 trips) (Daunt *et al.,* 2011b). Data were split into non-flight (foraging and resting), relevant to displacement effects, and flight, relevant to collision risk.

Mean maximum foraging range from the Isle of May colony was 42 km, with a maximum foraging range of 150 km recorded (Daunt *et al.,* 2011a). Foraging trips from Fowlsheugh were concentrated in a north-easterly to south-easterly direction, with a mean maximum foraging range of 35 km, and a maximum foraging range of 141 km recorded (excluding one outlier of 415 km). Foraging range from St Abb's Head was similar (mean maximum range of 32 km; maximum 108 km), but overall distribution was more focussed, in a south-easterly direction (Daunt *et al.,* 2011b).

Additional GPS tracking was conducted by CEH and RSPB (FAME) in 2012 from the Isle of May, St. Abb's, Buchan Ness and Fowlsheugh. Results were used to parameterise the CEH displacement model (Searle et al., 2014) except for data from Buchan Ness where tracked birds foraged predominantly to the north of the wind farms.

Guillemot

CEH conducted GPS tracking for FTOWDG on breeding adult guillemots from the Isle of May in June 2010, (33 birds, 112 foraging trips) (Daunt *et al.,* 2011a). The study found that guillemots showed a strong affinity to coastal as well as offshore regions. Birds departed from and returned to the Isle of May primarily on a bearing between north and east, and favoured depths of 40-50 m over depths of 60-70 m. Mean maximum foraging range from the Isle of May colony was 18 km, with a maximum foraging range of 61 km recorded (Daunt *et al.,* 2011a).

Fieldwork involving observations of trip durations and flight directions of guillemots from Fowlsheugh and St Abb's Head was conducted in summer 2011, however this study did not involve tagging of guillemots (Daunt *et al.,*2011b).

Additional GPS tracking plus the use of time-depth recorders was conducted by RSPB at Buchan Ness and Fowlsheugh in 2012. Results were used to parameterise the CEH displacement model (Searle et al., 2014).

Razorbill

CEH conducted GPS tracking for FTOWDG on breeding adult razorbills from the Isle of May in June 2010, (18 birds, 111 foraging trips) (Daunt *et al.,* 2011a). The study found that razorbills showed a strong affinity to coastal regions as well as offshore sand banks, with birds using the Firth of Forth and St Andrews Bay. Mean maximum foraging range from the Isle of May colony was 14 km, with a maximum foraging range of 69 km recorded (Daunt *et al.,* 2011a).

Additional GPS tracking was conducted by CEH at the Isle of May in 2012. Results were used to parameterise the CEH displacement model (Searle et al., 2014).

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[2] Forth and Tay Offshore Wind Developers Group

Puffin

GPS tracking was conducted by CEH for 7 puffins on the Isle of May in 2012. Results were used to parameterise the CEH displacement model (Searle et al., 2014, Harris et al., 2012). However, concerns about the small sample size and device effects causing individuals to undertake longer trips than usual meant that this data was not relied upon in MS Appropriate Assessment. Smaller tags for puffins are now available, and may prove more suitable for use at colonies during the breeding season (F. Daunt pers. comm.).

Other recent geolocator tagging studies have focussed on puffin dispersal at the end of the breeding season. A study on puffins breeding on Skomer found that adult puffins disperse widely during the non-breeding period, showing great variability in travel distances and directions (Guilford et al. 2011). A similar study on post-breeding puffins from the Isle of May showed that birds used the north-western North Sea most intensively, but that most puffins also made trips into the eastern Atlantic in the early winter (Harris et al. 2010).

Geolocator tags attached to puffins breeding on the Skelligs in Kerry, Ireland in August 2010 showed that all tracked birds travelled rapidly west into the North Atlantic at the end of the breeding season, with the majority undertaking transatlantic trips from Ireland to the Newfoundland-Labrador shelf. By October, all birds had moved back to the mid-Atlantic where they remained resident until returning to the breeding colony (Jessop *et al.,* 2013).

The use of GPS dataloggers and satellite and GPS tags to record where breeding seabirds are feeding in relation to the Forth and Tay OWF projects is likely to be continued, following on from pre-construction tagging studies undertaken by CEH (e.g. Daunt *et al* 2011a & 2011b). It would be useful to commence future tagging studies in the breeding season prior to construction activities commencing, with tagging studies also being conducted in the post-construction phase of the project, to increase the tagging datasets for baseline and post-construction studies.

It would be most cost-effective to consider running long-term post-construction studies (i.e. over two or three years) covering all consented OWF developments in the Forth/Tay area and possibly beyond e.g. including Moray Firth or other R3 developments, particularly to address movements of seabirds in the non-breeding season, although this issue may be more suitable to be addressed under SPORRAN.

More local studies in the breeding season, targeting breeding seabirds from the key SPAs should also be carried out over a similar time period initially, with review prior to any further work.

Francis Daunt (CEH) provided an overview outlining how post-construction tagging studies could be best applied to the monitoring questions being discussed for the Forth & Tay projects. This overview was circulated around the FTRAG-O group prior to the November 2015 meeting, with comments on the overview to be submitted within 2 weeks of that meeting.
Discussion points:

- *How best could a tagging study be combined with other survey methods (digital aerial or boat-based surveys) to address key monitoring questions for Forth & Tay projects?*

- *Would it be beneficial to ask Francis Daunt (CEH) e.g. to give a short presentation of his tagging overview at a FTRAG-O meeting followed by a Q/A session & discussion?*

Recording bird behaviour from a static platform

Another monitoring option under consideration is to document & record observed bird behaviour in relation to the presence of turbines from a stationary vessel or platform. This could be used to record e.g. behaviour in relation to collision, changes in flight height or flight direction, as well as presence/absence of birds within the wind farm area. Such monitoring would inform on the levels of displacement of species such as guillemots, razorbills, kittiwakes and gannets, as well as recording any visual behavioural changes such as reducing flight height within the wind farm, or changing direction before reaching the turbines.

There are some limitations with this method however, as it is not suitable in poor visibility (fog/low cloud) or at night, and typically observations can only cover a few turbines from one survey platform (vessel) at a time.

SNH highlighted the avoidance behaviour of breeding seabirds around turbines, flight height distributions of seabirds at wind farm sites and the displacement of kittiwake, puffin and other auks from wind farm sites as aspects requiring monitoring that should be included in any consent award (Marine Scotland 2014).

Visual observations have been carried out for seabirds and migrating passerines e.g. FINO platform in Germany (Hüppop *et al.* 2006). Visual observations of gannet flight behaviour were made at OWEZ wind farm in the Netherlands (Leopold *et al.* 2011).

This approach is currently being investigated as part of the Carbon Trust's Offshore Renewables Joint Industry Programme (ORJIP), which commenced at Thanet OWF in July 2014. To date only preliminary results have been collated and these are not yet publicly available.

Discussion points:

- *Would applying aspects of the ORJIP approach at a wind farm in the Forth & Tay area provide useful to comparative data from two different locations?*

Passive Integrated Transponder (PIT) tags

PIT tags are long-life, relatively low-cost and do not require a power source. PIT tags are similar to the traditional bird ring, as they do not have power or memory and simply give an identification number when they are read out (Fiedler 2009).

It is possible to use radar systems to track the PIT tags, and such systems can be "relatively cheap". Once located by the radar, individual PIT tags can be tracked. The range of the radar may therefore be a limiting factor. There may be possibilities of using military radar e.g. Leuchars or weather radar systems. In addition, PIT tags that are externally attached to the target species may be lost, while implanted PIT tags may affect fitness of tagged individual. There are no current examples of PIT tags being used with radar available.

One example where PIT tags have successfully been used is in a colony of common terns in Germany, where individual bird behaviour and the physiological condition of birds carrying PIT tags have been followed over many years. An individual's presence in the colony can be recognised by an automated recording system and their body weight can be taken when they roost on one of the poles that are connected to electronic balances (Becker & Wendeln 1997).

Discussion points:

- *Is there any more information available on the use of PIT tags for monitoring the distribution of seabirds? Could PIT tags be used to provide useful information for post-construction monitoring?*

Digital Cameras on turbines

Turbine mounted digital cameras have been used to monitor bird avoidance behaviour at individual turbines. Bird flights are tracked in 3 dimensions so height-based avoidance can be detected, and the majority of species can be identified. Using near-infrared technology allows birds to be detected at night as well as in daylight. Cameras can run on batteries when a turbine power source is not available, and data can be transmitted back to shore.

The main disadvantage with these systems is the cost, although this may reduce as the technology becomes more tested and more widely applied.

To date, one camera has been fitted to a turbine at Sheringham Shoal OWF (Mellor & Hawkins 2013), while near-infrared cameras are currently being tested at onshore wind farms in the USA (HiDef 2014). HD cameras are also being used as part of the current ORJIP study at Thanet.

Discussion points:

- *Is there any more information available on the use of turbine-mounted digital cameras for monitoring bird collisions?*
- *Need for power analyses to determine how many cameras would be required?*
- *What are the ballpark costs of such studies? Worth asking HiDef for an overview?*

Radar studies

Radar systems have been used to demonstrate flight paths through or around wind farms allowing levels of macro-avoidance, displacement or barrier effects to be determined. Radar studies are typically run during e.g. peak migration season. However, such systems require a stable platform for mounting, with power source, which may be a limiting factor in an offshore context. The radar systems typically record large amounts of data therefore there may be high processing costs associated with such studies, due to the time required. Identification of species can also be limited, and may require concurrent visual observations to determine the species involved.

Radar studies have been used at Horns Rev OWF (e.g. Christensen & Hounisen 2005), at Nysted OWF (e.g. Kahlert *et al.*, 2004) in Denmark and more recently at Egmond aan Zee (Krijgsveld et al., 2011). In addition radar are being utilised in the ORJIP CRM Project.

Discussion points:

- *Is the inclusion of radar as part of post-construction monitoring studies for the Forth & Tay OWF projects a practical option?*
- *What are the ballpark costs of such studies?*
- *Any more information?*

Visual tracking

Visual tracking using a rigid-hulled inflatable boat with observer, driver and data-recorder has been adopted by JNCC as a method of tracking tern species to determine foraging range. It may be possible to apply such a technique to other species, such as kittiwake.

Visual tracking has been used at an OWF to show differences in tern foraging distribution pre-, during and post-construction (Perrow et al., 2015), as well as by JNCC for their inshore SPA programme. Birds can be followed at a distance of up to 200m, although 50-100m is preferred, without apparent effects on the behaviour of most individuals. Continuous GPS recording allows the bird's track-line to be plotted.

Discussion points:

- *Is it practical to apply this method to gull species such as kittiwake to examine displacement of individual birds from the offshore wind farms?*
- *Would the resulting sample size be too small to be of any benefit?*
- *What is the range (km) to which birds can be followed?*
- *What are the costs of such a study? Would it be worthwhile asking JNCC for an overview?*

Turbine-mounted collision sensors and microphones

Turbine-mounted sensors and or microphones have been used in the direct detection of collision events at individual turbines. WT-Bird, a system for detecting and registering bird collisions at wind turbines, was developed at the Energy research Centre of the Netherlands (ECN) during the early 2000s (Wiggelinkhuizen et al, 2007). This system uses a combination of accelerometers and microphones to detect collision incidents, and infrared (active infrared) video cameras to record video footage of the event.

The sensors are located within the rotors and turbine towers, and detect potential collisions. The signal is analysed by software to filter out background and operating noise. The software can be adjusted to account for use on different types of turbines and under various weather conditions, such as rain. Two infrared (active infrared) cameras are mounted along with illumination on the lower part of the turbine tower and capture images of the area swept by the rotors.

Advantages of this system are that collisions can be recorded both day and night, with species identification possible during daylight possible.

ID Stat is a system designed to detect bird and bat collisions with wind turbines that has been developed and trialled onshore in France (Delprat 2011). Directional microphones are placed within the hub of the turbines at the base of each rotor; these are positioned to detect sounds within the rotors. The microphones and accompanying software detect potential collisions and filter out background noise and noise from rain. Once a potential collision is registered, information such as date, time, turbine and sensor ID are stored using data loggers and a message can be sent to the user via the GSM (mobile phone) network.

Trials of collision sensors mounted on offshore turbines have apparently been conducted at the Dutch Offshore Wind farm Egmond aan Zee (OWEZ), although no results appear to have been made available online.

Field tests onshore have been performed with satisfactory results. Image quality is currently insufficient to enable species identification during darkness. Suitability for offshore wind turbines is currently unknown, although tests are currently in progress.

Initial field tests for collision detection using microphones within turbines were promising, however there is no visual verification of collision events with cameras, therefore this system would be of limited use offshore.

Discussion points:

- *Any results from WT-Bird system available from OWEZ?*
- *What are the costs of fitting & running such systems? Would it be worthwhile asking ECN for further information on WT-Bird system?*

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Appendix A Initial questions and where they are covered in Key Questions

Question	Where covered
Is the macro-avoidance rate different to the rate estimated in the BTO review?	These five questions are covered by Q 1-3
Is the meso-avoidance rate different to the rate estimated in the BTO review?	
Is the micro-avoidance rate different to the rate estimated in the BTO review?	
Is the within windfarm avoidance rate the same as that estimated by the BTO Avoidance Rate report	
Is the total avoidance rate the same as that estimated by the BTO Avoidance Rate report	
Are macro avoidance rates different for wind farms with different turbine densities?	Covered by Q3 – if avoidance rates can be determined at different wind farms then the results can be compared.
Do flight height distributions differ significantly from those produced by Johnston *et al.* 2014?	Covered by Q4 & Q5
Do flight height distributions differ significantly between weather conditions, distance from shore, season, sex?	Covered by Q4-6
Do flight height distributions differ inside and outside the wind farm?	Covered by Q5
Does the influence of wind farms on flight height distributions extend beyond the wind farm boundaries?	Covered by Q4 & Q5
Do the flight height distributions differ between pre and post wind farm construction?	Covered by Q4 & Q5
Do flight height distributions change over time as birds habituate to the presence of WTGs?	Covered by Q7
Does the **GANNE and KITTI** population change pre, during and post construction?	Covered by Q18
Does adult survival or productivity change in **GANNE** or **KITTI**?	Covered by Q16 - 18
Can a significant change in density of **KITTI**, **PUFFI, RAZOR,** or GUILL in the wind farms be identified?	Covered by Q8
Can a significant change in density of **KITTI**, **PUFFI, RAZOR,** or GUILL be attributed to the WF?	Covered by Q9
Can a significant relationship between density and distance from WTG be identified?	Covered by Supplementary Q16
Is there a significant apparent difference in foraging behaviour inside/ outside the WF?	Covered by Q10
Does **KITTI**, **PUFFI, RAZOR,** or GUILL density change significantly with increasing WTG spacing/ density?	Covered by Supplementary Q15
Do **KITTI**, **PUFFI, RAZOR,** or GUILL densities vary significantly between seasons within the WFs more than outwith the WFs?	Covered by Q8 & Q9
Do the densities of **KITTI**, **PUFFI, RAZOR,** or GUILL within the WFs increase significantly over time e.g. due to habituation?	Covered by Q11
What proportions of **GANNE**, **KITTI**, **PUFFI, RAZOR,** or GUILL are deterred from passing through the WF?	Covered by Q13 & Q14

Question	Where covered
Do 60% of **GANNE**, **PUFFI, RAZOR,** or GUILL and 40% **KITTI** traverse around the wind farm rather than pass through it?	Covered by Q13 & Q14
Do barrier effects on species X occur out to 1km from wind farm boundary?	Covered by Q13 & Q14
Is there a significant difference in macro-avoidance rates due to turbine density	Covered by Q3 – if avoidance rates can be determined at different wind farms then the results can be compared.
Do barrier effect rates vary significantly between seasons, weather conditions, sex or age class?	Covered by Q13 & Q14
Do barrier effect rates change significantly over time e.g. due to habituation?	Covered by Q13 & Q14
Do foraging distances and trip durations increase significantly as a result of displacement/ barrier effects from the wind farm/s (or as estimated by the CEH displacement model)?	Covered by Q10
Attributing effects to population impacts/ Identifying mechanisms driving any changes in adult or adult productivity in **KITTI**, **PUFFI, RAZOR,** or GUILL.	Covered by Q17 - 19
Does adult survival decline due to displacement/ barrier effects by same amount predicted (or less) by CEH model)?	Covered by Q17 - 19
Do individuals differ in their equivalent time / energy budgets depending on whether or not they are displaced from the wind farms?	Not specifically covered, as considering effects at a population level.
Population level impacts of WF on **KITTI**, **PUFFI, RAZOR,** or GUILL.	Covered by Q17 - 19
Does the population size of the colonies with connectivity significantly change between pre and post construction?	Covered by Q17 - 19
Can evidence be found to determine that population changes were not driven by WF effects?	Population changes are covered by Q19. Main approach for other questions is to try and demonstrate WF effects.
Does species X at SPA Y encounter any other OWF during the non-breeding season?	Not covered in discussion document, as considering breeding season impacts only.