

Project Title	Seagreen Wind Energy Ltd
Document Reference Number	LF000009--CST-OF-REP-0016

Seagreen Ornithology Monitoring Strategy

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Rev	Date	Reason for Issue	Originator	Checker	Approver
01	17/06/19	Approved for use	[Redacted]		Lis Royle <small>Digitally signed by Lis Royle Date: 2019.06.19 16:28:20 +01'00'</small>

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1. Introduction

Seagreen Wind Energy Ltd (Seagreen) is progressing the development of the Seagreen Alpha and Seagreen Bravo offshore wind farms (OWFs) off the east coast of Scotland in the outer Firth of Forth and Firth of Tay area (Figure 1). The projects received consent under Section 36 of the Electricity Act 1989 from the Scottish Ministers in 2014 (the Section 36 Consents) (subsequently varied to remove wind farm capacity limits, Aug 2018) and were granted three Marine Licences from the Scottish Ministers in 2014, one for the Seagreen Alpha Generating Station, one for the Seagreen Bravo Generating Station, and one for the Offshore Transmission Works (OfTW). The project consents were confirmed in November 2017 following a legal challenge. The Onshore Transmission Asset (the onshore export cable and onshore substation) was granted Planning Permission in principle by Angus Council in 2013 (subsequently extended in 2016).

The Seagreen Alpha and Seagreen Bravo OWFs will together comprise up to 150 wind turbine generators (WTGs) with associated foundations, inter-array cables, Offshore Substation Platforms (OSPs) and meteorological masts. The OfTW cable corridor makes landfall at Carnoustie, in Angus (Figure 1).

This Ornithology Monitoring Strategy (OMS) focuses on the pre-construction survey proposals for 2019 and 2020, although potential during and post construction monitoring is highlighted. Seagreen plans to participate in the Contracts for Difference (CfD) auction later this year, and any during and post construction monitoring will therefore depend on the outcome of the auction.

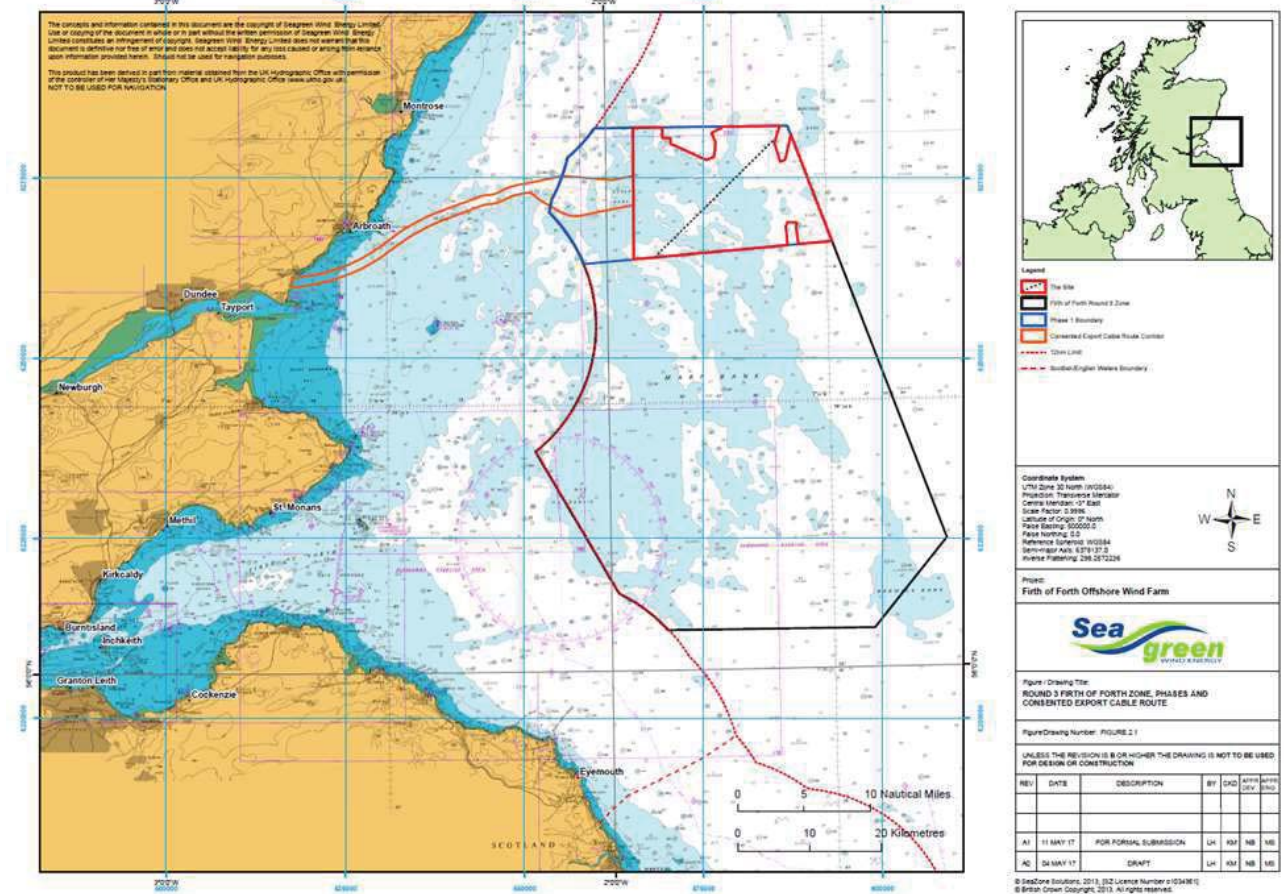


Figure 1.: Firth of Forth Zone, Seagreen Alpha and Seagreen Bravo OWFs and the OfTW.

1.1 Document Purpose

This document outlines Seagreen's proposals for the Ornithology Monitoring Strategy (OMS) for the Seagreen Alpha and Bravo Offshore Wind Farms (OWFs). The monitoring proposals have been designed to meet the requirements of Conditions of the Seagreen Alpha and Seagreen Bravo OWFs Section 36 consents (see Section 3 of this document). As well as reference to these Conditions, account has been taken of:

- the ornithological sensitivities identified in the 2012 Seagreen Alpha and Seagreen Bravo OWF Environmental Statements (ES) (Seagreen, 2012) and the 2013 Habitat Regulations Assessments (HRA) Report; and
- the Forth and Tay Regional Advisory Group Ornithology Sub-Group (FTRAG-O) agreed objectives for bird monitoring for the Firth of Forth and Tay offshore wind farms (FTRAG-O 2016);

Implementation of the OMS beyond March 2020 is subject to Seagreen being successful in this years' CfD auction.

1.2 Consultation

This document, outlining Seagreen's initial proposals for the OMS has been prepared in advance of formal technical consultation between Seagreen, Marine Scotland (MS), Scottish Natural Heritage (SNH), Royal Society for the Protection of Birds (RSPB) and FTRAG-O.

Informal initial discussions have also been held since January 2019 with the other Forth and Tay developers, with a view to developing a shared approach to pre-construction surveys over the April 2019 to March 2020 monitoring period. An outcome of these discussions has been a joint note (dated 28th February 2019) to combine aerial surveys over all three sites, to provide a consistent data collection and sampling. The responses from SNH, MS and RSPB following circulation of the 28th February briefing note were supportive of the coordination attempts (SNH 14th March, MS 13th March and RSPB 6th March, respectively). The Forth and Tay developers have therefore continued to liaise over monitoring, to ensure, as far as is practical, that aerial survey coverage is coordinated. This has led to progress towards coordinated aerial survey coverage, giving the continuous survey area shown in Figure 2.

The OMS will be finalised following further feedback from MS, SNH, RSPB and FTRAG-O.

2. Ornithology Baseline Summary and Key Sensitivities

The following sections provide a brief overview of the ornithology baseline conditions at Seagreen Alpha and Seagreen Bravo OWFs, as outlined in the ES (Seagreen, 2012).

2.1 Seagreen Alpha and Seagreen Bravo OWFs ES (Seagreen, 2012) and 2013 HRA Report

The Ornithology chapter of the 2012 Environmental Statement (ES) for Seagreen Alpha and Seagreen Bravo assessed the potential for impacts on seabirds, particularly those with breeding colonies within foraging ranges known at the time, but also including migratory species.

No significant impacts were predicted on any species from construction activities or decommissioning of either Project Alpha, Project Bravo, or Project Alpha and Project Bravo together. A Vessel Management Plan

was however proposed, to minimise disturbance to seabirds during this project phase, the production and implementation of which is a consent condition (Condition 15).

The key potential impacts identified during the assessment were the potential effects of operation, specifically collision risk, displacement and barrier effects. Collision risk was identified as potentially affecting gannet, kittiwake and herring gull.

The displacement of foraging birds from feeding areas at a scale that could potentially lead to a population level effect was identified as a concern for kittiwake, guillemot, razorbill and puffin. Displacement from foraging areas could lead to reduced feeding opportunities for adults and reduced chick-provisioning rates, which could in turn affect adult and chick survival respectively.

The potential for the Seagreen OWF to pose a barrier to birds transiting across the Seagreen site was identified for gannet, kittiwake, guillemot, razorbill and puffin. Puffin were considered to have particular sensitivity to barrier effects. Barrier effects could oblige birds to undertake extra flight activity, leading to increased energy budgets and reduced time for foraging, potentially affecting adult and chick-survival.

The Habitat Regulations Appraisal for Phase 1 conclude that there would be no adverse effects on any SPA, either alone or in combination with other plans and projects (Seagreen 2013, para. 5.23).

2.2 FTRAG-O Agreed Monitoring Priorities

Following the granting of Consents by the Scottish Ministers under Section 36 of the Electricity Act 1989 to construct and operate four offshore wind farms in the outer Forth and Tay, the Forth and Tay Regional Advisory Group (FTRAG) has been set up to meet the requirements of the Section 36 and associated Marine Licence conditions for the Forth and Tay developments. As part of FTRAG, an ornithology subgroup (FTRAG-O) was established to discuss and agree appropriate bird monitoring for the Firth of Forth and Tay OWFs.

Following a series of meetings, FTRAG-O agreed the key species of concern, the relevant SPAs and the potential impacts to be the main focus for future monitoring programmes (FTRAG-O 2016). The value of this FTRAG-O output is that it gives clearer guidance on the monitoring objectives appropriate to each Forth and Tay OWF, in order for the bird monitoring Conditions to be met. The relative importance of each SPA for each OWF was agreed between stakeholders, as were the potential effects that would need to be monitored (collision, displacement, barrier effects and resulting population effects). The distinction was also drawn about the effects it was appropriate to monitor within the Forth and Tay area, and those more appropriately monitored through some form of integrated national-scale monitoring programme. The key species, SPAs and potential impacts that require monitoring by Seagreen are summarised in Table 1. Of the five species listed, guillemot was considered lower priority in FTRAG-O discussions.

Table 1 Summary of key species, SPAs and potential impacts requiring monitoring for Seagreen

Species	Priority	SPA	Potential impact
Gannet	High	Forth Islands SPA	Collision
Kittiwake	High	Forth Islands SPA	Collision and Displacement effects
		Fowlsheugh SPA	Collision and Displacement effects
		St Abb's Head to Fast Castle	Collision (Alpha), Collision and Displacement effects (Bravo)
		Buchan Ness to Collieston Coast	Collision effects
Razorbill	High	Forth Islands SPA	Potential cumulative impact from Forth & Tay projects on SPA population due to displacement effects

Puffin	High	Forth Islands SPA	Displacement/barrier effects
Guillemot	Low	Forth Islands SPA	No potential effects

FTRAG-O also considered the key questions relating to potential impacts to be addressed by future monitoring programmes and the most appropriate methods to use (FTRAG-O 2016). The full list of the key questions agreed by the FTRAG-O group is included in Appendix A. As some of the issues identified are most appropriately dealt with at a national scale, reference was made to establishing a National Strategic Bird Monitoring Framework (“NSBMF”) to take forward this strategic monitoring (participation in such a national forum had also been referred to in the Consent Conditions for Seagreen Project Alpha and Seagreen Project Bravo – see Section 3). As confirmed by Tom Evans (Marine Ornithologist, Renewables and Energy Programme, Marine Scotland Science), in his email of 6th March 2019, NSBMF is equivalent to, and has been superseded by, the Scottish Marine Energy Research (ScotMER) Programme.

The combination of key sensitivities outlined in 2.2 and consultation feedback summarised in 1.2 have therefore helped in formulating Seagreen’s proposed pre-construction OMS (presented in Section 4).

3. Conditions of the 2014 Section 36 consent

The formulation of Seagreen’s monitoring proposals have been in response to the 2014 Section 36 Consent conditions relevant to seabird monitoring (given in Table 3). The Conditions (and Condition numbers) are the same for both the Alpha and Bravo consents.

Table 3 Relevant Section 36 Consent Conditions

Condition	Details
S36 Consent condition 26	<p>The Company must, no later than 6 months prior to the Commencement of the Development, submit a Project Environmental Monitoring Programme (“PEMP”), in writing, to the Scottish Ministers for their written approval. Such approval may only be granted following consultation by the Scottish Ministers with the JNCC, SNH, RSPB Scotland, WDC, ASFB and any other ecological advisors or organisations as required at the discretion of the Scottish Ministers. The PEMP must be in accordance with the Application as it relates to environmental monitoring.</p> <p>The PEMP must set out measures by which the Company must monitor the environmental impacts of the Development. Monitoring is required throughout the lifespan of the Development where this is deemed necessary by the Scottish Ministers. Lifespan in this context includes pre-construction, construction, operational and decommissioning phases.</p> <p>Monitoring must be done in such a way so as to ensure that the data which is collected allows useful and valid comparisons between different phases of the Development. Monitoring may also serve the purpose of verifying key predictions in the Application. In the event that further potential adverse environmental effects are identified, for which no predictions were made in the Application, the Scottish Ministers may require the Company to undertake additional monitoring.</p> <p>The Scottish Ministers may agree that monitoring may be reduced or ceased before the end of the lifespan of the Development.</p>

	<p>The PEMP must cover, but not be limited to the following matters:</p> <p>a. Pre-construction, construction (if considered appropriate by the Scottish Ministers) and post-construction monitoring surveys for:</p> <ol style="list-style-type: none"> 1. Birds; 2. Sandeels; 3. Marine fish; 4. Diadromous fish; 5. Benthic communities; and 6. Seabed scour and local sediment deposition. <p>b. The participation by the Company in surveys to be carried out in relation to marine mammals as set out in the Marine Mammal Monitoring Programme (“MMMP”); and</p> <p>c. The participation by the Company in a National Strategic Bird Monitoring Framework (“NSBMF”) and surveys to be carried out in relation to regional and / or strategic bird monitoring including but not necessarily limited to:</p> <ol style="list-style-type: none"> 1. the avoidance behaviour of breeding seabirds around turbines; 2. flight height distributions of seabirds at wind farm sites; 3. displacement of kittiwake, puffin and other auks from wind farm sites; and 4. effects on survival and productivity at relevant breeding colonies <p>All initial methodologies for the above monitoring must be approved, in writing, by the Scottish Ministers and, where appropriate, in consultation with the Forth and Tay Regional Advisory Group (“FTRAG”) referred to in condition 27 of this consent. Any pre-consent surveys carried out by the Company to address any of the above species may be used in part to discharge this condition subject to the written approval by the Scottish Ministers.</p> <p>The PEMP is a live document and must be regularly reviewed by the Scottish Ministers, at timescales to be determined by the Scottish Ministers, in consultation with the FTRAG to identify the appropriateness of on-going monitoring. Following such reviews, the Scottish Ministers may, in consultation with the FTRAG, require the Company to amend the PEMP and submit such an amended PEMP, in writing, to the Scottish Ministers, for their written approval. Such approval may only be granted following consultation with FTRAG and any other ecological, or such other advisors as may be required at the discretion of the Scottish Ministers. The PEMP, as amended from time to time, must be fully implemented by the Company at all times.</p> <p>The Company must submit written reports and associated raw data of such monitoring surveys to the Scottish Ministers at timescales to be determined by the Scottish Ministers in consultation with the FTRAG. Subject to any legal restrictions regarding the treatment of the information, the results are to be made publicly available by the Scottish Ministers, or by such other party appointed at their discretion.</p> <p><i>Reason: To ensure that appropriate and effective monitoring of the impacts of the Development is undertaken.</i></p>
<p>S36 Consent condition 27</p>	<p>The Company must participate in any Forth and Tay Regional Advisory Group (“FTRAG”) established by the Scottish Ministers for the purpose of advising the Scottish Ministers on research, monitoring and mitigation programmes for, but not limited to, ornithology, diadromous fish, marine mammals and commercial fish. Should a Scottish Strategic Marine Environment Group (“SSMEG”) be established (refer to condition 28), the responsibilities and obligations being delivered by the FTRAG will be subsumed by the SSMEG at a timescale to be determined by the Scottish Ministers.</p> <p><i>Reason: To ensure effective environmental monitoring and mitigation is undertaken at a regional scale.</i></p>
<p>S36</p>	<p>The Company must participate in any Scottish Strategic Marine Environment Group (“SSMEG”) established by the Scottish Ministers for the purposes of advising the Scottish Ministers on research,</p>

<p>Consent condition 28</p>	<p>monitoring and mitigation programmes for, but not limited to, ornithology, diadromous fish, marine mammals and commercial fish.</p> <p><i>Reason: To ensure effective environmental monitoring and mitigation is undertaken at a National scale.</i></p>
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4. Seagreen Proposed Ornithology Monitoring Strategy

The aim of this document is to outline the methods to monitor impacts on seabirds from Seagreen Alpha and Seagreen Bravo OWFs, in the context of previously identified key bird sensitivities, HRA requirements, the conditions highlighted above, and the agreed monitoring approaches already formulated through FTRAG-O and encapsulated in FTRAG-O (2016).

The OMS document at this stage focuses on the pre-construction survey proposals for 2019 and 2020. The monitoring methods for the operational phase of the OWF (notably collision) will be the subject of further future consultation with MS, SNH, RSPB and FTRAG-O.

4.1 Methods to monitor displacement and barrier effects

Having taken account of the Seagreen Alpha and Seagreen Bravo ES findings, the 2013 HRA Report, and the Conditions of consent, FTRAG-O identified displacement of kittiwake, razorbill and puffin as the key potential effect to monitor (Table 1). This was to determine whether predictions on displacement and barrier effects from the OWFs were accurate. Theoretically, displacement and/or barrier effects could lead to reduced breeding success or adult survival, and therefore generate population-level effects on SPA populations with connectivity to Seagreen Project Alpha and/or Seagreen Project Bravo. Solely monitoring breeding success or adult survival at SPA colonies in isolation would not determine whether displacement or barrier effects from OWFs were the cause of any changes identified (given that other variables, notably prey availability, and weather could influence these outcomes). In order to meet Condition 26 therefore, this section outlines the monitoring methods to be employed at Seagreen to address the following questions on displacement impacts, as agreed at FTRAG-O meetings:

- Can a significant change in densities of kittiwake, razorbill and puffin in the wind farms be identified?
- Can a significant change in densities of these species be attributed to the wind farms?
- Is there a significant difference in foraging activity by these species inside and outside the wind farms, and can this be associated with the presence of the wind farms?
- Do densities of kittiwake, razorbill and puffin inside the wind farm change with time from construction (i.e. due to habituation)?
- Is there evidence of connectivity between breeding birds from specific colonies and the wind farm footprints?

In formulating pre-construction monitoring proposals, the barrier effects identified at FTRAG-O meetings as a key predicted impact to be addressed by monitoring have also been considered. The following question regarding barrier effects was agreed through FTRAG-O meetings:

- What percentage of birds avoid the wind farm boundary?

Digital aerial surveys (March 2019 to March 2020 Inclusive)

To help monitor displacement and barrier effects, Seagreen will undertake digital aerial surveys of the site plus an agreed buffer between March 2019 and March 2020 inclusive (and with Inch Cape running aerial surveys from April 2019, there will be monthly coverage of all the Forth and Tay sites from April 2019 to March 2020 inclusive). The March and April surveys were undertaken independently for each site, but from the May survey (completed on May 21st) to August inclusive, the survey will cover all sites in one go, flown in one day. Monthly aerial surveys are also being flown for Seagreen Phase 2 and Phase 3 areas, which will provide additional data coverage of the area immediately adjoining Phase 1 to the south.

These aerial surveys encompass the entire breeding season (including pre-breeding and post-breeding dispersal), and so covers the period highlighted during FTRAG-O discussions as the key stages regarding potential impacts at SPAs in the vicinity. The purpose is to obtain baseline data against which to test for significant displacement and barrier effects once the OWFs are operational.

Whilst it has been agreed that the aerial survey will run, in the first instance, for 12 months, a further breeding season may be considered, based on the results of the 2019 surveys.

As noted above, the Forth and Tay developers (Near na Gaoithe (NNG), Inch Cape (IC) and Seagreen) are undertaking a combined approach to pre-construction ornithology aerial surveys (Joint Note 28th February 2019). NNG began aerial ornithology surveys in June 2018 to collect pre-construction data, so the existing survey area for the NNG development (plus buffer) has been extended to include the Inch Cape and Seagreen Alpha and Seagreen Bravo development areas, together with buffers (Figure 2). Surveys to date have consisted of transects spaced 2km over the NNG site and a 12km buffer. Transect widths are 250m wide, based on a twin camera system collecting 125m each. Two additional cameras have also been collecting data for future analysis if required. NNG's survey methodology has been designed based on power analysis undertaken at Beatrice Offshore Wind Farm and Moray East Offshore Wind Farm suggesting a 12.5% coverage of the site should provide sufficient power.

The broad extent of the combined aerial surveys is shown in Figure 2. The sites were flown independently initially. Up to August, daylight length is sufficient to cover the combined aerial survey area in one day using 2km transects and 2 planes, so from May to August inclusive the combined survey area will be flown in one day. The aerial survey contractor (HiDef) is currently investigating whether using 3 planes over the winter months will enable this combined area to also be covered within one day, despite the shorter daylight length.

The 12km buffers currently being used for NNG and Seagreen Alpha and Seagreen Bravo, and the 4km buffer for Inch Cape, give a total survey area of 3,204km² at present. This would provide a significant amount of contextual data. The final survey extent will be confirmed with FTRAG-O consultees.

Monitoring during construction may be considered based on the construction programme, if required, for a key period (notably chick rearing, over May to July). Over the longer-term perspective for aerial survey monitoring however, it is not proposed to carry these out throughout the construction phase. Evidence from existing wind farms suggests that construction activities may result in temporary localised disturbance around construction activities for some species. Therefore, this would not provide a useful baseline against which to compare distributions. Furthermore, the sensitivities identified through the EIA and HRA processes, and the questions identified by FTRAG-O were on potential effects during the wind farm's operational phase.

Prior to the wind farm becoming operational, Seagreen will discuss the approach to monitoring with MS, SNH, RSPB and FTRAG-O, in light of evidence on displacement and barrier effects available at the time.

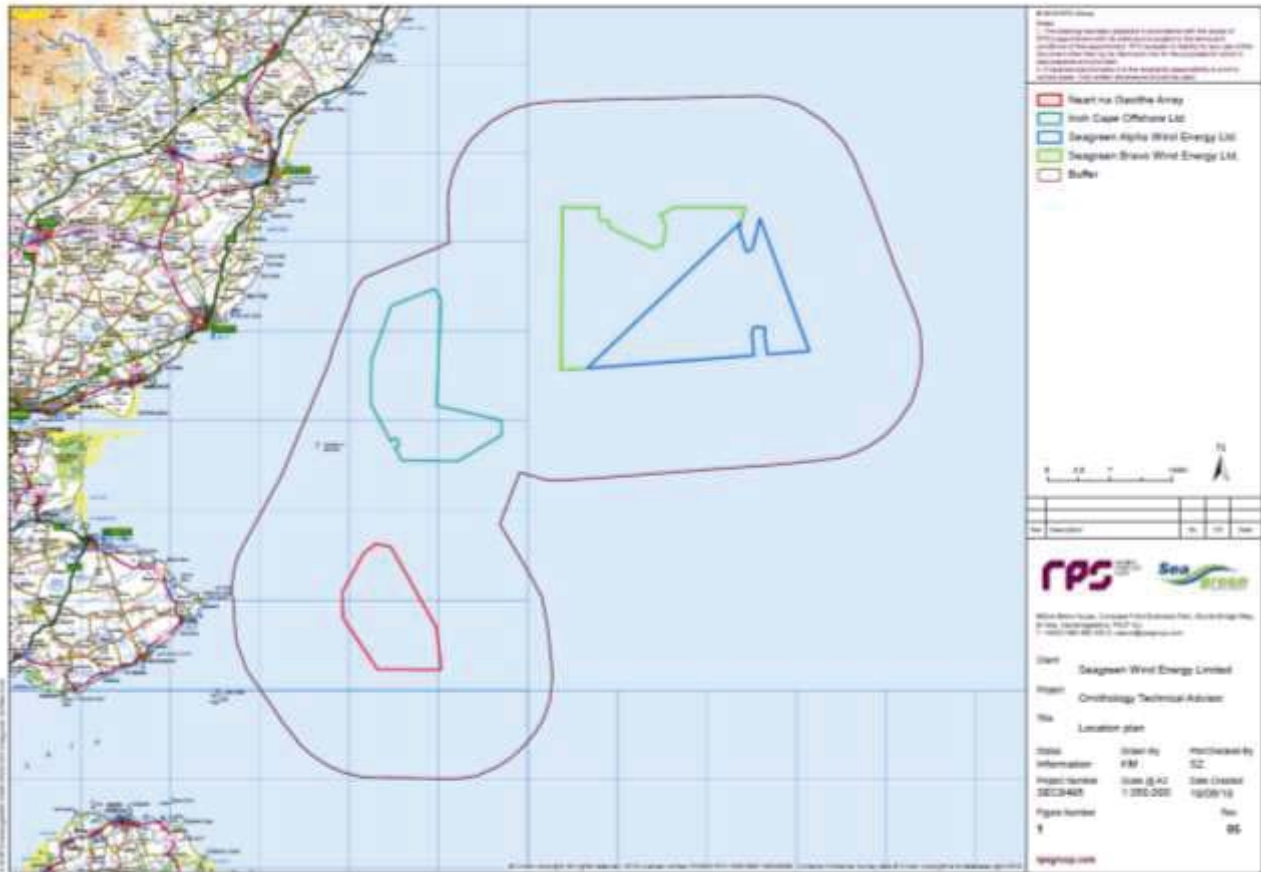


Figure 2: Proposed Forth and Tay developers combined aerial survey area.

Post-construction digital aerial survey data will be directly comparable with the pre-construction digital aerial survey data, and therefore it will be possible to directly compare densities of key species within the development area and in the surrounding area for the pre- and post-construction periods.

It is currently envisaged that post-construction surveys will be conducted for two years once the wind farm is operational, over the March to October period (inclusive), covering the breeding season and post-breeding dispersal. The requirement for further studies beyond this period will be considered in consultation with FTRAG-O, following analysis of the second year of post-construction survey data. This will include a power analysis to consider the benefit of undertaking further surveys.

Monitoring Population Nesting, Nesting and Productivity at Key Breeding Colonies

Subject to land owner access approval, and in liaison with MS, SNH, RSPB and FTRAG-O, it is proposed that Seagreen will support colony-based monitoring for the OMS, at Fowlsheugh and St. Abb’s Head SPAs in 2020.

The purpose is to provide baseline data for key species to inform any population effects from the Forth and Tay wind farms caused by displacement and/or barrier effects, as well as collision.

Work at the colony level provides the opportunity to record population, nesting and productivity information for a significant sample size of kittiwake, razorbill, herring gull and puffin, and would involve field observation by a surveyor on site monitoring breeding activity over the breeding season. Key demographic parameters will be monitored, notably nesting, hatching, provisioning, and fledging. This is to support the investigation of adult survival and productivity rates, to help identify population changes to the Forth and Tay SPAs. This monitoring is proposed at both SPAs, for 2020.

In the event of a positive CfD outcome, Seagreen would finalise arrangements with RSPB to appoint a Research Assistant ahead of the 2020 breeding season, to undertake the work at Fowlsheugh (funded by SSE). Potentially as part of the Research Assistant's remit, or through some other means, this would include support to enable RSPB to collate and synthesise the many years of pre-existing long-term seabird datasets from Fowlsheugh so that the resulting time series can be used as a baseline against which to assess changes identified during operational monitoring.

Parallel discussions are also underway with National Trust for Scotland for St. Abb's Head, with a view to providing the same support for colony monitoring and collation and synthesis of pre-existing datasets.

To further facilitate monitoring at Fowlsheugh, and given the RSPB site manager's work in this field already, support would also be provided to RSPB in development of drone applications for seabird counts.

Monitoring Foraging Distribution and Ranges from Key Breeding Colonies

In 2020, it is proposed to support tagging of a small sample of kittiwakes at both of the Forth and Tay SPAs, in collaboration with other tagging initiatives and subject to access and Health and Safety considerations. Seabird tagging studies provide detailed quality data on individual bird foraging behaviour for key periods within the breeding cycle. Results also compliment information derived from digital aerial surveys, providing detailed behavioural insights helpful in interpreting density and distribution patterns recorded by aerial surveys (for the period the two forms of data collection operate concurrently).

As with aerial surveys, tagging is also applicable to monitor bird activity pre-construction and during operational phases, helping to identify responses of individual seabirds to the presence of OFWs. Tracking data also help determine connectivity between birds using the OWF area and SPA colonies in the vicinity.

Given these multiple benefits and the ability of tagging to provide key monitoring data, FTRAG-O highlighted its use to monitor flight activity, displacement, barrier effects and SPA connectivity for kittiwake, and displacement for foraging razorbill and for guillemot.

To build on previous studies, and to ensure duplication was avoided, a review of previous tagging studies was completed for the Forth and Tay area, including liaison with Francis Daunt of the Centre for Hydrology and Ecology (CEH). These tables are provided as an Appendix to this document.

In light of this review, and Seagreen's intention to include tagging as a key part of its OMS, Seagreen propose to include tagging as part of its OMS in 2020 (subject to approval by MS, SNH, RSPB and FTRAG-O).

The technology and approach to tagging in 2020 will be developed in discussion with MS, SNH, RSPB and FTRAG-O in advance of the 2020 breeding season. The outputs from ScotMer's research 'Adapting new non-invasive tags to sea birds' will be considered in identifying options to take forward.

To help prepare for the 2020 colony monitoring and tagging, appropriate locations and protocols will be established ahead of the 2020 breeding season, particularly given the access challenges likely to be involved at Fowlsheugh and St. Abb's.

4.2 Methods to monitor collision and/or avoidance

The Seagreen Alpha and Seagreen Bravo ES findings, Conditions of consent, and FTRAG-O all identified the need to monitor collision impacts for gannet and kittiwake once the OWFs were operational. The following key questions on collision impacts were agreed through FTRAG-O meetings:

- Does collision occur and are there empirical methods to record seabird collisions at offshore wind farms?
- What are the collision rates? Or
- What are the micro, meso and macro avoidance rates?
- Do flight height distributions differ inside and outside the wind farm?
- Do flight height distributions differ significantly in different weather conditions?
- Do flight height distributions change over time as birds habituate to the presence of WTGs?

The issue of collision risk impacts evidently only applies once the site is operational. Prior to the OWF becoming operational therefore, Seagreen will discuss the approach to monitoring with MS, SNH, RSPB and FTRAG-O, in light of macro and micro-avoidance evidence available at the time.

4.3 Methods to monitor population level impacts

In light of SNH, MS and RSPB concerns that the combination of collision, barrier effects and displacement may cause population level effects at SPAs around the Forth and Tay, FTRAG-O identified three requirements for monitoring:-

- What is the rate of adult productivity for each of the key species at SPAs for those species?
- What is the rate of adult survival for each of the key species at SPAs for those species?
- How do these vary across wind farms and SPAs with different levels of connectivity?

Seabird breeding colony and associated tagging studies have the potential to answer these questions and therefore Seagreen is willing to contribute resources to tagging studies in 2020 (on kittiwake, herring gull or guillemot primarily). Seagreen is committed to this process, either through targeted local studies or contributing to national strategic studies in accordance with Condition 26, through the Scottish Marine Energy Research (ScotMER) programme.

ScotMer exists to improve understanding and assess the environmental (and socio-economic) implications of offshore renewable developments. It is an initiative that involves collaboration from industry, environmental NGOs, Statutory Nature Conservation Bodies, and other interested stakeholders, to facilitate

the sustainable development of offshore renewable energy in Scottish waters. This body of research will support sound scientific decision making and management through filling knowledge gaps and using new research to inform future decision making and policy.

There are two parts to the ScotMER programme: the evidence maps that provide a comprehensive framework of gaps in knowledge, and the research programme that is structured around this framework.

Findings from the monitoring carried out through Seagreen’s OMS will help contribute to the wider work monitoring the key seabird populations identified by FTRAG-O.

5. Summary

Table 5 summarises proposed ornithology monitoring for Seagreen, subject to successful CfD outcome.

Table 5 Summary of monitoring proposals for Seagreen

Project Phase	Proposed Survey	Timing and Duration	Data Acquired	Reason
Pre-construction	Digital aerial surveys	1 year (March 2019 to March 2020) prior to construction	Pre-construction seabird distributions, densities, flight directions, flight heights (if feasible), behaviour (where feasible).	Baseline distribution data for comparison with later phases.
	Monitoring at breeding colony, specifically key demographic parameters, including nesting, hatching, provisioning, and fledging of key species to support investigation of adult and survival and chick productivity and survival. Tagging studies at Fowlsheugh and St. Abbs Head in 2020, subject to H&S requirements.	1 year (April to August 2020)	Data on productivity and foraging distribution of key species at Forth and Tay SPAs.	Baseline productivity and ranging data for comparison with later phases.
	Participation in ScotMER	To be agreed	N/A	To contribute resources and share data for studies that are relevant to

				completion at the regional or national-scale (rather than within the Forth and Tay)
Post-construction	The scope and methods for post-construction monitoring will be considered in liaison with MS, SNH, RSPB and FTRAG-O prior to Seagreen's operational phase. Possible approaches are provided below, although these are subject to further discussion.			
Post-construction	Digital aerial surveys.	2 years (March to October)	Post-construction seabird distributions, densities, flight heights, flight directions.	Comparison with pre-construction data for displacement monitoring.
Post-construction	Method to be confirmed prior to operational phase, depending on available technology.	To be confirmed prior to operational phase, depending on available technology.	Flight activity for evidence of macro, and micro avoidance.	Monitoring avoidance behaviour to inform collision risk.
Post-construction	Monitoring, key demographic parameters at breeding colony.	Minimum 1 breeding season after turbines operational.	Data on productivity and foraging distribution of key species at Forth and TayFowlsheugh SPAs.	Comparison with pre-construction data for population demographics.
	Tagging studies could be considered as part of this: key species to be confirmed in liaison with FTRAG-O.	Minimum 1 breeding season after turbines operational, potentially subsequent seasons depending on data collected.	Tracks between colonies and feeding areas in relation to turbines.	Comparison with pre-construction data Monitoring barrier effect Data could feed into potential displacement and productivity analyses.

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Appendix A

This appendix provides a summary of key questions which have been discussed at the recent series of FTRAG-O meetings.

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

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?
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

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
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

14. What is the rate of adult productivity for each of the 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?

Appendix B

Audit of gannet tagging

Year	Number tagged		Funder	Research group	Tag type	Publications/source	Other information
	Bass Rock	Bempton					
1998-2003	53		Uni	Hamer	Sat-tag	Hamer et al 2007	
2003	13		Uni	Hamer	SatTag/temp /pressure	Hamer et al 2009	
2010		14	RSPB		Sat-tag		
2011		13	RSPB			Langston et al. 2013	
2012		15	RSPB				
2010-2011	?				GPS/ depth	Cleasby et al 2015a	
2011-12	no.?				GPS/alitmeter	Cleasby et al 2015b	
2013-15	no.?				3D sat-tags	Lane, 2015	
2016	?						
2017	?						
2018	?						
all years	66	42					

Audit of kittiwake tagging

Year	Number tagged				Funder	Research group	Tag type	Publications/source	Other information
	Is May	Fowlsh .	StAbbs	Buchan					
2010	36	0	0	0	FTOWD G	CEH	GPS	Daunt et al., 2011a	91 foraging trips
2011	0	35	25	0	FTOWD G	CEH	GPS	Daunt et al., 2011b	93 trips Fowlsh, 70 trips StAbbs
2012	15	15	15	5	FAME	CEH/RSP B	GPS	Searle et al., 2014	
2013	16	0	0	0	FAME	CEH/RSP B	GPS		
2014	11	0	0	0	FAME	CEH/RSP B	GPS		
2015	?	0	0	0					
2016	?	0	0	0					
2017	?	0	0	0					
2018	16	0	0	0	NNG	CEH	GPS remote download		1-2 weeks
all years	94	50	40	5					

Audit guillemot tagging

Year	Number tagged				Funder	Research group	Tag type	Publications/source	Other information
	Is May	Fowlh .	StAbbs	Buchan					
2010	33	0	0	0	FTOWD G	CEH	GPS	Daunt et al., 2011a	112 foraging trips
2011	0	0	0	0					
2012	20	10	1	2	FAME	CEH/RSP B	GPS		
2013	20	0	0	0	FAME	CEH/RSP B	GPS		
2014	8	0	0	0	FAME	CEH/RSP B	GPS		
2015	?	0	0	0					
2016	?	0	0	0					
2017	?	0	0	0					
2018	25	0	0	0	NNG	CEH	GPS remote download		1-2 weeks
all years	106	10	1	2					

Audit razorbill tagging

Year	Number tagged				Funder	Research group	Tag type	Publications/source	Other information
	Is May	Fowlh .	StAbbs	Buchan					
2010	18	0	0	0	FTOWD G	CEH	GPS	Daunt et al., 2011a	111 foraging trips
2011	none	0	0	0					
2012	16	0	0	0	FAME	CEH/RSP B	GPS	Searle et al., 2014	
2013	7	0	0	0	FAME	CEH/RSP B	GPS		
2014	5	0	0	0	FAME	CEH/RSP B	GPS		
2015	?	0	0	0					
2016	?	0	0	0					
2017	?	0	0	0					
2018	15	0	0	0	NNG	CEH	GPS remote download		1-2 weeks
all years	61	0	0	0					

Audit puffin tagging

Year	Number tagged				Funder	Research group	Tag type	Publications/source	Other information
	Is May	Fowlh.	StAbbs	Buchan					
2010	0	0	0	0					
2011	0	0	0	0					
2012	7	0	0	0	?	CEH			showed -ve behav. change
2013	?	0	0	0					
2014	?	0	0	0					
2015	?	0	0	0					
2016	?	0	0	0					
2017	?	0	0	0					
2018	26	0	0	0	NNG	CEH	GPS remote download		showed -ve behav. change
all years	33	0	0	0					