Arklow Bank Wind Park 2

Environmental Impact Assessment Report

Volume III, Appendix 12.19: Offshore Ornithology Technical Report - Migratory Bird Survey Methods (RFI March 2026)

sse Renewables

Arklow Bank Wind Park 2

Migratory Bird Survey Methods

A Desk-based Evidence Review of Migratory Bird Survey Methods

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Acronyms

Term	Definition
ABWP2	Arklow Bank Wind Park 2
AI	Artificial Intelligence
BTO	British Trust for Ornithology
CRH	Collision Risk Height
CRM	Collision Risk Modelling
mCRM	Migratory Collision Risk Modelling
DAS	Digital Aerial Survey
DAU	Development Applications Unit
DCCAE	Department of Communications, Climate Action and Environment
DCEE	Department of Climate, Energy and the Environment
EIAR	Environmental Impact Assessment Report
ESAS	European Seabirds At Sea
LiDAR	Light Detection and Ranging
NIS	Natura Impact Statement
NPWS	National Parks & Wildlife Service
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring
PCH	Potential Collision Height
RFI	Request For Information
VP	Vantage Point
WTG	Wind Turbine Generator

1 Introduction

1.1.1 Following Arklow Bank Wind Park 2's (ABWP2) receipt of a Request for Information (RFI) from An Bord Pleanála (now referred to as An Coimisiún Pleanála), in April 2025, and in response to the observation submitted by the Development Applications Unit (DAU) during the statutory consultation process in August 2024, SSE Renewables requested GoBe Consultants Ltd (GoBe) to provide support on activities related to migratory non-seabird (hereafter referred to as "migratory birds") surveys.

1.1.2 As part of this workstream, a desk-based review of migratory bird survey methods was undertaken to inform this evidence document. The document set out the benefits and limitations of different survey approaches and existing datasets, including a consideration of how these can be effectively used to support the ABWP2 baseline characterisation.

1.1 RFI

1.1.1 The RFI issued by An Coimisiún Pleanála was received in April 2025. The RFI sets out the additional information required to support the application for ABWP2 and emphasises the importance of migratory birds in the area with the request to submit further information to strengthen the assessment regarding such matters.

RFI Reference	Content of request
12f	Migratory Waterbirds: The Environmental Impact Assessment Report (EIAR) and Natura Impact Statement (NIS) make little or no reference to migratory waterbirds in general. The DAU notes that a significant number of migratory waterbirds (in terms of species and absolute numbers) migrate to and from Ireland across the Irish Sea. The south-east region comprises a large number of internationally important wetlands including North Wicklow Coastal Marshes, Cahore, Wexford Harbour and Slobs, Tacumshin, Lady's Island and Ballyteigue which hold birds a large proportion of which, given their breeding ranges, migrate across the Irish Sea. These populations of waterfowl and waders originate from breeding areas largely to the East (continental Europe/Asia), North-East (Scandinavia) and North-West (Iceland). No information has been provided with respect to their migration patterns – including timings, flight altitudes, orientation and primary migration corridors. The DAU observation raises concerns in relation to surveying of migratory waterbird species during key migration times (i.e. spring and autumn). It is stated that coastal vantage point surveys are insufficient and that reliance on published literature does not provide detailed or precise data movements. The DAU has concerns that the proposed development has the potential to have significant impacts upon migratory waterbirds and the Conservation Objectives of the SPAs where they are listed. The DAU states that the applicant should have not only considered but implemented appropriate survey methodologies in order to detect and assess the level of bird migration through the proposed development area, working collaboratively with other Irish Sea ORE applicants. The VP (vantage point) survey results submitted by the applicant have spatial limitations in terms of robustness and have not been used in quantifiable

RFI Reference	Content of request
	assessments. There is also limited information on flux or passage of birds through the proposed array area itself during migration (east-west and north-south). Having reviewed all the information presented, the Board is of the view that impacts to migratory species have been insufficiently assessed. The applicant is requested to address the purported data gap to enable the assessment of potential impacts of the proposed development on migratory birds. Radar (horizontal and vertical surveys) (or similar) at the array area during peak migration periods should be utilised to provide site-specific data, which could be used to support the applicant's current assessment and provide quantitative information on the passage of birds to feed into collision modelling. Should radar not be conducted and an alternative survey methodology utilised, comprehensive justification for the alternative should be provided. Peak migration periods during which data are to be collected can be further informed through review of existing data and published literature relevant to the project area and region. Whilst the DAU makes reference to the key migration times being spring and autumn, the Board considers that migration information during the winter months would also be of assistance to the assessment (e.g. irruptive cold weather movements from the continent and UK). The applicant is invited to consider this aspect for inclusion also. The applicant should note reliance on literature to fill knowledge gaps, while useful, does not provide adequate data to ensure a comprehensive assessment of potential effects on birds.
12j	Terrestrial Bird Species: The DAU consider there to be deficiencies in the assessment of land-based avifauna, with CRM data based on general assumptions and omission of migrant non-seabird species. The DAU recommends additional data and consideration of survey/monitoring options such as: targeted deployment of passive acoustic devices at headlands and offshore nocturnal boat transects; review of available ringing/tracking data for migratory species and/or species which are known/likely to conduct staging/dispersal movements; and use of thermal imaging devices (hand-held/drone) surveys targeted at likely peak periods of passage. The Board requests that further assessment is carried out regarding impacts on terrestrial bird species. The applicant is requested, having regard to the above comments to address the purported data gap and potential impacts of the proposed development on terrestrial birds.

1.2 Scope of Document

1.2.1 This desk-based review has been undertaken to evaluate available survey methodologies and existing datasets relevant to the migratory birds, with the aim of informing and supporting the approach adopted by ABWP2 in response to the RFI. The review considers the benefits and limitations of different methods and identifies how existing data can be used to strengthen the evidence base. It does not constitute a new assessment or feed into the collision risk modelling (CRM), but rather provides justification for the selected survey approach and highlights opportunities to complement existing work.

1.2.2 The key survey methods that are relevant for monitoring migratory birds offshore, including those outlined in the Department of Communications, Climate Action and Environment (DCCAE) (2018) guidance, now known as the Department of the Environment, Climate and Communications (DECC), are considered in this evidence document. They are;

- Coastal Vantage Point (VP) surveys;
- Bioacoustic monitoring;
- Land-based radar survey;
- Offshore boat transects; and
- Thermal imaging cameras,

1.2.3 In addition, a search for existing data sources was conducted to identify relevant information which could be used to support ABWP2 in responding to the RFI.

1.2.4 A search of publicly available documentation was also undertaken, with information on the use of the above-mentioned survey methods extracted and summarised. This review focused on survey aims, methodology, applications and outcomes in the context of the assessment. Relevant sources of information were located through accessing databases of large infrastructure applications, developer websites, peer-reviewed scientific literature and targeted searches for key search terms on online search engines.

1.2.5 This report summarises the information gathered through the desk-based review, outlines the benefits and limitations of the different survey methods and existing datasets, then considers how this information can be used to support ABWP2 in responding to the RFI.

2 Evaluation Criteria

2.1.1 The evaluation criteria outlined below focus on the ability of each of the methods listed in Section 1.21.21.2 to collect key information that could be used to further understand migratory birds of relevance to ABWP2. Any outputs considered under these criteria are not intended for use in the current ABWP2 assessment or in migratory CRM (mCRM). Rather, they provide evidence-based justification for the selected survey approach and identify opportunities to complement existing information, where appropriate. The criteria regarding the suitability of the survey methods are:

- Ability to identify the species;
- Ability to identify the number of birds present;
- Ability to identify the proportion of birds flying at potential collision height (PCH);
- Coverage of development footprint (or scalability of data to development footprint); and
- Practicality of deployment across relevant migration periods (spring and/or autumn).

2.1.2 Other parameters such as flight speed and body size (that are used within standard CRMs) are not required from survey methods at this stage, as they can be derived from peer-reviewed scientific literature and applied, where appropriate. Likewise, flight direction is not considered as essential here, though these data may provide useful context.

2.1.3 In addition to the criteria above, consideration has also been given to each method's ability to collect as complete and usable dataset as possible (i.e. the proportion of birds within the detection range for which the parameters listed above can be reliably obtained). Where autumn-only information is referenced, this reflects the period most likely to capture peak migratory passage for relevant species, in the main due to migrant populations during autumn including both breeding adults and their young. It does not prejudice the assessment nor the broader evidence base, and spring/winter movements can be addressed by existing datasets and literature where appropriate.

3 Review of Survey Methods

3.1 Coastal Vantage Point (VP) surveys

Introduction

3.1.1 Coastal VP surveys are land-based observations undertaken by observers at fixed locations along the coastline, chosen for their clear visibility of the survey area (Moray Firth Offshore Renewables Ltd, 2012). The observers scan a 180˚ field of view, to a maximum of 5 km, for birds for a set number of hours per day, documenting species present, flight height (categorised into height bands), direction, distance and the flight lines (path taken across the area). Binoculars and a scope are used for both detection and identification of birds. This method gathers data suitable for providing contextual data around the potential collision risk of migratory non-seabird species.

Deployment to date

3.1.2 VP surveys can be a key part of the baseline setting process for onshore wind developments, being used to assess the likelihood of collisions of target species such as raptors and geese. This survey technique is also used through migratory periods, designed to capture adequate data across the spring and autumn periods. The VPs are stratified according to the target species ecology and reference to their peak migration movement should be included (NatureScot, 2025). However, they have been used less frequently to collect data on bird migration offshore (for example Moray Firth Offshore Renewables Ltd (2012)), with most pre-application VP data collection from offshore projects focussing on flight behaviour or locally breeding seabirds, e.g. Smartwind 2013, RWE 2024.

Limitations of this method

3.1.3 The limitations of this method include restricted spatial coverage and detection issues due to the defined observation radius and external factors such as visibility and weather conditions. VPs are undertaken during daylight hours, meaning nocturnal migration cannot be monitored using this method. Additionally, because VP surveys are conducted from land, they cannot fully inform on bird migration through offshore areas that are outside of the observers sight range. While they are valuable for providing the regional context, they are less effective for providing data on the specific movement across the development footprint.

3.1.4 Long-term monitoring is limited by the availability and endurance of observers and should, therefore, be seen as a limitation of this approach. However, in comparison with other observer led approaches, such as vessel-based methods, long-term deployment is more viable with less weather, health and safety and logistical concerns (when compared to the offshore surveying) and addresses the collection of critical data parameters as effectively as vessel-based methods.

3.1.5 Both the ability to collect the key parameters and the limitations of coastal VP surveys are summarised in Table 3.1

Table 3.1. Key strengths and limitations of VP surveys for a migratory bird study

Key parameter	Measurable with method?	Scalable to whole site?	Scalable to whole migration period
Number of birds	Yes	Yes	More so than vessel-based surveys
Species identification	Yes	Yes	More so than vessel-based surveys
PCH	Yes – with limitations	Yes, with limitations	More so than vessel-based surveys

Ability to collect key parameters

3.1.7 VP surveys offer a number of benefits, for example a high level of species identification, with complete counts of all detected flying birds and scope for observations to be classified as a proportion at PCH. Additional data, such as flight direction, can be collected which allows assumptions to be made regarding the likelihood of any migratory flights noted to have passed through the ABWP2 array area.

3.1.8 VP surveys benefit from their static nature, which provides continuous observation from a fixed location. It allows for extended monitoring periods without interruption, improving consistency in detecting birds across different times of day and weather conditions. There is also the potential for complementary acoustic detection, where appropriate.

Use of this method in combination with others

3.1.9 In combination with nocturnal bioacoustic monitoring this approach could provide the full suite of critical parameters for both diurnal and nocturnal migration, with relatively long-term deployment covering the span of a full migration period. Weekly VP surveys covering the full migration period would be sufficient to quantify migration at a given site.

3.2 Bioacoustic surveys

Introduction

3.2.1 Bioacoustic surveying involves deployment of a recording device, placed either on land or a platform offshore to capture bird calls over extended periods. This is a non-invasive system, operating autonomously over weeks or months, with recordings later analysed by an ornithologist to identify species and estimate the number of birds detected. These data can inform the species present and, therefore, whether a particular species migrates through a specific area or not during the survey period.

Deployment to date

3.2.2 Bioacoustic monitoring of bird migration (in particular, nocturnal bird migration) is well established, with large scale terrestrial schemes such as the British Trust for Ornithology (BTO) led Polesia Project Collaboration (BTO, 2025a), which comprises a network of over 400 Passive Acoustic Monitoring (PAM) recorders, conducted in Belarus and Ukraine. The use of PAM can provide accurate identification of birds from their calls, as all species have a unique sonogram or spectrogram that can be detected and interpreted (Marquez-Rodriquez et al., 2025). However, it is noted that to date in Ireland and the UK there are no long-term projects deploying PAM offshore specifically to monitor migratory birds (Birdlife, 2024).

Limitations of this method

3.2.3 Bioacoustic monitoring offers strong potential for detecting vocalising species during migration, but does have some inherent limitations within the context of the key parameters defined here. However, while species (or at the very least, species group) identification is achievable for all detections, there are some species that do not habitually vocalise while migrating, meaning PAM provides robust data for those detected, but may underrepresent silent flyers. PAM does not directly measure flight height, though precautionary assumption is applied that assumes detections occur below 300 m. However, the survey data does not confirm whether birds are flying within or below PCH, so their potential contribution to collision risk assessment remains uncertain from the bioacoustics survey data alone.

3.2.4 Therefore, the method collects robust data on those birds detected, however, some birds present may not be detected due to vocalisation behaviours. As such, this method would need to be paired with another monitoring approach that could collect the full suite of key parameters or fill in the gaps identified in order to have data on the complete range of relevant species.

3.2.5 Finally, offshore bioacoustic monitoring is a relatively new application, which has not yet been widely deployed at scale. Practical considerations include equipment servicing, data processing (automation) and specialist expertise to review sonograms for bird identification.

3.2.6 Both the ability to collect the key parameters and the limitations of bioacoustic monitoring are summarised in Table 3.2.

Table 3.2. Key strengths and limitations of bioacoustics monitoring for a migratory bird study

Key parameter	Measurable with method?	Scalable to whole site?	Scalable to whole migration period
Number of birds	Yes	Yes	Yes
Species identification	Yes, for those that vocalise	Yes, for those that vocalise	Yes, for those that vocalise
PCH	Yes	Yes	Yes

Ability to collect key parameters

3.2.7 Bioacoustic monitoring can be used to collect species level data on migratory birds. It is primarily used to monitor nocturnal migrating birds, but can also be deployed to collect diurnal data. Intensity of migration can be inferred from these data, although absolute numbers of migrants cannot be determined, with flock size or passage rates estimated through expert judgement.

3.2.8 PAM offers the ability for long-term deployment covering entire migratory periods and can operate autonomously between servicing intervals. However, deployments require regular battery and memory card replacement, which can involve significant logistical considerations, including vessel access, personal costs, health and safety requirements and reliance on suitable weather windows.

3.2.9 When scaled appropriately, bioacoustic data can estimate the flux of migrating birds across the study area. If this is not feasible, with understanding of the range of the monitoring equipment, monitoring data from a small number of PAM recorders can be treated as a sample that can be scaled to the full extent of a site.

Use of this method in combination with others

3.2.10 Bioacoustic monitoring alone would capture valuable contextual data for nocturnal (and potentially diurnal) migration. However, to aid in species identification of birds that cannot be inferred from sound recordings or are not vocal, as well as flight height and direction, land-based and / or boat-based visual observation surveys could be deployed in tandem. Both methods can be deployed over the long-term, ideally spanning the full migration season, enabling a more rounded data set to be collected.

3.3 Land-based radar

Introduction

3.3.1 Land-based radar monitoring involves deploying a fixed system that emits electromagnetic waves to detect bird movements in flight. The dual-polarisation Doppler radar can distinguish birds from weather-related activity capturing data on flight height and speed (Wing *et al.*, 2023). It is important to note that not all radar systems can capture fight height, this is obtained through the operation of both horizontal and vertical radar units. These systems allow for a continuous wide-scale monitoring of bird movement, which is especially valuable during migration periods. However, the spatial coverage of land-based radar is limited to the detection range of the installed unit (typically up to several kilometres offshore) and the system cannot be scaled to cover the entire development footprint without deploying multiple units. This constraint means that while land-based radar provides detailed localised data, it is not practical or cost effective for full-site coverage of offshore wind farms (OWFs).

Deployment to date

3.3.2 Both wide-scale weather radar and dedicated bird radar systems have been used to quantify movements of birds (and indeed insects) (Wang *et al*., 2023 (a study that utilises onshore weather radar networks)), with many global academic studies of bird movement such as BioDAR (Lukach *et al*., 2024, again utilising data from onshore weather radar) and the Swiss Ornithological Institute Radar studies (Swiss Ornithological Institute 2023, using land-based dedicated bird radar systems). Weather radar covers very wide spatial scales and detects large scale movement of birds *en masse*, detecting flocks of birds and recording detail such as altitude and number of birds with relatively low precision. Dedicated bird radar systems operate at a smaller scale, collecting data on individual birds with greater precision, even allowing some information on bird size to be determined.

3.3.3 Radar has been used to study bird migration at offshore developments in Europe and beyond. Radar has been used prior to construction for baseline monitoring and to inform wind turbine generator (WTG) locations within an array area, as well as for post-construction bird collision monitoring and for WTG shutdown (curtailment) on demand applications. The technology has been implemented to successfully monitor bird migration patterns in real time over a long-term deployment in areas expected to host high levels of migration, such as Ocergy's Blue Oracle project in the Gulf of Lyon in the Mediterranean Sea (Ocergy, 2025). In addition, dual deployments of horizontal and vertical radar have been recently used to monitor 3D flight tracks and flight altitude in support of projects utilising 'shutdown on demand' to reduce collision at eight projects in the southern North Sea (Rijkswaterstaat 2025). Radar has also been deployed by Mainstream Renewable Power (2024) and partners to monitor bird migration with the goal of filling knowledge gaps regarding offshore bird migration, though is currently not published, to support the development of the planned Arven OWF (OceanWinds 2025) and other North Sea projects which are preparing their planning application(s). Radar data have been used in combination with satellite imagery and citizen science data to attempt to fill these gaps (Mainstream, 2024), albeit those outputs are not yet published.

Limitations of this method

3.3.4 Although radar systems can detect the approximate size of a bird, they cannot identify birds to species level (or in many cases even species group level). For any stakeholder or project that is looking to collect data that aims to provide additional information to inform the assessment of impacts on migratory birds, this limitation is critical in two ways. First, radar would need to be combined with other methods in order to determine the species involved in each radar detection (for example using observation data during the day or bioacoustics data at night). This integration significantly increases time and resource requirements, as it involves coordinating multiple technologies and survey teams over the relevant periods to achieve meaningful species-level identification. Second, radar will capture both all migratory and all non-migratory birds. As such filtering the dataset to focus only on migratory birds adds complexity and opportunity for error. Capturing only migratory birds has not been achieved through radar alone to date, as such filtering would need to rely on an approach that is as yet untested, which would require additional analytical effort and specialist input, increasing resource demands.

3.3.5 Another potential limitation for radar is that many migratory birds such as ducks, geese and waders may fly low over the sea, potentially making them difficult to detect and/or quantify (Cook *et al.*, 2012). This is due to radar detections being impacted by wave clutter, adverse weather conditions and potential blackspots caused by offshore infrastructure, all of which can obscure or distort signals at low altitudes, particularly close to the sea surface. This is an issue when a wider understanding of migratory bird use of an array area is required and when estimating the proportion of birds at PCH, as birds not at risk would be excluded from such calculations meaning that the PCH would be overly precautionary.

3.3.6 In addition to the limitations of radar, this method is very costly which could make projects financially unviable. This is especially true considering it would nevertheless need to be combined with other methods in order to deliver the required data.

3.3.7 Both the ability to collect the key parameters and the limitations of radar are summarised in Table 3.3.

Table 3.3. Key strengths and limitations of radar for a migratory bird study

Key parameter	Measurable with method?	Scalable to whole site?	Scalable to whole migration period
Number of birds	Yes	Yes	Yes
Species identification	No	No	No
PCH	Yes (with caveats)	Yes	Yes

Ability to collect key parameters

3.3.8 Radar can be used to quantify bird flux through a given area. This can determine the number of birds, the height at which they are flying (if the right radar system is deployed) and, therefore, the proportion or birds flying at PCH (within the range of the radar). Radar systems can operate continuously over extended periods (weeks or months) and can cover or be scaled to cover entire development footprints. Therefore, radar deployment can collect data on almost all of the critical parameters listed in Section 2, noting the limitations around species identification.

Use of this method in combination with others

3.3.9 If a bespoke radar system were to be deployed in order to inform qualitative assessment of impacts to migrant birds, further methods that inform the key gaps left by radar would need to be deployed simultaneously. Radar monitoring would potentially cover the 24-hour period and entire migration periods to identify the presence of bird(s). As such, any in combination data collected by another survey method to facilitate species identification would likely need to cover both day (e.g. observers) and night (e.g. PAM) and be of a duration that gives a sample size adequate for sufficient alignment and integration with the radar data. Thus, considerations of how cost-effective such a combined approach would need to be taken into account, as well as occupational and logistical considerations regarding the long-term stationing of observers at landfall sites or on vessels offshore.

Further to this, linking observations made in real time by observers, or recorded at night by PAM equipment, to radar detections may be tenuous at best. A lack of directionality in PAM means that recorded calls cannot be linked to specific radar detections or locations. Observations made by observers may focus on those birds most likely to be missed by radar (i.e. observers are more likely to detect birds flying low over the water, which are the birds most likely to go undetected by radar due to signal interference caused by wave clutter and surface conditions).

3.4 Offshore boat-based transects

Introduction

3.4.1 Boat-based transect surveys involve observers documenting bird activity along a predetermined transect, generally following the European Seabirds at Sea (ESAS) methodology (Camphuysen *et al.*, 2004). Observers record species present, their distance from the vessel, and flight height using distance and height bands. The survey method provides consistent data on seabird distribution, flight height and behaviour within, for example, a potential wind farm area. Data on migratory non-seabirds is recorded *ad hoc*, as boat-based surveys are less useful for non-seabird species (see below Limitations of this method).

Deployment to date

3.4.2 Boat-based surveys were the predominant method for capturing bird data offshore (through the ESAS methodology) before the advent of digital aerial survey (DAS) in European waters. While boat-based surveys focussed on seabird species, some projects also used this approach to collect *ad hoc* migratory non-seabird data e.g. Forewind (2021), Moray Firth Offshore Renewables Ltd (2012) (where a dedicated migration observer worked alongside ESAS surveyors during standard baseline surveys). However, dedicated boat-based surveys focussing on bird migration do not appear to have been carried out, other than to supplement data collected during radar and camera deployments in the development of 'shutdown on demand' systems such as that developed by Rijkswaterstaat (2025).

Limitations of this method

3.4.3 This method has several limitations. Although species identification rates should be accurate, the area within which birds may be detected and identified is relatively small and high-flying birds may go undetected due to the scanning regime implemented by the human observers. Due to the noise of vessels, wind and waves flight calls of smaller passerines flying overhead may also go unheard by onboard observers, also reducing overall detection levels. This would not be critical if the area surveyed provided an adequate sample, which could be scaled to represent the whole proposed development, however, defining the limits of an area effectively monitored by human observers would be difficult to do accurately and would require a species-specific limit to be set for each species detected. As such, scaling data from observer-led boat-based surveys are not recommended. Therefore, this approach is most appropriate for gathering site-specific data at a particular point in time along a defined transect, rather than for understanding migration patterns across larger areas or regions.

3.4.4 Another critical limitation of this method is the cost and risks associated with long-term deployment. Long-term deployment i.e. covering full migration periods would be essential given the sporadic nature of bird migration, with short-term deployment more likely to return a small dataset (a snap-shot) and potentially miss out on large scale migratory movements completely. To counter this, observers would need to be on vessels on site for long periods of time, which introduces substantial health, safety and logistical considerations, including crew rotation, accommodation and vessel scheduling.

3.4.5 A final limitation to consider would be the inability to collect data at night. Many species of birds are exclusively nocturnal migrants and given the obvious limitations on detecting and identifying these birds at night, observational data would be sparse or non-existent for many key migratory species such as wildfowl and waders.

3.4.6 Flight height estimation is prone to human error, which can be augmented through laser range finders, though these do not work effectively for smaller species of birds at distance as they are difficult to lock onto. However, this brings additional cost through equipment and personnel.

3.4.7 The extent of data collection is limited when compared to other methods as this is not continual and requires human effort.

3.4.8 Both the ability to collect the key parameters and the limitations of boat-based surveys are summarised in Table 3.4.

Table 3.4. Key strengths and limitations of boat-based observers for a migratory bird study

Key parameter	Measurable with method?	Scalable to whole site?	Scalable to whole migration period
Number of birds	Yes	No	No
Species identification	Yes	No	No
PCH	Yes – with limitations	No	No

Ability to collect key parameters

3.4.9 Observer-led boat-based surveys have the capacity to deliver a high level of species identification during the hours of daylight, with complete counts of all detected birds, with scope for observations to be classified for PCH estimates. Laser rangefinders can be used to augment the measurement of flight height for larger species. However, these are more effective on birds that are close to the vessel (as it becomes easier to hit targets on closer birds). Given that the presence of, or proximity of the vessel may influence bird flight height, laser rangefinders have not been considered for this task. Use of this method in combination with others may lead to more productive results.

3.4.10 While this method may have the capacity to add crucial species identification data from within the proposed array area to a study where this was lacking (such as a radar study), the limitations regarding long-term deployment and the sporadic nature of bird migration make combining these two methods impracticable. Further additional or alternate methods would also need to be added in order to collect data on nocturnal migrants.

3.5 Thermal Imaging

Introduction

3.5.1 Thermal imaging cameras are typically mounted on to a fixed structure and operated remotely or autonomously using software. These cameras detect birds based on their heat signatures producing data on bird flight height and speed based in low light or at night-time. Processed images can also provide insight into flight paths and direction.

Deployment to date

3.5.2 Thermal imaging cameras have been deployed within OWFs in the post-construction phase in projects such as Aberdeen Bay Wind Farm in the UK North Sea (Vattenfall, 2023) and the pre-application phase for Humboldt Wind Energy in Californian waters off the western coast of the USA (Schneider *et al*., 2024). These studies discuss seabird interactions with OWFs and examine uncertainties within the collision risk assessment following analysis of data collected within these projects. Thermal imaging cameras were deployed at both project sites to capture data continuously during nocturnal hours. Studies at Aberdeen Bay Wind Farm have also used additional of artificial intelligence (AI) technology developed by Spoor to record 3D birds flight paths which could document micro-avoidance behaviours around operational turbines (Vattenfall, 2025). Similar technology was used for the Humboldt Wind Energy Area, California, where both thermal imaging and stereo vision technology (ThermalTracker-3D) were deployed on a buoy integrated with light detection and ranging (LiDAR), capturing 3D flight paths across the development area (Schneider *et al*., 2024). While thermal imaging has been used along with other methods in collecting continuous data, these surveys do not rely on thermal imagery alone. There are currently no studies using thermal imaging in isolation for OWFs to specifically monitor bird migration which are available in the public domain.

Limitations of this method

3.5.3 Although thermal imaging can determine bird flight heights and the number present in certain conditions, this method cannot be used to identify species accurately, since thermal images lack the detail needed to identify species at more than a group level. As with radar this survey method would need to be combined with other methods to identify species for each image (for example the additional use of bioacoustics).

3.5.4 Furthermore, adverse weather, such as rain or heavy cloud cover can also interfere with the camera's detection of birds since infrared radiation is absorbed by moisture. Additionally, thermal imaging can cover only a low spatial scale (for example units tend to be effective over a maximum range of 1,250 m), which limits its effectiveness for large-scale monitoring and is less effective for smaller species with distance.

3.5.5 Both the ability to collect the key parameters, and the limitations of thermal imaging are summarised in Table 3.5.

Table 3.5. Key strengths and limitations of thermal imagery for a migratory bird study

Key parameter	Measurable with method?	Scalable to whole site?	Scalable to whole migration period
Number of birds	Yes	No	Yes
Species identification	No	No	No
PCH	Yes	No	Yes

Ability to collect key parameters

3.5.6 Thermal imaging is especially useful to detect birds that migrate during the night-time or during low light levels when most migration tends to occur (Osterhaus et al., 2025). Additionally, these cameras can determine the number of birds and determine flight height from images under ideal conditions.

Use of this method in combination with others

Further methodologies are required alongside thermal imaging to inform key gaps left by thermal imaging. While thermal imaging is effective for nocturnal monitoring, daytime data collection would need alternative methods such as radar (only to capture data on a broader scale), or visual observations. The cost of the combined approach would need to be considered, as would health and safety if long-term land or boat-based observations are required.

4 Review of existing data sources

4.1.1 Existing data sources (including ringing and tracking data, and citizen science platforms (eBird, Trektellen, BirdTrack)) were reviewed to identify any relevant data which could be used to support the AWBP2 and/or add context regarding local bird migration patterns – including timings, flight altitudes, orientation and primary migration corridors within the area, as per the RFI.

4.1.2 Trektellen, BirdTrack and eBird enable users to submit bird observations with precise location data, including data on bird numbers and flight direction. For each, these data can be accessed via the web, allowing users to view their own submission, discover bird distributions, abundance, vocalisations and habitat use and trends through submitted data. Likewise, large scale datasets from a given location or area can be accessed through each portal. Data quality is maintained via a review system for rare species or particularly high counts of birds.

4.1.3 Trektellen is a bird observation database holding data on counts of visible migration, bird ringing data and (primarily nocturnal) acoustic monitoring of bird migration. Data can be explored by location and species, with available historical data that can sorted by spring and autumn seasons. Unfortunately, this database has no recent submissions relevant to the Wicklow and Wexford County areas and, therefore, this data source is not suitable for the AWBP2 assessment. Data older than this period have not been considered as they may be misleading in terms of understanding current local movements of birds.

4.1.4 BirdTrack and eBird allow users to record bird observations at a species level, along with the number of individuals and additional detail on age, sex and behaviour, where relevant. BirdTrack only provides data within 30 days of a sighting via the web portal with past data only available by request to the (BTO), which would be charged for commercial use. BirdTrack data are generally temporally sparse, collected *ad hoc*, and generally without any related effort data. As such, data within BirdTrack are considered unlikely to inform a migration study beyond some simple presence data. Thus, BirdTrack data were not considered appropriate to aid the assessment.

4.1.5 In contrast, the eBird web-browser allows the user to view summarised annual archived data, as well as giving access to raw data on request. Notable listed sites that would be relevant to the ABWP2 array area include Wicklow Head, Arklow Ponds and Nature Reserve, Wicklow Harbour and Broad Lough (eBird, 2025). An example of the autumn migrants recorded at these locations in October include Eurasian curlew (*Numenius arquata*), bar-tailed godwit (*Limosa lapponica*), common scoter (*Melanitta nigra*), golden plover (*Pluvialis apricaria*) and ringed plover (*Charadrius hiaticula*) (eBird, 2025).

4.1.6 Examples of the type of data products offered by eBird are presented in Figure 1 and Figure 2 below. These outputs are based upon data from all years.

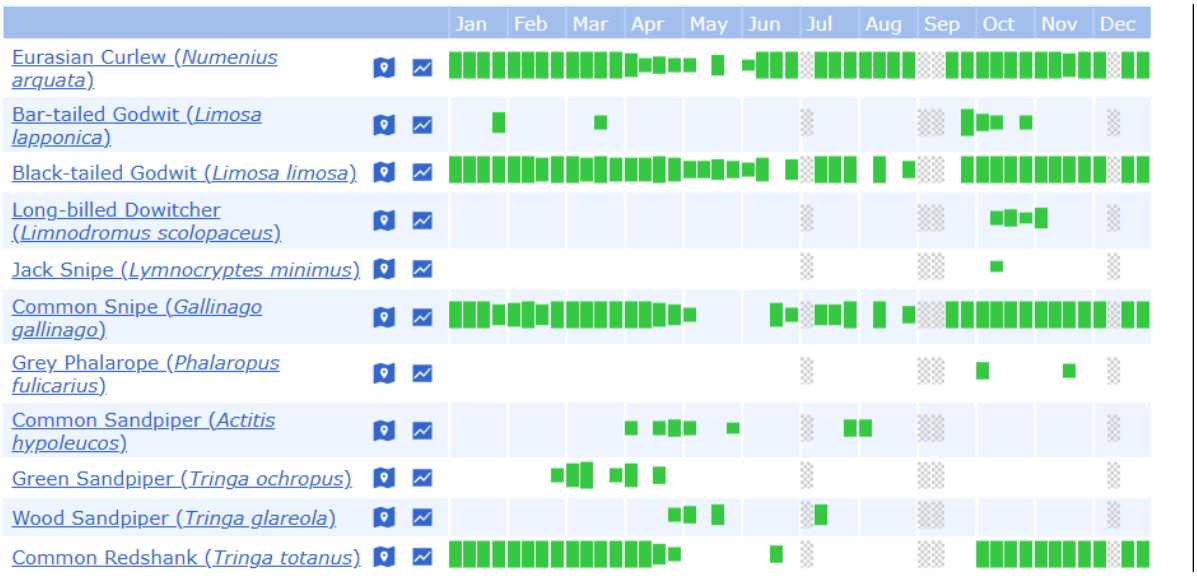

Figure 1. Example of eBird bar charts (eBird 2025). These present a visual summary of the proportion of complete lists (i.e. observations where all identified species were recorded) on a monthly basis, giving an indication of relative likelihood of encountering a given species at a given site at a given time of year.

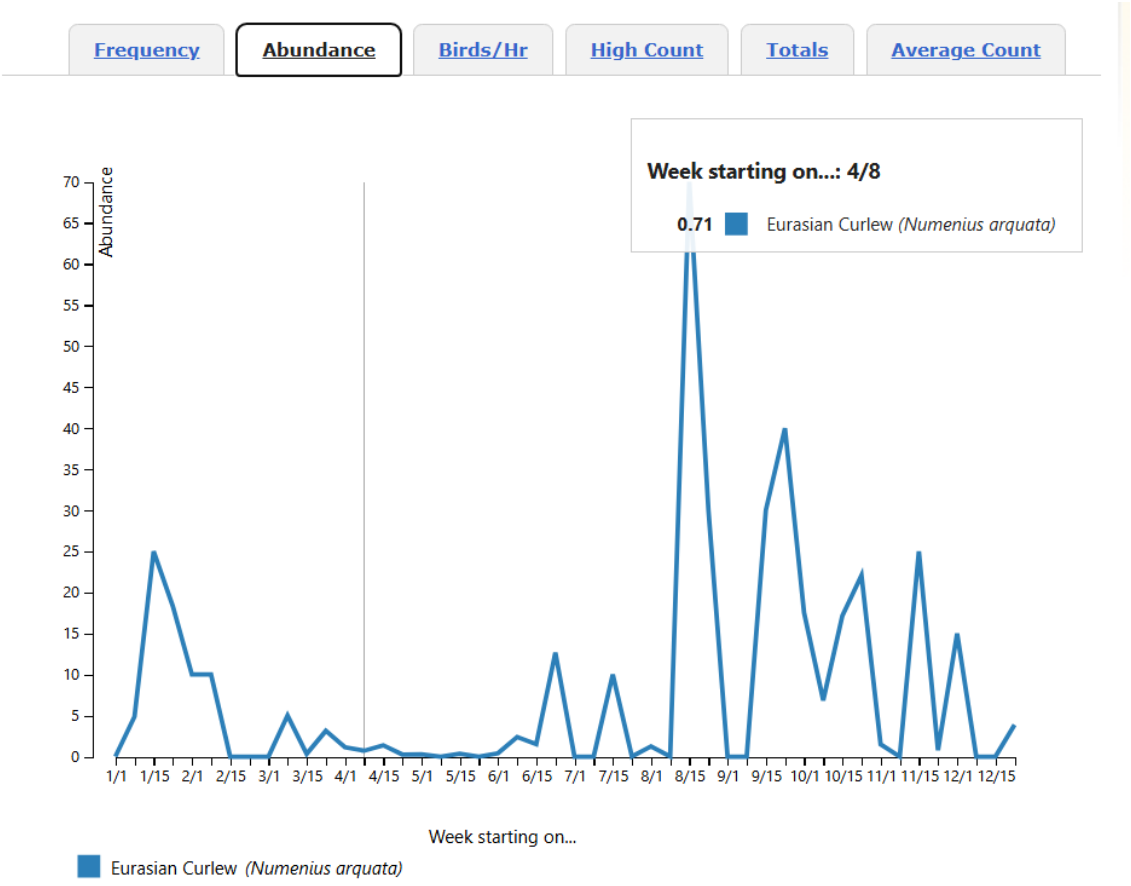

Figure 2. Example of eBird line graphs (eBird 2025). These present an annual summary of occurrence of given species. The tabs across the top of the graph allow the user to present frequency (i.e. the proportion of complete lists within which the species occurs), abundance, birds per hour (relating abundance to effort), high counts, average counts and totals.

4.1.7 These data sources can inform which migratory species regularly occur within the region and, therefore, which may be most likely to occur within the ABWP2 array area, but these data would not be considered comprehensive. The inconsistent nature of citizen science recording means that a robust quantitative assessment with these data cannot be undertaken, as there is a lack of confidence in the abundances. If collected across the whole migration period these data sources can provide broad context in terms of passage through the region of interest, but could not be relied upon as the best available data to inform formal impacts assessments for use within an EIAR or NIS given the uncertainties regarding coverage.

4.1.8 Historical ringing data were reviewed through The Migration Atlas: Movements of the Birds of Britain and Ireland (Wernham et al 2002). This source provides a useful broad overview of the suite of species likely to migrate across the ABWP2 array area and allows inference of the scale of the migration within any given locale, relative to other areas. In addition, more recent ringing data were accessed through https://migrationatlas.org/, ensuring that ringing data more representative of the present day were considered. However, ringing data only present the start and end point of a journey and as such, cannot inform the flux of birds through any given point remote to where ringing takes place, or the height at which any flux happens. As such, ringing data have not been considered further.

4.1.9 Tracking data could potentially offer useful data when assessing migration through a given site, as tracking data can include species and flight height, and data would be recorded both by day and by night.

4.1.10 Motus data could provide key insights into bird movements across the development area. However, there are currently no Motus projects registered in Ireland and therefore no receivers are currently in place. Placement of a Motus receiver within the proposed array area could give information on the species of birds that are passing over the Irish Sea, but given the sensitivity of receivers can only be estimated it would not be possible to determine whether detected birds had passed through the proposed array area or not. In addition, information regarding flight height and flight direction would be lacking, unless these could be determined through an array of receivers.

4.1.11 Tracking data are available for a very limited number of species and for each species tracked, only a very small number of birds are tagged. As such, the scale of tracking data available make it useful for determining the migratory activity of the tracked birds, but much less useful for determining the species diversity and scale of flux through any given area. As such, tracking data have not been considered further. Where available, tracking data for key migratory species can set field data within a wider spatial and temporal context. For example, tracking data for whooper swan, Greenland white-fronted goose and pale-bellied brent goose that describe migration routes and timing could add context to any project and site-specific data that are collected. An example of the kind of information that tracking can provide is presented in Figure 3.

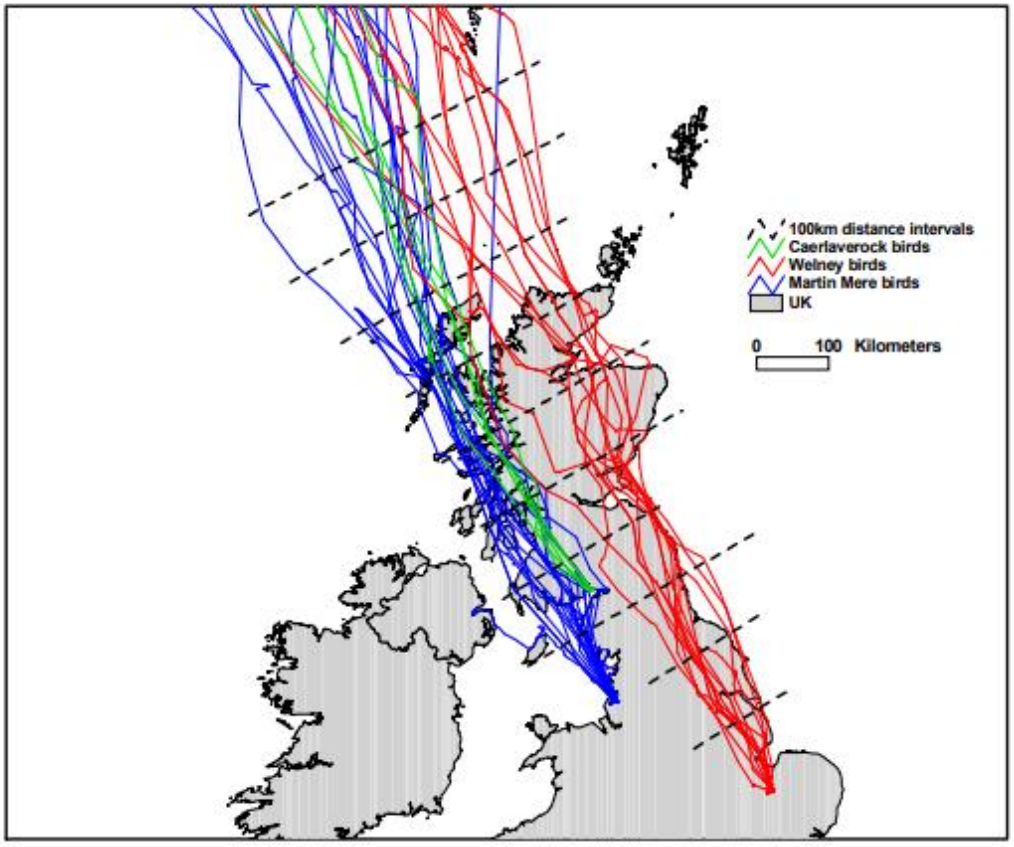

Figure 3. Migration routes of tracked whooper swans. Taken from Griffen *et al.,* 2010

4.1.12 Use of existing tracking data may provide helpful context to data collected and provide the required level of regional context for a limited suite of species (i.e. those for which tagging exists) However, to do this for all species would require a bespoke tagging program of all species of interest, which is beyond the scope of this project.

5 Discussion

5.1.1 In their observation the DAU noted the importance of the south-east of Ireland for migratory birds, with migration occurring across the Irish Sea, and that little reference to migratory birds has been made in the NIS and EIAR. Critically, the RFI notes:

No information has been provided with respect to their migration patterns – including timings, flight altitudes, orientation and primary migration corridors.

5.1.2 The RFI then goes on to state that coastal vantage point surveys are insufficient as a sole survey method and that existing data do not provide sufficient detail on migratory movements. As such, the RFI states that:

The DAU states that the applicant should have not only considered but implemented appropriate survey methodologies in order to detect and assess the level of bird migration through the proposed development area

5.1.3 In order to address the questions raised within the RFI relating to migratory birds and their migration patterns, flight heights, flight directions and migration routes, the Applicant reviewed all reasonable methods to fill such data gaps, as described in this report. The conclusion drawn from the review of different surveys methods identified VP surveys and PAM deployment as the most suitable to answer the questions posed within the RFI and as such SSE implemented a programme of surveys with observer based coastal VP survey methods to collect migratory bird data augmented by PAM data collection.

5.1.4 These surveys are adjudged to be able to provide the required information on the species that migrate through the proposed development area and coastal areas immediately adjacent to it. VP surveys will collect data on flight heights, flight directions, species and number of birds seen during diurnal migration from coastal watchpoints. The PAM surveys will collect information on the species migrating through the proposed development area in the offshore array area, as well as at coastal headlands during dusk, through the night and at dawn. The numbers of birds involved can be estimated and judgements can be made about flight heights from the latter method. As such, the two methods combined can substantially enhance the understanding of bird migration within and in close proximity to the area of the proposed development.

5.1.5 It should be noted, however, that there remains some uncertainty with regard to the bird flight heights from PAM data, including the counts of birds involved and lack of species identification for those species that do not vocalise while migrating by night from the PAM. The PAM surveys, therefore, cannot inform the estimate of the proportion of birds flying at PCH within the proposed development area, which makes these data insufficient to inform a quantitative collision risk assessment.

5.1.6 To estimate collision risk mortality rates of seabirds a baseline of two years' worth of monthly data is recommended, informed by DAS that collect high quality data on the species or species groups involved, bird abundances and densities within a given area. These data are augmented by well researched and established standards such as avoidance rates, flight height data, flight speed and levels of nocturnal activity in order to inform a quantitative collision risk assessment. This forms part of the application process and for example in the UK, is carried out in consultation with the relevant statutory nature conservation bodies.

5.1.7 In contrast, the Applicant has been asked to make judgements regarding the proposed development's potential collision impact on migratory birds while the project is within the post-application phase. The Applicant thus has little time to agree and establish monitoring programmes that are comparable with those used to inform CRM of seabirds. This is especially pertinent given that the standard approach for assessing impacts on migratory birds in all UK jurisdictions is to model impacts using a standard approach informed by known migration ranges, national and flyway populations. This is typically undertaken during the Application stage for UK developments.

5.1.8 Therefore, the Applicant considers that a tailored, data-driven assessment of migratory collision risk - covering a wide range of species across all migratory seasons - cannot be undertaken as applied to seabird collision assessments, within the time frames allocated.

5.1.9 In order to justify the monitoring approaches implemented by the Applicant, existing technologies and methodologies for monitoring bird migration were assessed.

5.1.10 A review of different survey methods has been provided and no single monitoring approach reviewed herein provides the full data requirement in order to assess predicted impacts to migratory non-seabirds from collisions.

5.1.11 Migratory birds tend to travel during the night-time to take advantage of the cooler, calmer weather conditions which can reduce energy expenditure (Komal *et al.*, 2017), and to lower the potential predator interaction (Lank, 1989). Migrating during the night is favoured by the majority of migratory bird species. However, some wader and large wildfowl species may undertake both nocturnal and diurnal migration. Diurnal migration may be advantageous for these species as it provides increased foraging opportunity as well as allowing for visual cues to aid navigation (Komal *et al.*, 2017; Van Gils *et al.*, 2005; Wege and Reveling, 1983). Therefore, monitoring nocturnally and diurnally is required to collect a comprehensive dataset of migration.

5.1.12 Both radar and thermal imaging can be implemented continuously for the long-term (i.e. covering entire migration periods or even whole annual cycles), providing data on the number of birds migrating within a given area, and PCH if appropriate technology is used. However, in order to identify individuals to species level throughout the 24-hour period, both diurnal VP observers and nocturnal PAM would need to be deployed alongside these methods to provide sufficient data. There are also logistical issues with the implementation of hi-tech solutions such as radar at such short notice. The acquisition of relevant licencing for radar, and the issue of powering long-term deployment of any technology offshore were also considered as key limitations with this method that ultimately led the Applicant to implement other methods. Additionally, the deployment of three survey methods would increase the cost of this monitoring, and the information gained through the deployment of radar or thermal imagery (i.e. bird numbers and height) can both be either measured or estimated from VP or PAM surveys to an appropriate level for the purpose of understanding the baseline environment.

5.1.13 Boat transects surveying was the industry standard for the monitoring of seabirds at sea before the inception of DAS, with seabird surveyors often collecting additional data on migratory birds. However, this method has multiple limitations (see Section 3.4) which would restrict the level of data reliably captured by observers (e.g. data collection would be limited to hours of daylight). Combining this method with nocturnal PAM would fill this data gap but due to health and safety concerns regarding long-term deployment of observers at sea, especially throughout the 24-hour period, together with the costs associated with long-term vessel deployment over entire migratory periods would make combining a vessel based approach unfeasible, unless there was a suitable vessel of opportunity available (i.e. a vessel which was going to be stationed within the ABWP2 array area for other work, onto which bird monitoring teams could be deployed). As such, due to the suite of limitations associated with the method (e.g. lack of data for nocturnal migration, the potential for high flying birds to go undetected, and the potential for bird behaviour to be influenced by the presence of the vessel), thus potentially biasing measurements of height, this method alone is not considered suitable. This method would need to be integrated with other approaches such as PAM in order to fulfil the full suite of requirements.

5.1.14 Coastal VP surveys would be able to capture all key parameters with the addition of direction of travel of birds, which can be used to infer the likelihood of individuals to enter the ABWP2 array area. Although this method has similar limitations to boat-based surveys, it is considered a more viable option based on health and safety considerations and based upon the substantially lower cost of deploying observers on land compared to at sea. To ensure comprehensive data for all key parameters across entire migration periods both diurnally and nocturnally, the addition of nocturnal PAM is recommended. The combination of these methods overcomes the limitations associated with the other methods discussed (i.e. no species ID for radar, and no nocturnal coverage for offshore boat surveys).

5.1.15 Bioacoustics allow for the collection of all critical parameters; however, this method should be paired with another methodology to achieve detection of species that do not vocalise while migrating. Diurnal coastal VP surveys would be cost effective and would provide data on diurnal migration and non-vocal birds, as well as providing all key parameters.

5.1.16 In the context to acquire critical parameters listed in Section 2, the combination of bioacoustic monitoring and coastal VP surveys would provide the most complete suite of the parameters required. Bioacoustic monitoring continuously monitors during the night, providing species identifications and estimates of flight height and numbers involved. The VP surveys would ensure that diurnal data on species, number and flight behaviour (flight height and direction) are collected. Species identification is critical for species specific assessments therefore this is priority for both diurnal and nocturnal surveys.

5.1.17 Therefore, bioacoustic monitoring (PAM) in combination with coastal VP surveys is proposed in order to collect the full dataset required for CRM of migratory species within the ABWP2 array area.

5.1.18 As such, it has been recommended that the monitoring programme should consist of a combination of two onshore diurnal Vantage Point surveys and data capture from one onshore and two offshore nocturnal SM4 Passive Acoustic Monitoring units to record the diversity and abundance (where possible) of migratory non-seabird species ('target species') in the vicinity of the proposed Array Area. The PAM should be run continuously during this period (i.e. every night during this period) with weekly six-hour sessions at each VP.

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