OFFSHORE RENEWABLES JOINT INDUSTRY PROGRAMME (ORJIP) FOR OFFSHORE WIND

CARBON TRUST

Summary report of focused group workshop (D04b)

Closing the Loop: Feasibility study to determine a feedback approach for post-consent monitoring to reduce consenting risk in future assessments

September 2025

orjip working to accelerate offshore consenting

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ORJIP Offshore Wind

The Offshore Renewables Joint Industry Programme (ORJIP) for Offshore Wind is a collaborative initiative that aims to:

- Fund research to improve our understanding of the effects of offshore wind on the marine environment.
- Reduce the risk of not getting, or delaying consent for, offshore wind developments.
- Reduce the risk of getting consent with conditions that reduce viability of the project.

The programme pools resources from the private sector and public sector bodies to fund projects that provide empirical data to support consenting authorities in evaluating the environmental risk of offshore wind. Projects are prioritised and informed by the ORJIP Advisory Network which includes key stakeholders, including statutory nature conservation bodies, academics, non-governmental organisations and others.

The current stage is a collaboration between the Carbon Trust, EDF Energy Renewables Limited, Ocean Winds UK Limited, Equinor ASA, Ørsted Power (UK) Limited, RWE Offshore Wind GmbH, Shell Global Solutions International B.V., SSE Renewables Services (UK) Limited, TotalEnergies OneTech, Crown Estate Scotland, Scottish Government (acting through the Offshore Wind Directorate and the Marine Directorate) and The Crown Estate Commissioners.

For further information regarding the ORJIP Offshore Wind programme, please refer to the Carbon Trust website, or contact Ivan Savitsky (ivan.savitsky@carbontrust.com) and Žilvinas Valantiejus (zilvinas.valantiejus@carbontrust.com).

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- Joint Nature Conservation Committee (JNCC)
- Natural England
- NatureScot
- Royal Society for the Protection of Birds (RSPB)
- Scottish Government Marine Directorate

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Contents

List of Tables

List of Figures

List of Abbreviations

CES	Crown Estate Scotland
DAS	Digital Aerial Surveys
EIA	Environmental Impact Assessment
FAIR	Findable, Accessible, Interoperable, Reusable
GLM	Generalised Linear Model
iPCoD	Interim Population Consequence of Disturbance
MDE	Marine Data Exchange
NEEOG	North East, East Developers Ornithology Group
OCLG	Offshore Consenting and Licencing Group
OWEC	Offshore Wind Evidence and Change Programme
OWEKH	Offshore Wind Evidence and Knowledge Hub
OWF	Offshore wind farm
PAG	Project Advisory Group
PCM	Post-Consent Monitoring
POSEIDON	Planning Offshore Wind Strategic Environmental Impact Decisions
RAG	Regional Advisory Group
ScotMER	Scottish Marine Energy Research
SNCB	Statutory Nature Conservation Body
TCE	The Crown Estate

Executive Summary

This report presents a summary of a focused feedback workshop held on 5 December 2024 as part of the Closing the Loop: feasibility study to determine a feedback approach for post-consent monitoring to reduce consenting risk in future assessments project. The aim of the workshop was to gain high-level feedback from stakeholders about key issues identified in the work to date on the project relating to improving the use of post-consent monitoring data, and to discuss some of potential solutions developed through insights developed through findings from research so far.

To read this document quickly: focus on the executive summary, which briefly describes the key discussion points during the stakeholder workshop.

For an overview of stakeholder engagement in the project, read 1 Introduction

For an overview of the how the workshop was run, read 2 Focused group workshop – approach.

For key findings from the workshop, read sections 3.1 (Discussion of feasibility of potential solutions) and 5 (Participatory discussion around the use of data from PCM within the development of SNCB guidance (Session 2)).

The main issues discussed during the focused feedback workshop included the following:

- **Resourcing issues** are a challenge under the current context, for actors across the industry (not just the public sector bodies), in terms of limited staffing resources. Specific challenges include having sufficient staffing and necessary expertise which directly impact the ability to overcome barriers and delays in the current context, as well as challenges for creating more robust management frameworks and infrastructures. Unless addressed, resourcing issues will continue to constrain progress, given the rapid increase in offshore wind renewable energy anticipated in light of the UK Government's pledge to quadruple offshore wind by 2030 to 60GW.
- **Working together across the industry to implement data standards that are FAIR** – findable, accessible, interoperable and reusable – to ensure data being gathered under existing and future post-consent monitoring requirements can be analysed using pooled or meta-analyses approaches.
- **Working 'smarter'** was considered an opportunity to create opportunities to achieve change that could benefit actors across the industry. Some examples included working to improve communications and transparency of information about how post-consent monitoring data and reporting are progressing through the consenting process, and engagement to support stakeholders in understanding the importance and value of uploading post-consent monitoring data in a timely manner.
- **Potential solutions** for Closing the Loop **need to be resilient into the future**, taking practical and technical factors into account (i.e. increasing levels of data being collected; integration of data from new technology) as well as contextual factors (likelihood of additional impacts on marine life, such as those caused by the increasing severity of storms etc).
- **Applicability across all UK administrations**, is also key, taking account of practical and resource limitations faced by smaller administrations. This is particularly relevant to areas such the transferability of evidence to new areas, species, and over time, which may be treated and interpreted differently across UK administrations which take varying approaches.

- The potential for adopting a **strategic approach to post-consent monitoring** was felt to offer substantial potential for addressing the challenges of understanding the impacts of offshore wind farms (OWFs) at a more comprehensive level. However, moving to a strategic approach would require large changes in several of areas such as process and policy, and this would need to work alongside post-construction data requirements on developments already operational or under development.
- The need for **research outputs**, including academic publications, to **clearly indicate the underlying assumptions and limitations** of research and data presented, and give a strong indication of the **confidence placed in the results**, to help stakeholders determine the transferability of evidence across different contexts.

1. Introduction

In the UK offshore wind sector, developers are typically required to conduct post-consent monitoring of offshore wind farm (OWF) impacts as part of their licence conditions, which can be costly and challenging to implement. These data, and lessons learned about OWF impacts, are invaluable in the further development of the industry, as they could help reduce uncertainty in the consenting process and are crucial in the context of both cumulative and future project-based assessments. However, there is currently no strategic feedback mechanism or requirement for data collected during post-consent monitoring to be integrated into the assessment process. The Closing the Loop: feasibility study to determine a feedback approach for post-consent monitoring to reduce consenting risk in future assessments project is adopting a pluralistic approach to understanding the barriers and potential solutions to incorporating post-consent monitoring data back into the consenting process, including seeking understanding of current procedural, technical, scientific, and statistical issues, and considering potential future post-consent monitoring requirements.

The evidence base regarding seabird behaviour around offshore wind developments will increase with post-construction monitoring, and so it is important that this emerging evidence is considered within the decision-making process. Due to lack of directly relevant empirical data and high uncertainty around key inputs to assessments, such as avoidance and displacement rates, Statutory Nature Conservation Bodies (SNCBs) recommendations have followed a precautionary approach. Incorporating empirical evidence on seabird-OWF impacts from post-consent monitoring data into assessments should ultimately overcome the need for such precautionary approaches. However, the generation of a robust empirical evidence base alone will not be sufficient to ensure this, and active mechanisms, such as regular analyses of data (including data pooled or aggregated across multiple projects), peer- reviewed academic publications, and endorsement through Technical Topic Groups at the Offshore Wind Evidence and Knowledge Hub (OWEKH) may be needed to ensure that SNCBs have access to clear outputs which are easy to interpret and utilise and of direct relevance to their guidance. Such outputs should encompass consideration of the factors required by SNCBs in decision making, which are often overlooked in recommendations produced by the academic community when disseminating scientific research, such as transferability of outputs to other sites and species, consideration of how data and evidence can be incorporated within assessment tools, and the timing and process of producing new guidance.

Stakeholder engagement for the Closing the Loop project involves a staged approach to inform the understanding of, and develop potential solutions to, these procedural, technical, scientific, and statistical issues. Many of the key barriers and potential solutions to 'closing the loop' will be institutional, characterised by a small set of organisations with different responsibilities for decision-making in relation to the assessment process and to post-consent monitoring data collection requirements. As such, the initial stages of stakeholder engagement (semi-structured interviews and focused group workshop) focus on organisations such as regulators, oversight managers and SNCBs for all administrations across the UK, as well as engaging with representatives from industry to seek their views.

- The first stage (reported in **Closing the Loop – Summary report of stakeholder interviews (D04a)**) focused on capturing a detailed understanding of barriers to using post-consent monitoring data, and potential mechanisms for resolving them, through a series of semi-structured interviews with individuals representing organisations playing a role in the regulatory and consenting processes, along with a practitioner and industry representation. These interviews sought to understand processes within different organisations and identify where steps to 'closing the loop' may be missing, implemented partially, or improved. Outcomes from these interviews were integrated into a **Closing the Loop – Synthesis of evidence (D01)** report, which is an output of this project.
- The second stage, an online focused group workshop (similar to a focus group, Nyumba et al, 2018), is reported in this document **Closing the Loop – Summary report of focused group workshop (D04b)**. This workshop was held online on MS Teams on 5th December 2024.
- The third stage of stakeholder engagement (spring 2025), involved a workshop with a broader set of stakeholders from across the offshore wind industry, to present the draft recommendations, and obtain feedback on them. Feedback from this workshop was used to refine and finalise a set of recommendations and develop a high-level roadmap, outlining key measures and priorities to ensure the use of post-consent monitoring data within future decision-making (see **Closing the Loop – Recommendations & roadmap (D05)** report).

This report summarises the activities and outcomes of the focused group workshop. The workshop was divided into two sections. The first centred on gaining feedback from participants on the potential solutions put forward by the project team (which were developed in the **Closing the Loop – Synthesis of evidence (D01)** report). The second part used an interactive app developed within the project to frame qualitative discussion around the use of data from post-consent monitoring within the development of SNCB guidance. The interactive app and the context in which it was used for discussion is presented here. Outcomes from both parts of the workshop are presented and summarised.

2. Focused group workshop – approach

Participants representing organisations playing a role in the assessment, consenting and regulatory stages of OWF development across the UK were invited to participate in a half-day workshop in early December 2024. A subset of interviewees who took part in the first round of stakeholder engagement (semi-structured interviews) were invited to participate in the focused group workshop. Due to the participatory nature of the workshop, we required one participant per organisation and limited the size of the workshop to 14 participants. Representation across the sector included regulators, oversight managers and SNCBs for all administrations across the UK, industry representation, a practitioner (consultant), and a researcher. Organisations are listed in Appendix 1: Organisations represented at the workshop. Prior to beginning this round of stakeholder engagement, the research proposal was reviewed by the Research Ethics Committee of the James Hutton Institute (reference: JHI-HRE-0261) to ensure the workshop would be conducted in line with good practice ethical research guidelines and the workshop was carried out in line with the ESRC's research ethics guidance for social research. Potential participants were sent an information sheet (Appendix 2: Interview consent form) and prior to the workshop commencing, each participant was asked to sign consent form (Appendix 3: Information sheet). The workshop participants agreed that 'Chatham House Rules' applied to the discussions, meaning that the topics of conversations can be discussed externally, but not attributed to individual participants.

The workshop was held online over 3 hours, divided into two sessions. The aims of the workshop were to:

- Gain high-level feedback about the barriers identified, based on results from stakeholder interviews, the seabird review and the review of process, policy, and data availability
- Develop consensus about the feasibility of the potential solutions presented by the project team
- Discuss factors that should be taken into account when incorporating data and evidence arising from post-consent monitoring data within assessments
- Contribute to the subsequent development of draft recommendations from the Closing the Loop project, recognising stakeholder needs and constraints that account for existing barriers to uptake in the use of post-construction monitoring data.

During the first session, the project research team presented results of earlier activities in the project through a Synthesis of Evidence approach, highlighting the key issues and potential solutions identified so far regarding the use of post-consent monitoring data in assessment processes. This presentation included findings from a review of current seabird data and modelling, a desk-based review of current policy, process and data availability, and semi-structured interviews with relevant actors (of which the participants in the session had taken part), highlighting issues identified relating to data management and frameworks, procedural issues, and technical/statistical issues, followed by an interactive session and discussion about the feasibility of potential solutions, with participants contributing to a Miro board to inform assessment of feasibility.

The second session adopted a participatory approach, framed around an interactive app developed by the research team. The app aims to allow stakeholders to explore, quantitatively, how pre- and post-consent monitoring data can be used to provide evidence that will help to inform guidance around cumulative assessments and future project-level assessments, and to assist in identifying and resolving specific barriers to achieving this outcome. The app was used in this workshop to facilitate discussion relating to pooling data; transferability of data across time, space and species; and understanding the impact of external shocks (such as marine heatwaves) on the ability to predict the effects of windfarms on bird species. The app allowed workshop participants to explore how pre- and post-construction data can be used to inform their decision-making. Discussion during the workshop centred on these issues relating to how and when data and evidence are incorporated into guidance and advice, including:

1. The level of data that needs to be made available so they can be brought into evidence across multiple projects using for example pooled- or meta-analyses
2. How transferability (e.g. across time, space, species) is taken into account for when reviewing evidence
3. How and when data and evidence are incorporated into guidance, including exploring evidence thresholds and criteria.

The interactive app was presented in three sections, corresponding to the discussion questions set out above. Each section of the app was presented on a shared screen, with a live demonstration of a set of scenarios, and then a discussion was initiated by the lead facilitator on the project team. The workshop was recorded for the project team to have an accurate record of the discussions. A transcription of the workshop was also produced.

Feedback and insights received during the workshop will further inform the development of draft recommendations and a roadmap for incorporating post-consent monitoring data back into the consenting process, as the final outputs of this project.

3. Key barriers and potential solutions to closing the loop (Session 1)

The project team presented findings to date on the key issues and potential solutions identified to closing the loop, for incorporating post-consent monitoring data back into the assessment process. These were produced by integrating previous activities over the project into the **Closing the Loop – Synthesis of evidence (D01)** report. The presentation of barriers and potential solutions to closing the loop included issues relating to i) procedural issues, ii) data management and policy issues; iii) challenges in dissemination of new evidence and translating data to guidance; and iv) technical and statistical issues.

Potential solutions were presented via an online whiteboard app (Miro, Figure 1), and participants were asked to consider whether these ideas were *feasible*, *feasible with some changes*, or *not feasible in the current context*. Participants could use as many coloured dots as they wanted, and there were no obligations to assign a coloured dot to every potential solution. It was recognised that some of the potential solutions presented would require high level government support, including the provision of more funding and resources. These suggestions were still included for discussion, recognising that some of the changes required to close the loop may have substantial resourcing implications. The number of dots assigned to each potential solution in Figure 1 was not intended to capture a quantitative response. Rather, these were used by the project team within the workshop to motivate discussion and identify key points.

An open discussion followed, enabling participants to comment freely on some of the potential solutions. Conversation included broader discussions, such as whether monitoring ideas should be included within the application process, and a need to be clearer about the purposes of monitoring on a broader scale, including wider discussion about the scientific questions being asked (and answered) through monitoring requirements on projects. The project team used the results of the activity to inform whether there was consensus on the feasibility of each solution. Participants were also invited to write on blank sticky notes (not shown in Figure 1) to detail any solutions they thought were missing or misrepresented, as well as additional details they felt were useful to the feasibility exercise. Figure 2 shows the same solutions as Figure 1, in a more accessible, readable format.

Figure 1. Screenshot of online whiteboard of potential solutions, with indications of whether workshop participants felt they were feasible (green dots), feasible with some changes (yellow dots), or not feasible (red dots) under the current context.

<u>Please note</u>: the number of dots on each sticky note should not be taken as a quantifiable response: this activity was intended to motivate discussion and identify where feasibility challenges might arise. The table (Figure 2) on the next page lists the solutions proposed for discussion within the online whiteboard in a readable format.

Procedural
SNCBs and others develop examples of how/where PCM reports have helped update advice
SNCBs and other organisations resourced to invest in data managers, to help manage and facilitate access to and use of PCM data
SNCBs, regulators and other organisations resourced to invest in new staff to meet demand of continued expansion of offshore wind
Stakeholders across the industry establish greater clarity on governance and responsibility
Regulators and oversight managers develop overview on monitoring reporting
Stakeholders develop annual evidence review programme
Data management and policy
TCE and CES continue to invest in the Marine Data Exchange to be a resilient data management framework
TCE and CES continue commitment to work closely with developers to ensure data are FAIR and uploaded
Wording of site leases and marine licencing conditions developed with FAIR data expectations and formats clearly defined
Marine licence conditions include data upload to the MDE within a defined timescale
Policy tools developed to improve use of PCM data, such as statutory instruments from the Energy Act (2023)
Dissemination and translating data to guidance
OWEKH potential take on the role of disseminating information on PCM when papers and reporting become available
Government and industry invest in strategic research projects to enable researchers to undertake relevant meta-analyses
Consolidate data across multiple projects, contributing to strong opportunities for collation of regional or meta-analysis projects
SNCBs and regulators work together to co-produce a regular schedule for evidence review across all parts of the UK
Technical
International data standards established for typical PCM data, similar for example, to standards established for underwater noise monitoring
Emerging methodologies reflected in best practice guidance for analyses and modelling
PCM outputs clearly linked with adaptive management within the same development, or in future wind farm assessments
A pipeline for data management developed across the OWF lifecycle
Clear oversight of the data management pipeline across all OWFs
Other types of data (e.g. tracking, radar, rangefinder) should be considered for PCM, ensuring collision risk and sub-lethal effects can be quantified and linked to population consequences

Figure 2. Overview of content of proposed solutions presented in online whiteboard on previous page, presented from left to right, and top to bottom, for each section.

3.1. Discussion of feasibility of potential solutions

The outcome of the discussion and whiteboard feasibility assessment by participants is synthesised under the headings of the potential solutions.

Procedural solutions

- There was broad support for developing further examples of how PCM reports have helped update advice in the past, and for the need for additional resource and staff. Current examples of where guidance has been updated are discussed in the **Closing the Loop – Synthesis of evidence (D01) report Section 6.6** (and refer to the **AssESs – Summary report of uncertainty and approaches to evaluating uncertainty review (D01)**) and also case studies where guidance has not been updated based on evidence from PCM analyses are discussed in the **Closing the Loop – Synthesis of evidence (D01) report Section 6.4**.
- Some concerns were expressed about feasibility relating to the financial and staffing limitations experienced by stakeholders across the industry in the current context.
- There was broad agreement that working together to establish greater clarity on responsibility, and developing an annual evidence review programme was possible, but again, would likely require some additional changes or resourcing.

Data management and policy

- Workshop participants indicated support for The Crown Estate (TCE) and Crown Estate Scotland (CES) to continue to invest in the Marine Data Exchange (MDE) and work closely with developers in ensuring data follow FAIR data principles, emphasising the importance of data that is interoperable and reusable for undertaking pooled analyses.
- It was noted that work is underway to improve the MDE to provide a clearer overview of what data have been provided by developers, to improve transparency on data availability.
- There was uncertainty about whether the wording of site licences and marine leasing conditions could be changed to specify FAIR data expectations and formats.

Dissemination and translating data to guidance

- Participants indicated support for government and industry to continue investing in strategic research projects for meta-analyses, although questions were raised about who would be responsible for consolidating data across multiple projects.
- Participants felt it is feasible for OWEKH to take on role in disseminating information on PCM when papers and reporting becomes available. However, concern was expressed about the UK-wide applicability of OWEKH's remit, given resource limitations on the ability of stakeholders across all UK administrations to be involved with OWEKH at the current time.

Technical

- Many of the potential solutions presented in the 'technical' category were felt feasible in some way in the current context, although in most cases, some would require changes within the current context.

3.2. Broader topics raised when discussing potential solutions

3.2.1. Staffing and resourcing constraints, and the necessary prioritisation of casework

- Staffing resource is a constraint across the industry, with public sector representatives referencing a recruitment freeze, and industry representatives emphasising that constraints applied in their context as well.
- Concern was raised that many potential solutions seem to rely on SNCBs having much higher levels of staffing resource than is currently the case, raising the question of *what should SNCBs stop doing*, to accommodate any additional responsibilities. The enormous scope of areas of existing responsibility (covering the whole of the seabed and thus including responsibility for developments relating to e.g. cables, oil and gas, and pollution response, in addition to offshore renewables), was highlighted in relation to workloads, as well as the current operating context for many in the public sector.
- Workshop participants emphasised that pre-consent casework is necessarily prioritised and that, in the current context, even if additional resourcing were made available, it would likely go towards case management rather than data management roles, leading to additional challenges in ensuring data are uploaded fully at the post-consent stage. These roles and responsibilities were noted to require distinct skillsets, and thus should not be considered interchangeable. Concern was expressed that, without further resourcing, progress would be limited.

3.2.2. Investigating opportunities for working 'smarter'

- Recognising resource limitations, participants expressed support for considering how the industry could work 'smarter' and help develop best-practice, increasing communication and coordination between organisations to benefit the industry as a whole.
- Greater visibility about progress on reporting and discharge of monitoring reports was considered one potential solution that would provide more transparency for industry partners in relation to progress on review processes, while ensuring greater visibility to other actors about expectations on timelines for the availability of data and reporting, with TCE and CES indicating plans are already in place to make this happen.
- Developing best-practice and industry standards or codes of conduct was proposed as an opportunity to address some of the barriers arising, while recognising that important work has already been done in this area that seems not to have led to change but could be revisited. For example, the Renewable UK Offshore Consenting and Licencing Group (OCLG) has previously published papers including a *Proposed strategy for post-consent monitoring of offshore wind farms in England* (OCLG, 2015) and discussion paper outlining an approach for a *Strategic ornithological post-consent monitoring plan* (OCLG, 2017).
- Workshop participants also highlighted the importance of finding time and space for higher-level thinking about the overall purposes of PCM requirements and their implications for the understanding of the marine environment and the impacts of OWFs; and to ensure staff within regulators and SNCBs receive training about new developments and technologies, to ensure clarity about proposed technologies presented in monitoring plans.

3.2.3. Low support for using leasing and licencing conditions to specify data requirements

- One of the potential solutions discussed was that site leases and marine licencing conditions could be developed with FAIR data expectations and formats clearly defined. However, participants felt that licencing conditions were something of a "blunt instrument" in relation to the issues being discussed. Workshop participants felt it would be better to consider other ways to encourage industry stakeholders to understand the potential value of PCM data, and to work to take a softer approach by communicating expectations and standards clearly in a constructive manner. Suggested actions included sending a reminder of the expectation to upload data to the MDE in the communication sent to developers about licence discharge and building data requirements into monitoring plans (rather than licence conditions). Such ideas would be more subtle pathways of improving best practice in the industry but could lead directly to improvements.
- Participants also emphasised the importance of clarity about what can be delivered through licence and consent conditions, emphasising requirements to link monitoring requirements to identification of significant impacts in an Environmental Impact Assessment (EIA) for a specific application.

3.2.4. Any proposed solutions must be applicable across the whole of the UK

- Workshop participants emphasised that any potential solutions for closing the loop need to be applicable across the whole of the UK. Some of the proposed solutions presented in the workshop for example include reference to the role of the Offshore Wind Evidence and Knowledge Hub (OWEKH), an initiative of The Crown Estate. Resourcing constraints mean that not all UK administrations are able to participate in OWEKH, and as such, there is a risk that if potential solutions are integrated into OWEKH's responsibilities, not all UK administrations will be represented.
- Participants highlighted that the applicability of evidence does change across UK context, potentially meaning the same evidence could leading to different guidance being necessary in different UK administrations, given the diverse contexts and habitats (e.g. gannet nesting grounds) round the UK coastline.

4. Interactive app

4.1. Introduction

The focused group workshop adopted a participatory approach in the second session (Section 5), using an interactive app developed within the project to frame qualitative discussion around the use of data from PCM within the development of SNCB guidance. Here, we present the app in the context that it was used in the workshop. The Closing the Loop app is an interactive web-based application built using Shiny in R software and was designed to allow stakeholders to explore, quantitatively, how pre- and post-construction monitoring data can be used to provide evidence that will help to inform guidance around cumulative assessments and future project-level assessments, and to assist in identifying and resolving specific barriers to achieving this. The app is user-driven, allowing stakeholders to explore a range of scenarios relevant to their own institutional processes, and a comparison of scenarios can be helpful in identifying and understanding decisions and trade-offs involving the incorporation of evidence from PCM into guidance. The aim of this was to enable participants to explore the potential for using PCM data to inform updates to SNCB guidance, and to assist in identifying and resolving specific barriers to achieving this. This exploratory approach, delivered via a simple, user-friendly interactive tool, was demonstrated at the workshop, and allowed stakeholders to explore a range of scenarios relevant to their own decision-making processes, with outcomes synthesised into recommendations relating to implementation and uptake of the strategic approach.

The app is primarily designed to motivate discussion around increasing the use of PCM data that are either already available or currently being collected, rather than to inform discussions around future monitoring requirements. The app is divided into three sections, each of which is specifically designed around a key discussion topic relating to the use of evidence arising from PCM in updating SNCB guidance.

The first section of the app focuses on the statistical power and uncertainty associated with estimating windfarm effects, if they exist, from PCM data. This section of the app allows users to compare different scenarios relating to amounts and sources of data (e.g. number of years, number of projects). It is primarily designed to inform discussion around data availability rather than levels of data collection, such as how PCM data can be made available to add to the evidence base, which informs SNCB guidance updates whilst also reflecting sensitivities around the release of data. This discussion also includes questions around data anonymisation and the use of pooled analyses to synthesise information across multiple projects.

The second section of the app focuses on exploring the impact of variability on statistical power and uncertainty and is used to frame discussion around ways in which transferability (e.g. across time, space, species) can be accounted for when reviewing evidence and updating guidance.

The final section of the app explores how recommendations and guidance will evolve as increasing amounts of information from PCM become available, and the ways in which external shocks to the study system (e.g. avian flu, marine heatwaves) could be accounted for in this process. This scenario motivates discussion around the frequency with which evidence is reviewed and the criteria for updating SNCB guidance as well as the challenges of attributing observed differences between pre- and post-construction periods to windfarm effects in the context of a changing environment.

The app is not designed to either provide definitive quantitative outputs (which would depend on an extensive analysis of existing monitoring data, beyond the scope of this project) or to propose or advocate for an approach to the analysis of post-construction data. The app is designed as a cross-cutting communication mechanism to enable and structure discussions between different stakeholders in a focused feedback workshop.

For the app to have a fast run time, which was crucial for the live demonstration during the focused group workshop, we designed it base on annual project-level abundance using relatively simple and standard methods, which is also a reflection of high-level aggregate information that may be most readily available from PCM data. This does not imply that the approach used in the app is 'industry best practice' data analysis, and we highlight that there can be substantial benefits in utilising more sophisticated modelling approaches and in working with disaggregated data. Similarly, the focus on project-level abundance is not designed to capture all possible uses of these data, but rather to capture one of the most common ways in which current PCM data may be summarised and used. The app explores how PCM data from multiple projects can be utilised via pooled analysis or meta-analysis, into evidence that can inform the assessment process. Using a simulation-based approach requires a simplified structure for data aggregation and analysis, and the use of a simple statistical model is also designed to ensure that the operation of the app is transparent, straightforward to interpret, and fast to run. Overall, the objective of the app is to provide a mechanism to motivate and structure productive stakeholder discussion around the processes by which evidence from PCM can be incorporated into SNCB guidance and is not a best practice framework for the analysis of actual PCM data.

4.2. App specification

The app was developed using the open-source software `R v4.4.0` (R Core Team, 2024) and the `Shiny` package (Chang et al. 2024), which is used to build interactive web applications (apps). The app is divided into three sections (see Section 4.3 for more detail). In each section, users can change input parameters to create different scenarios around data collection and analysis.

The list of the core packages used to develop the app, including the versions used, can be found in Table 1. For the workshop, the app was temporally hosted online in the `shinyapps.io` platform (https://closing-the-loop.shinyapps.io/closing-the-loop-app/). The source code is also stored in a GitLab repository.

Table 1. List of core packages used to develop the app

Package	Version
`dplyr`	1.1.4
`ggh4x`	0.2.8
`ggplot2`	3.5.1
`shiny`	1.8.1.1
`shinyBS`	0.61.1
`shinydashboard`	0.7.2
`shinyglide`	0.1.4
`shinyWidgets`	0.8.6

4.3. Sections of the app

The app is divided into sections and the sidebar allows users to navigate between different sections of the app. There are three tabs in the sidebar (Figure 3) in addition to a project overview (which provides a summary of the overall purpose, scope, and capabilities of the app):

1. **Explore the ability to detect effects of windfarms under different scenarios of data availability**: simulates scenarios where the user can explore how the availability of pre- and post-impact data can influence the ability to detect the effect of wind farm developments *if* such an effect exists.

2. **Explore the impact of natural variability on the ability to detect effects of wind farms**: examines how natural spatial variability in the populations of species (due to ecological factors like food availability and breeding sites) influences the potential to detect wind farm effects if they exist.

3. **Explore how guidance will evolve as increasing amounts of evidence from PCM become available**: focuses on how the ability to detect windfarm effects and uncertainty in estimated impacts, will change over time, as increasing levels of PCM data become available. It also explores how external shocks (like marine heatwaves or storms) impact on the attribution of changes in abundance over time to windfarm effects, and the implications of this for the incorporation of emerging evidence from PCM into SNCB guidance.

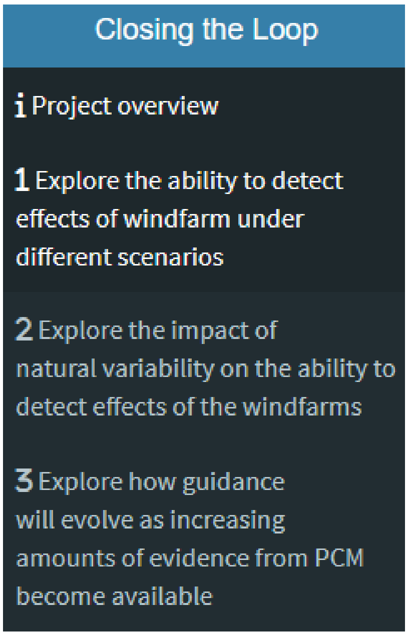

Figure 3. Overview of the different sections within the app

4.4. Explore the ability to detect effects of windfarms under different scenarios

This section allows the users to simulate and analyse the effects of a hypothetical offshore wind (OW) development on the abundance of a species over time. The user can customise several input parameters, run simulations, and visualise the results. The goal is to assess the power to detect an assumed impact of windfarms on abundance, estimate the magnitude of impact (percentage change), and visualise the uncertainty in the estimation of magnitude of impact. Users select the number of projects and years of data available (Figure 4) - note that this functionality is primarily designed to inform discussions around data availability in a pooled analysis or meta-analysis rather than to inform data collection.

4.4.1. Input parameters

Number of projects with available data: Specifies the number of projects (studies) to simulate, ranging from 1 project to 10 projects. Each project has a randomly chosen start year and a random duration of pre- and post- impact data collection.

Analysis timeframe (in years): The total number of years over which the simulated projects start data collection, ranging from 5 to 10 years.

Range of years with pre-impact data per project: Define the range of years for data collection before impact, ranging from 2 to 5. The simulation will randomly select the number of pre-impact years within this range to use for each project.

Range of years with post-impact data per project: Define the range of years for data collection after impact, ranging from 2 to 5. The simulation will randomly select the number of post-impact years within this range to use for each project.

Baseline abundance: Species abundance during pre-impact years, which has to be a positive number.

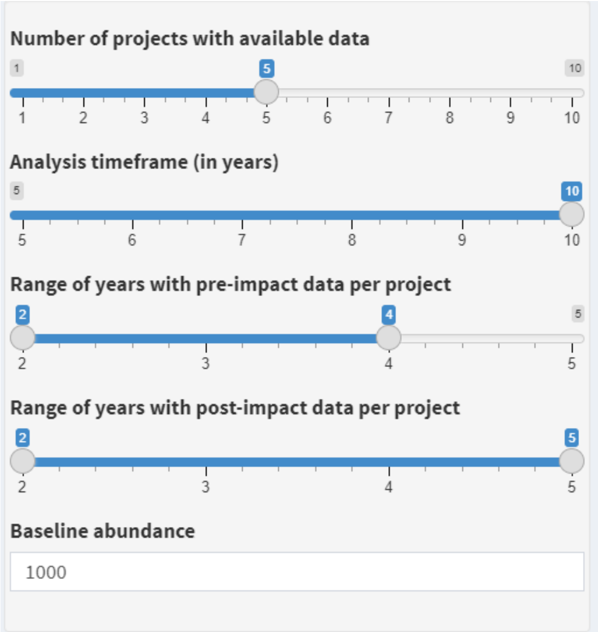

Figure 4. Overview of the different input paraments that the users can explore in Section 1. These parameters were used to simulate the data displayed in Figures 5-7.

4.4.2. Data simulation

For each project, a random starting year within the analysis timeframe is chosen, and the number of years spent collecting pre- and post- impact data is randomly assigned based on the input for pre- and post-impact ranges. The spatial and temporal distribution of the projects and their respective data collection periods can be visualised on the "Data simulations" tab (Figure 5).

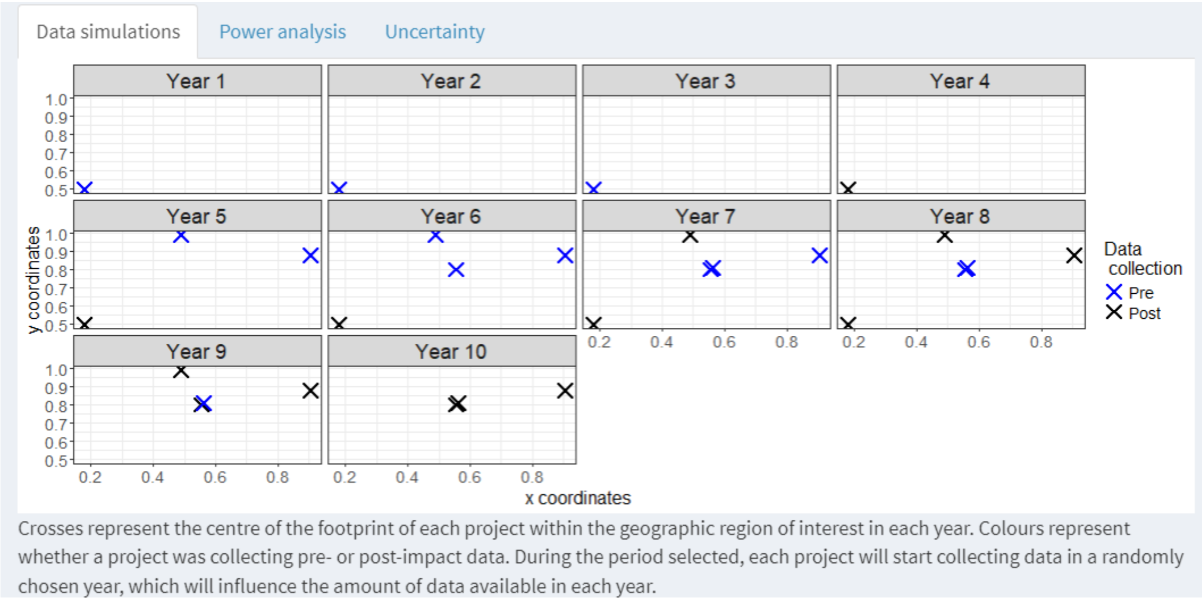

Figure 5. Example of the plot displayed in the "Data Simulations" tab in Section 1 and associated explanatory text. The input parameters used are shown in Figure 4.

Figure 5 shows the location of each project in terms of its x and y coordinates, with different colours indicating whether data collection occurred during the pre- or post-impact periods. The number of the projects, number of pre- and post-impact data collection will vary based on the inputs specify by the user. The locations of the windfarms are randomly selected (note that footprint characteristics are not considered here, the windfarms are simply denoted as point locations). Each panel in Figure 5 represents one year of data collection and the colour of the windfarm shows whether data are being collected pre-impact (blue) or post-impact (black).

The abundance of species in each project is simulated using a Poisson distribution with a logarithmic link function. The model assumes that the abundance is influenced by the windfarm effect, expressed as a percentage of change from the baseline abundance. During post-impact period, this effect varies from 0 to -50% (on the original scale) following a pre-defined list of possible effects and is zero during pre-impact period (as windfarms are not present). The model also includes noise (variability) around abundance, added via a uniform distribution (ranging from -0.5 to 0.5 on a log scale), as aggregated ecological count data will often be overdispersed (e.g. have higher levels of variability than we would expect from a Poisson distribution). For each project, data were simulated 100 times for each scenario of windfarm impact.

4.4.3. Data analysis

A generalised linear model (GLM) with a quasipoisson distribution (e.g. Poisson distribution, with standard errors adjusted to account for the effects of overdispersion) is used to estimate the effect of the period (pre- vs. post-impact) on abundance for each simulated dataset, allowing us to test if there is a statistically significant change in abundance and if so, if the magnitude of the effect. The model is fitted separately for each simulated dataset. The model calculates estimated effect size, standard deviations, and p-values for the period (pre- vs. post-impact) across all simulations for each level of windfarm effect. These results are used, for each hypothesised magnitude of windfarm effect, to calculate the statistical power of detecting an impact of that magnitude and the uncertainty around the estimated impact.

Note that, within this section, we are assuming that windfarm effects and noise (unstructured natural variability) are the only causes of variation in abundance over time, and so systematic changes in abundance between pre- and post-impact periods can be attributed to windfarm effects. This is an idealised situation, which we use to explore the ability of PCM to inform evidence around impacts of windfarms in the absence of other causal factors. In the later two sections of the app we extend the simulations and analyses in order to explore more realistic situations in which windfarm effects, if they exist, occur simultaneously with other changes (e.g. spatial variability and external shocks), so that observed changes cannot always be attributed to windfarm effects.

4.4.4. Power analysis

A power analysis was then carried out by calculating the proportion of simulations for which the difference between pre- and post-impact abundance is significantly different from zero. A plot displaying the statistical power to detect an impact (change in abundance between pre and post impact periods) as a function of the hypothesised true level of impact (windfarm effect) can be found on the "Power analysis" tab (Figure 6).

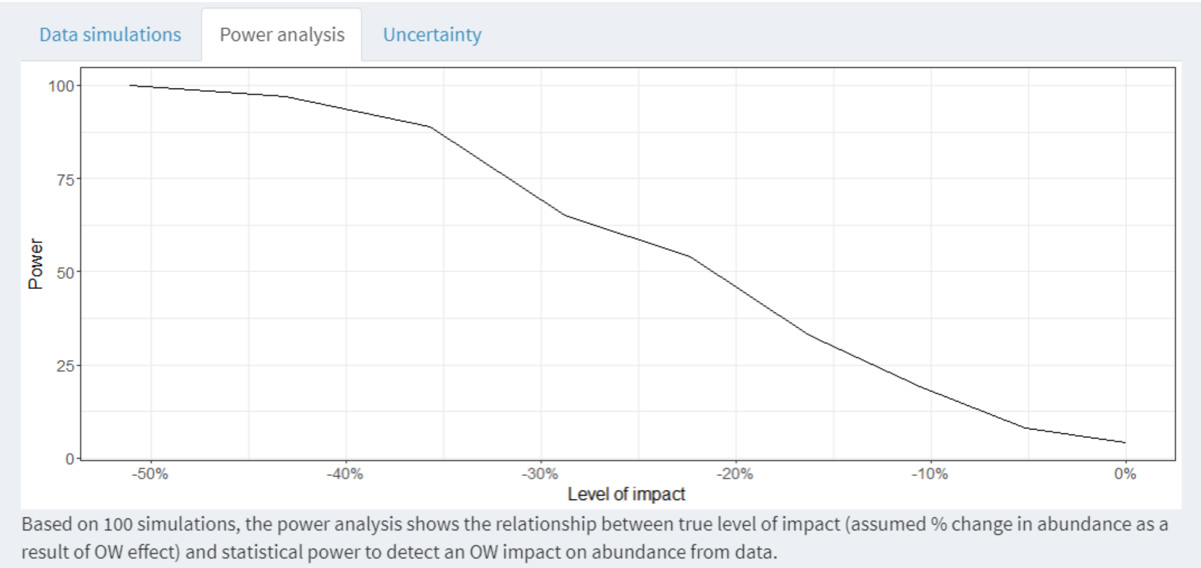

Figure 6. Example of the plot displayed in the "Power analysis" tab in section 1 and associated explanatory text. The input parameters used are shown in Figure 4.

4.4.5. Uncertainty analysis

The mean estimated level of impact and associated uncertainty were also calculated and visually compared with the true level of the impact used in the simulations. The relationship between the true level of impact (windfarm effect) and the estimated impact on abundance (estimated coefficient from the GLM) can be visualised on the "Uncertainty" tab. The plot includes the mean estimated impact with 95% confidence intervals (whiskers) and the identity line (dashed), which represents the point where the estimated impact equals the true impact. This plot helps users understand the uncertainty associated with their estimates of the windfarm effect, including the range of possible values and how precise the estimates are.

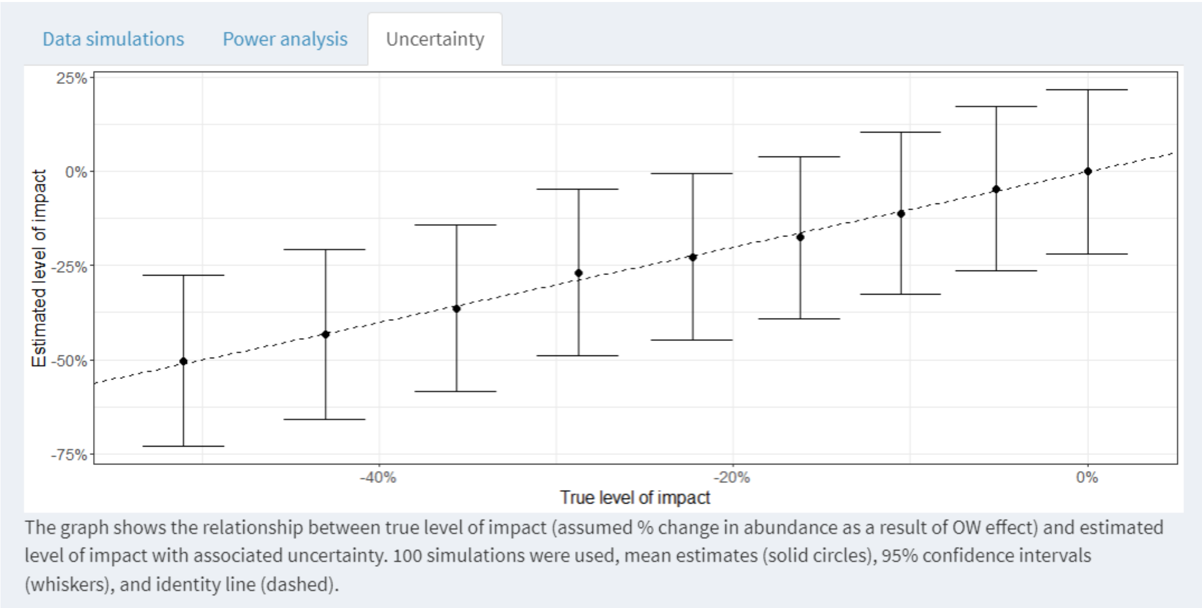

Figure 7. Example of the plot displayed in the "Uncertainty" tab in Section 1 and associated explanatory text. The input parameters used are shown in Figure 4.

4.5. Explore the impact of natural variability on the ability to detect effects of the windfarms

We extended the previous simulations and analyses to include spatial variation in the habitat of offshore windfarm developments and its impact on abundance. This section is designed to inform discussions around the transferability of evidence, and the potential value of auxiliary data (e.g., habitat information) in enabling transferability.

As in the previous section, the process followed by the app involves a simulation of data collection from multiple projects, followed by statistical analysis to estimate power and uncertainty. However, habitat variation is introduced to account for spatial differences in responses to windfarms development (Figure 8). Such variation impacts on the ability to transfer evidence from one project to another, so this section allows the user to explore how the spatial distribution of projects across different habitats influences the ability to detect an effect of windfarms on species abundance. It allows users to explore the potential benefits of incorporating auxiliary data (e.g. on habitat) into analyses, to potentially increase transferability. Although "habitat" is used in this section, this is purely illustrative, and the aim of this section is to stimulate wider discussions around how transferability across space, time and species, can be considered and improved when using evidence from PCM data to inform guidance.

4.5.1. Input parameters

Number of projects with available data: Specifies the number of projects (studies) to simulate, ranging from 5 project to 10 projects. Each project has a randomly chosen start year and a random duration of pre- and post- impact data collection.

Analysis timeframe (in years): The total number of years over which the simulated projects start data collection, from 5 to 15 years.

Range of years with pre-impact data per project: Define the range of years for data collection before impact, ranging from 2 to 5. The simulation will randomly select the number of pre-impact years within this range to use for each project.

Range of years with post-impact data per project: Define the range of years for data collection after impact, ranging from 2 to 5. The simulation will randomly select the number of post-impact years within this range to use for each project.

Baseline abundance: Abundance during pre-impact years. Needs to be a positive number.

Proportion of projects in habitat 1: Defines the proportion of projects that will be placed in habitat 1 (habitat on the left side of the x-axis, ranging from 0 to 0.5). The remaining projects will be assigned to habitat 2 (habitat on the right side, ranging from 0.51 to 1).

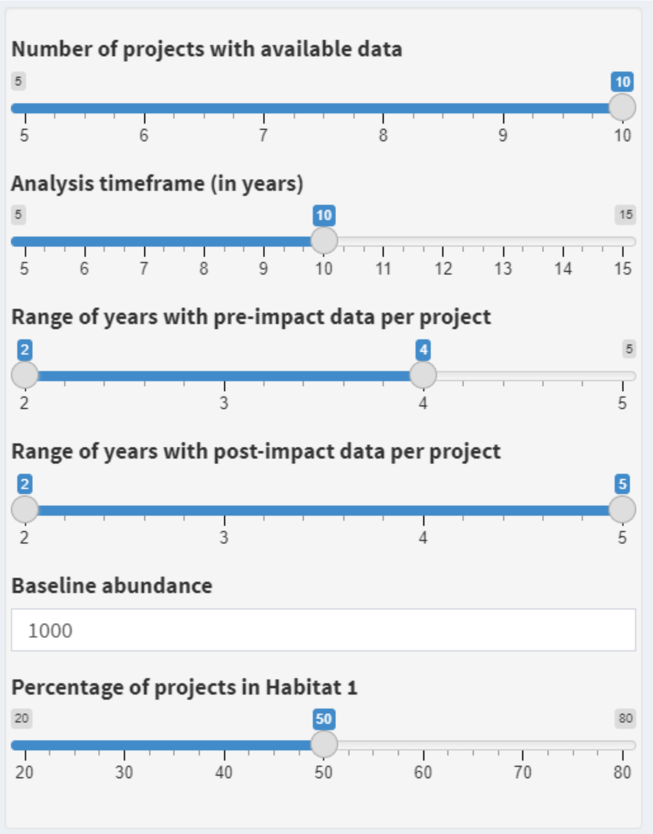

Figure 8. Overview of the different input paraments that the users can explore in Section 2. These parameters were used to simulate the data displayed in Figures 9-11.

4.5.2. Data simulation

As before, a random starting year within the analysis timeframe is chosen for each project, and the number of years spent collecting pre- and post- impact data is randomly assigned based on the input for pre- and post-impact ranges. However, here projects are assigned to one of two habitats based on the input proportion of projects in habitat 1.

The spatial variation in project locations and how data collection periods are distributed across the two habitats can be visualised in the "Data simulations" tab. Figure 9 shows the spatial distribution of projects across the two habitats. It shows the locations of each project on the x-axis (representing the habitat), coloured by whether the data was collected pre- (blue) or post- impact (black). The habitat split is indicated by a vertical line at x = 0.5.

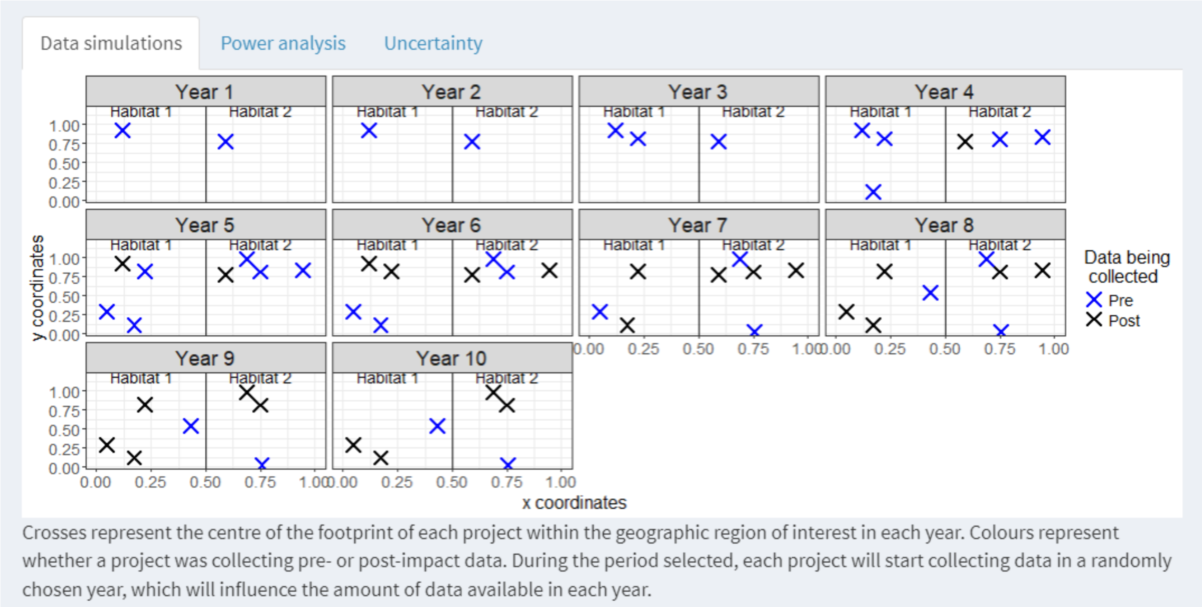

Figure 9. Example of the plot displayed in the "Data Simulations" tab in section 2 and associated explanatory text. The input parameters used are shown in Figure 8.

The abundance of species in each project is simulated using a Poisson distribution with a logarithmic link function. The abundance is modelled as a function of:

- The windfarm effect (a pre-defined list of possible effects from the offshore wind farms on the species, expressed as a percentage of change from the baseline abundance and ranging from 0 to -50%), accounting for pre- vs. post-impact data collection period.
- A habitat term, which allows different abundances based on the habitat.
- An interaction term between habitat and period, reflecting different effects depending on whether data are collected before or after the wind turbine impact.
- Random noise that is added to each simulated data point using a uniform distribution.

For each project, data were simulated 100 times.

4.5.3. Data analysis

A generalised linear model (GLM) with a quasipoisson distribution is used to estimate the effects of windfarm, habitat, and their interaction on species abundance. Two different models are fitted to the simulated data, one in which habitat data are assumed to be available and the other in which they are assumed to be unavailable. In practice, this reflects that auxiliary data relevant to the estimation of windfarm effects, such as habitat, may not always be readily available – in some cases, auxiliary data may not be directly collected as part of PCM but may be available through linking PCM with other sources of data.

4.5.4. Model without habitat

The model uses a binary variable representing whether the data is from the pre- or post-impact period and a project identifier as explanatory covariates. Although habitat information is not specifically included in the model (to reflect situations in which such data may be unavailable, or not readily available), by including a project identifier we allow the abundance to differ between projects. This allows the model to capture the spatial variability between projects, but not to estimate the mechanisms that underpin this variability.

4.5.5. Model with habitat

This model is similar to the first but incorporates the habitat variable in the analysis, reflecting the situation in which auxiliary (habitat) data are available. As in the first model, a binary variable representing whether the data were collected during the pre- or post-impact period was included, but now we also include an explanatory variable indicating the habitat type (habitat 1 or habitat 2). This allows the model to examine how habitat type influences the response variable during different periods. The interaction between period and habitat is also included in the model, which helps to determine if the effect of the pre- and post-impact periods differs between habitats. This model evaluates how the combination of the pre/post impact periods and habitat type influences the counts of the event of interest, thereby providing insights into the effect of habitat on the response variable over time.

Both models are run separately for each simulated dataset, and for different hypothesised windfarm effects, allowing for insights into how different windfarm effects may influence model outputs. The results of both models are then summarised, including mean estimates, standard deviations, and p-values, and the outputs from both models are combined into a final dataset for comparison.

4.5.6. Power analysis

As before, statistical power was calculated as the proportion of simulations for which the difference between pre- and post-impact abundance is significantly different from zero. A power analysis was run for each model (with and without habitat information) and the results visually compared. The power analysis plot can be found on the “Power analysis” tab. Figure 10 shows the comparison in the statistical power to detect an impact on species abundance, with and without the inclusion of habitat information in the analysis. It shows the relationship between the true level of impact (windfarm effect) and the power to detect that impact for each case. Figure 10 demonstrates how including habitat variation in the analysis can affect the power to detect a windfarm effect on abundance. A higher power indicates a greater likelihood of detecting an impact.

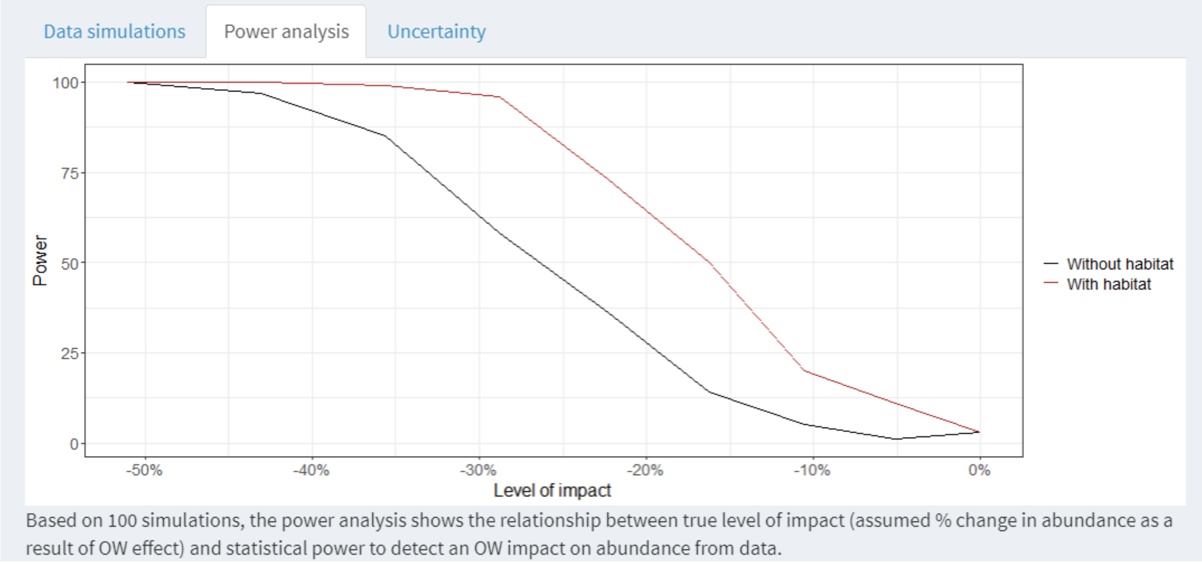

Figure 10. Example of the plot displayed in the "Power analysis" tab in Section 2 and associated explanatory text. The input parameters used are shown in Figure 8. The power curve for the model with habitat included is shown in red and the one without shown in black.

4.5.7. Uncertainty analysis

As before, the mean estimated level of impact and associated uncertainty were also calculated and visually compared with the true level of the impact used in the simulations. Figure 11 shows the "Uncertainty" tab displaying the true vs. estimated impact on species abundance, including associated uncertainty (confidence intervals). The estimates are shown separately for models with and without habitat information. This plot provides insights into how the inclusion of habitat information into the analysis affects the accuracy of the estimated windfarm effect, as well as the uncertainty surrounding these estimates.

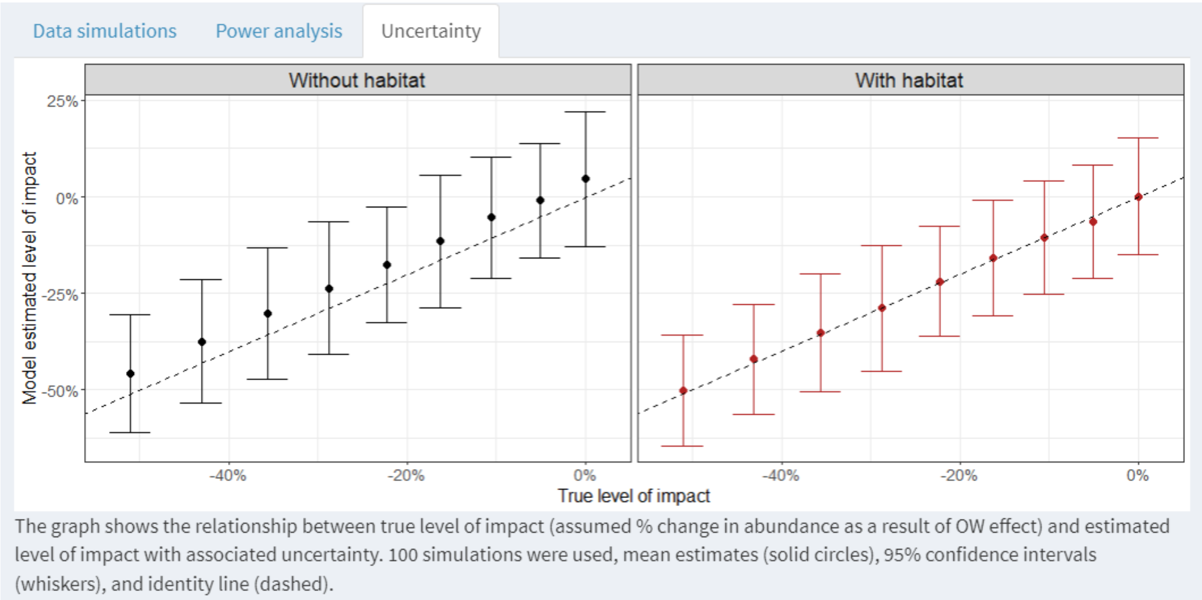

Figure 11. Example of the plot displayed in the "Uncertainty" tab in section 2 and associated explanatory text. The input parameters used are shown in Figure 8.

4.6. Explore how increasing amounts of post-consenting monitoring can feed into guidance

This section extends the previous simulations and analyses to explore the ways in which power to detect windfarm impacts, as well as the associated uncertainty estimates, evolve over time as new data become available. Increasing amounts of evidence from PCM will become available over the coming years, and this section is designed to motivate discussion around the frequency with which data are reviewed and criteria and thresholds for updating guidelines. This section considers the ways in which external shocks, such as marine heatwaves, storms and disease impact upon this process. External shocks create potential for changes in abundance over time to be mis-attributed to windfarm effects, and so have implications for the ways in emerging evidence for PCM are incorporated into guidance. Figure 12 shows the input parameters for this section.

4.6.1. Input parameters

Number of projects with available data: Specifies the number of projects (studies) to simulate, ranging from 10 to 30 projects. Each project has a randomly chosen start year and a random duration of pre- and post- impact data collection.

Analysis timeframe (in years): The total number of years over which the simulated projects start data collection, from 10 to 20 years.

Range of years with pre-impact data per project: Define the range of years for data collection before impact, ranging from 2 to 5. The simulation will randomly select the number of pre-impact years within this range.

Range of years with post-impact data per project: Define the range of years for data collection after impact, ranging from 2 to 5. The simulation will randomly select the number of post-impact years within this range.

Baseline abundance: Abundance during pre-impact years. Required to be a positive number.

Review and update frequency: Frequency of data re-analysis, starting from the second year after post-impact data is available.

External shocks: If the user opts to simulate external shocks, a year is selected in which a reduction in abundance, assumed to have a cause other than the windfarm, will occur for half of the projects.

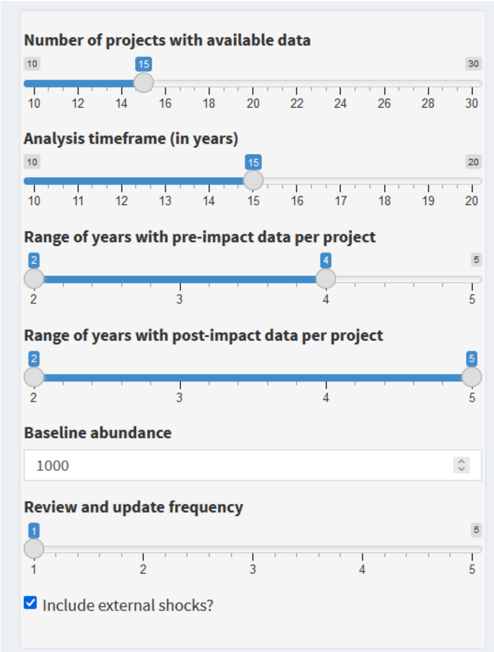

Figure 12. Overview of the different input paraments that the users can explore in Section 3. These parameters were used to simulate the data displayed in Figures 13-15.

4.6.2. Data simulations

For each simulation, the model generates abundance data using the Poisson regression described in the section "Model with habitat". This is done for all projects and over 100 simulations. Figure 13 shows an example of when external shocks are added, the model adds an additional step to the simulation: a specific external shock is applied to year 6 for half of the projects. This shock reduces the bird count by a fixed value (500 birds) during that year. The simulation ensures that the bird count does not drop below zero.

As before, the spatial variation in project locations and how data collection periods are distributed across the two habitats can be visualised in the "Data simulations" tab (Figure 13). Here projects are distributed equally per habitat. If external shocks are selected, the header in the year when external shock occur will be showed in red.

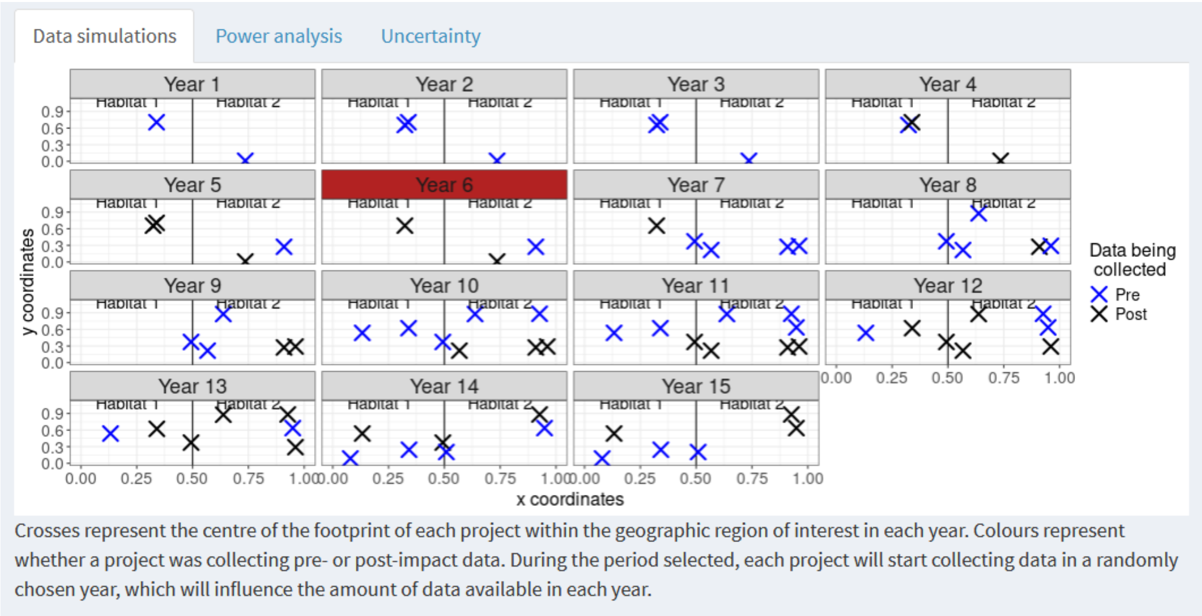

Figure 13. Example of the plot displayed in the "Data Simulations" tab in section 3 and associated explanatory text. The input parameters used are shown in Figure 12.

4.6.3. Power analysis

Instead of running one power analysis for the entire period, here we analyse the data in increments, starting from the second year after post-impact data are available with the frequency of increments specified by the user (e.g. every 1 year, every 2 years, etc.). This allows for a dynamic understanding of how the power to detect impacts, and the uncertainty in estimates, change as more evidence accumulates. If external shocks are selected, two plots are shown in the "Power analysis" tab. Figure 14 shows the relationship between the windfarm effect (level of impact) and statistical power for each year that the data is reviewed. The x-axis represents the level of impact, the y-axis shows the power to detect that impact and the colours the different review years.

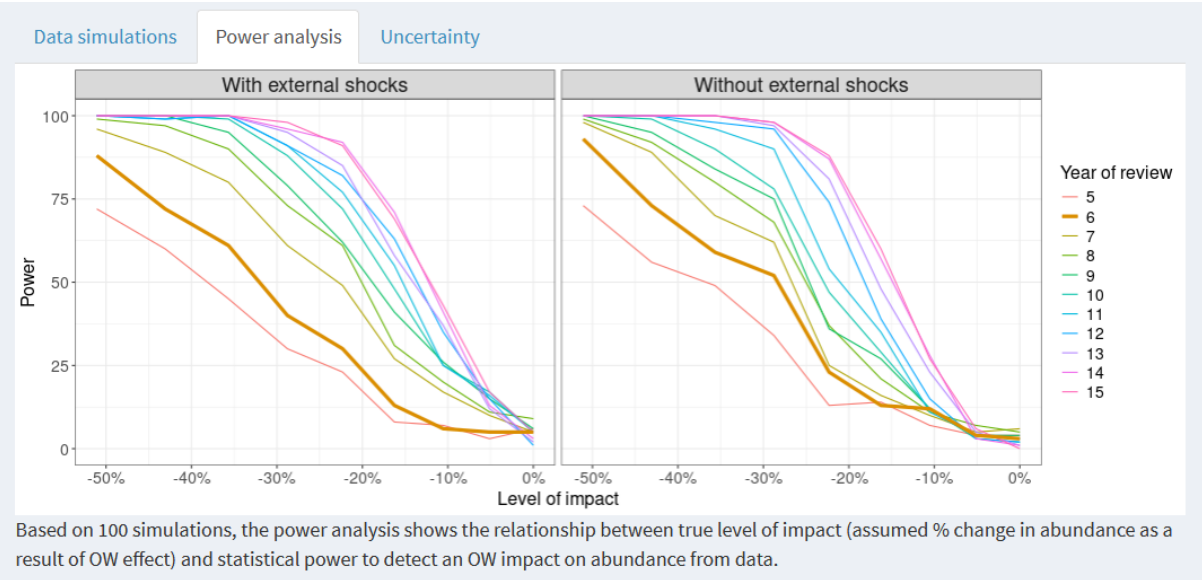

Figure 14. Example of the plot displayed in the "Power analysis" tab in Section 3 and associated explanatory text. The input parameters used are shown in Figure 12. Each colour line represents a power calculation using the data available up until the review year.

4.6.4. Uncertainty analysis

As before, the uncertainty around the mean estimate can be visualised in the "Uncertainty" tab (Figure 15). If external shocks are selected, the mean estimates and associated uncertainty for the models with external are plotted in red and the ones for the model without external shocks are plotted in black so that users can visualise the difference in mean estimates and uncertainty when a shock has occurred in one year and how this propagates over time. If external shocks are not selected, only a plot for the model without external shocks will be showed.

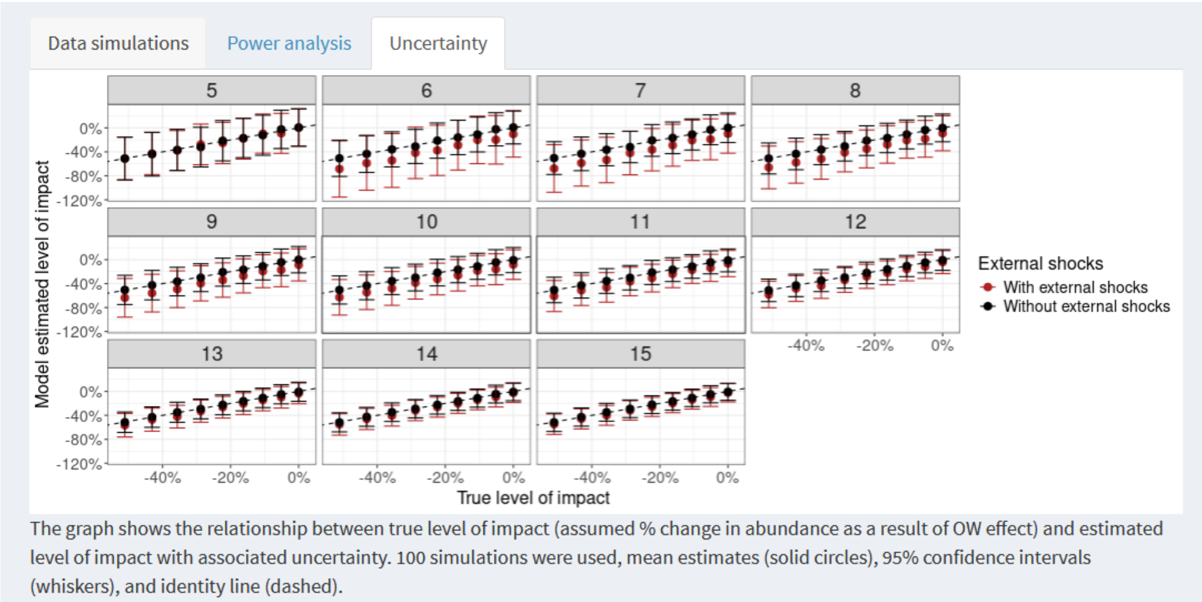

Figure 15. Example of the plot displayed in the "Uncertainty" tab in Section 3 and associated explanatory text. The input parameters used are shown in Figure 12.

5. Participatory discussion around the use of data from PCM within the development of SNCB guidance (Session 2)

The second session used a participatory approach that allowed stakeholders to explore how pre- and post-consent monitoring data can inform cumulative and project-level assessments, as well as identify barriers to achieving these outcomes. The app was presented in three sections, with live demonstrations and facilitated discussions on data pooling, transferability across time, space, and species, and the how effects of external factors like marine heatwaves may impact on the evaluation of windfarm effects on bird species. Key discussion points included the level of data needed for pooled analyses, how transferability is considered, and how data is incorporated into guidance. Here, we present the outcomes of those discussions of the issues to consider around bringing data into evidence across multiple projects.

5.1. Pooling data across projects will offer important evidence, but needs FAIR data and resourcing

There was broad agreement that working across the industry to ensure data created are FAIR (findable, accessible, interoperable and reusable) is crucial for enabling pooled analysis to be undertaken across projects. However, reference was made to challenges such as those experienced by the OWEC Planning Offshore Wind Strategic Environmental Impact Decisions (POSEIDON) project in collating and analysing data across multiple projects, where interoperability and reuse of data were challenging due to data being stored across different repositories, and in different formats.

Recognising limitations that data already created cannot be retrospectively made FAIR, participants welcomed efforts to ensure best data practice going forward.

Regulators and oversight managers are increasingly engaging with industry partners to communicate the potential benefits of making data FAIR to enable a pooled approach, and there was a call for development of case studies of where evidencing how adopting such principles in data collection can lead to benefits for actors across the industry.

The potential for using data collection standards (such as have been introduced internationally with Passive Acoustic Monitoring) was also discussed, again looking to future developments, with recognition of the need to ensure any benefits of adopting a standardised approach to data collection are visible to industry partners. This would enable data to be gathered in a more standardised manner, and such changes will only be felt in the medium-long term.

Even with successful pooling of data across projects, participants felt that challenges about comparability of data across different studies (including practical factors e.g. dates of data collection, breeding cycles, location in relation to nesting habitats etc, and technical factors relating to data formatting etc) mean there will always be inconsistences when pooling data across projects.

Participants drew attention to a recent study by Verena Peschko and colleagues presented at the ScotMer/NatureScot workshop "Evidence to Guidance Workshop – Displacement of Seabirds" (held 3 October 2024), drawing on findings from Germany (Peschko et al. 2024). However, participants expressed concern that data and reporting are too diverse in the UK context such that a similar analysis would be unlikely to deliver meaningful results. Another example raised was the Interim Population Consequence of Disturbance (iPCoD) for marine mammals, developed by SMRU Consulting, and which is currently being used in other European countries.

Findings from the Finding out the Fate of Displaced Birds project, which developed the SeabORD model (Searle et al. 2018) were also discussed as an example of research considered a 'step in the right direction' in relation to understanding displacement through using pooled data.

5.2. Taking a strategic approach to PCM was felt to offer greater potential for understanding the impacts of offshore wind farms

Participants discussed how a strategic approach to PCM would offer greater understanding of the impacts of OWFs beyond what can be achieved through pooled analyses, potentially creating greater holistic understanding, rather than trying to combine what one participant called "piecemeal" studies. A strategic monitoring approach was proposed as one that could focus resources on understanding issues such as improving understanding of collision risk across the board.

While many participants highlighted potential benefits of taking a more strategic approach to PCM, there was recognition of the need to create necessary policy environments to support strategic monitoring, and that adopting such an approach would require substantial flexibility within the current governance context, including a wholesale shift in approach to the rationale for undertaking monitoring. Importantly, any strategic approach adopted would need to be developed in a manner that ensures developers are able to fulfil their project-specific licencing conditions as currently stated and are able to realise the benefits of a more strategic approach.

- Participants commented that the definition of 'strategic monitoring' would likely change between different stakeholder organisations, leading to a brief discussion about "What is meant by strategic monitoring?". As such, participants felt any discussion of adopting a more strategic approach to PCM should be preceded by an opportunity to reach common agreement on what such an approach would entail.

- There was a need to ensure clarity about who would be responsible for strategic monitoring, highlighting how developers would be likely to be most engaged in regions where they have development interests, and that provision needs to be made to ensure developers can continue to meet leasing and licencing conditions at the project level.
- Strategic monitoring was felt to offer an opportunity to move beyond validating impacts, which was considered a binary approach by one participant. Instead, adopting a larger-scale monitoring programme would allow a more detailed understanding of how and why impacts occur.
- It was noted that some developers have worked together to adopt a more strategic approach to PCM, with the example of how the North East, East Developers Ornithology Group (NEEOG) have implemented strategic monitoring in practice. In an industry-led initiative, NEEOG partners have contributed to a central resource to undertake digital aerial surveys (DAS) across a wider area than would be possible on project-by-project approach and are initiating collaboration on seabird tagging deployments. This approach was recognised as mobilising resources more rapidly than would be possible through government-funded research (although public-industry research collaborations are also beneficial in this context), and in delivering a wider programme of monitoring than was initially indicated, increasing the knowledge and understanding of the cumulative impacts of OWF.
- Importantly for the success of the NEEOG programme, participants indicated that NEEOG is actively involving the relevant SNCB in discussion about specific areas on which to focus for their monitoring, and the relevant regulator is engaging with NEEOG partners to ensure licencing conditions for individuals projects are being fulfilled while undertaking monitoring in a more strategic/regional manner.
- The Regional Advisory Groups (RAGs) for OWFs in Scottish waters were also discussed as an example of good practice of clusters of developments are coming together to undertake monitoring.

5.3. Accounting for transferability when reviewing evidence

Within discussions of transferability of data across projects, discussion arose about how academic researchers can better communicate their findings such that they are more accessible to non-academic partners across the industry. Participants emphasised the importance of ensuring that research outputs, including academic publications, clearly indicate the **underlying assumptions and limitations of research** and data presented, and give a strong indication of the **confidence placed in the results**, as some of the challenges in relation to the transferability is that research outputs often omit to include details about the underlying assumptions and context.

5.3.1. Communication of research findings

- There are different types of research publication: research contract reports, often developed in discussion with Project Advisory Groups which involve representatives from across the industry, are often considered more ‘usable’ by practitioners and experts within the non-academic sector. Academic journal publications go through a peer-review process that provides additional confidence and context to a publication and is considered the 'gold standard' for scientific knowledge, which SNCBs acknowledge is useful when considering including new evidence into guidance. However, some of the practical value of findings can be lost through the academic peer-review process.

- Participants suggested that researchers in an academic context could help by creating short policy notes or easy-to-read executive summaries of their work, emphasising the applicability and transferability of findings to the OWF industry.
- The potential was raised that the Offshore Wind Evidence and Knowledge Hub (OWEKH) could have a role in breaking down topics into sub-topics in more detail, if needed (Evidence Notes summarising the evidence base on a topic-by-topic basis is anticipated to be a key output of OWEKH). It was noted however, that OWEKH, as an initiative of The Crown Estate, and as mentioned earlier, resourcing constraints mean that not all UK administrations are able to engage with OWEKH at this time, leading to concerns about inclusiveness of this approach across the whole of the UK.
- Recognising the benefits of peer-review as review by experts, it was also noted that processes such as workshops, review of PCM reporting by statutory consultees, and involvement in Project Steering Groups, also fulfilled a 'peer-review' role, providing external advice and input into the research and reporting/publication processes, even where those processes are different from academic peer review.

5.4. Incorporating data and evidence into guidance

With the continued expansion of the UK offshore wind industry, and increasing uncertainty given the impacts of climate change (i.e. both physical impacts, such as stronger more sustained extreme events, and knowledge impacts, such as uncertainty about how seabirds will respond to climatic changes), participants discussed challenges in understanding baselines for evidence going forward. Workshop participants emphasised how decisions are made on the best-available data at the present time, but the increasing uncertainty caused by factors such as climate change and the increasing amounts of data and PCM reporting from OWFs already in operation or coming into operation, will mean that incorporating data and evidence into guidance will likely become more challenging in future.

5.4.1. Knowledge exchange across the industry

- The provision of advice needs consistency but also relies on precedence and must account for potentially unintended consequences of new evidence. These factors make the development of new guidance a complex task. New findings and evidence can sometimes create a push for change, but a distinction was made during the workshop between adding to the body of evidence on which SNCBs draw from, rather than such evidence *being* the body of evidence. Gannet displacement was given as an example, where data consistently indicates a displacement rate of 70-80%, meaning that such consistency could be acted upon. Yet the challenge of UK-wide introduction of such findings was raised, given the different habitats (e.g. nesting sites) of gannets around the UK coastline, and hence transferability to different areas is still uncertain.
- Participants felt there was value in opportunity to learn from others across the industry and internationally. Workshops bringing experts across the industry together and the ScotMER

Symposium were considered important opportunities for getting different perspectives on data and hearing directly from researchers. Such workshops were felt to be a good way of collating views from different experts, but challenges arise when reporting or evidence raises more questions than it answers, and/or opens other doors of uncertainty.

5.4.2. Further impacts of staffing and resource limitations

- The challenges relating to incorporating data and evidence into guidance often relate to resourcing issues across the industry. This challenge will be compounded if staffing and resource constraints continue, as, in addition to staffing needs for case management and data management, staffing expertise and time is needed review evidence, and to understand and discuss its implications. Investment is also needed in IT infrastructure, as well for training staff on new tools and data systems, to ensure staff are able to continue performing their roles into the future.
- In resource-limited organisations, finding the time to review evidence and update guidance is challenging when responsibilities also include meeting statutory deadlines in case management.
- Participants also highlighted how even if OWEKH or other organisations create platforms and spaces for effective review, finding time to participate in such initiatives on additional to existing responsibilities, was considered extremely challenging, or not feasible.

6. Conclusions

Feedback from proposed potential solutions gave broad support for developing further examples of how PCM reports have informed advice in the past, alongside a recognition of the need for additional resources and staffing. Current examples of where guidance has and has not been updated based on the analyses of PCM data will be discussed further in the final recommendations report for this project. Collaborative efforts to clarify responsibilities and establish an annual evidence review programme were also seen as achievable, although they would require further resourcing. Participants indicated support for continued investment in the Marine Data Exchange (MDE) by The Crown Estate and Crown Estate Scotland to work with developers to in ensuring that data follow FAIR principles. Similarly, government and industry investment in strategic research projects for meta-analyses was welcomed. OWEKH was considered a feasible mechanism for disseminating PCM information as new reporting becomes available, and many technical solutions were regarded as viable, albeit with some changes required in the current context.

However, concerns were raised about the feasibility of certain potential solutions due to financial and staffing constraints across the industry. There was uncertainty about whether site licences and marine leasing conditions could be amended to specify FAIR data expectations and formats. Concerns were raised over who would be responsible for consolidating data across multiple strategic research projects. Additionally, participants expressed concern about OWEKH's ability to operate effectively across all UK administrations, given existing resource limitations.

Key points that arose from the potential solutions discussions in the workshop are that staffing and resource constraints remain a significant challenge across the industry, affecting both public and private sector organisations. The recruitment freeze in the public sector and wider industry limitations raise concerns about how additional responsibilities could be accommodated. Pre-consent casework is prioritised, and the distinct skillsets required for these roles further complicate resource allocation. Resourcing issues limit the ability to review and incorporate new evidence into guidance. Investment in IT infrastructure and staff training is required to support the increasing amount of data that will be produced. However, even when organisations like OWEKH create platforms for evidence review, it is challenging for staff to find the time to engage due to existing workloads.

Despite resource limitations, there is support for working ‘smarter’ by improving coordination, communication, and best practice across the industry. Increasing transparency on reporting progress, revisiting existing best-practice guidance, and ensuring staff receive training on new developments and technologies were identified as key opportunities for improvement. Finding time for strategic thinking about the overall purpose of PCM requirements and implications for the understanding of the marine environment and the impacts of OWFs was highlighted as an important function.

There was little support for using leasing and licencing conditions to mandate specific data requirements. Participants felt that such conditions would be too rigid and instead favoured a more constructive approach, such as improving communication around expectations, sending reminders to developers, and integrating data requirements into monitoring plans rather than formal licence conditions.

Proposed recommendations must be applicable across all UK administrations. Resourcing constraints currently limit participation in initiatives such as OWEKH, raising concerns about representation if solutions are tied certain organisations. Additionally, environmental and regulatory differences across the UK administrations mean that evidence may lead to varying guidance in different regions, further highlighting the need for flexibility in any proposed approach.

The **bringing data into evidence discussion** found there was agreement that FAIR principles should be applied to data collection, to better enable pooled analysis to be undertaken across projects. Participants recognised that efforts are being made to ensure datasets are made available as soon as possible. However, there are challenges around data collation, availability, management, and governance and while past data cannot be retrospectively improved, participants welcomed efforts to ensure best practice is adopted and to develop case studies demonstrating the benefits of FAIR principles. Greater standardisation of data collection could help in the long-term, with participants emphasising the benefits would need to be visible to industry partners. Concerns were raised about practical and technical differences around the UK that the applicability of international studies are limited.

A strategic approach to impact monitoring could enhance understanding beyond individual studies, but it requires policy changes, clearer definitions, and ensuring developers can meet licensing obligations. Collaborative efforts like NEEOG demonstrate the potential for industry-led strategic monitoring.

Improving research communication is essential, as findings often lack clarity on assumptions and confidence levels. Policy notes or summaries could enhance accessibility, and platforms like OWEKH (Evidence Notes) could help but face resource constraints. The expansion of the UK offshore wind industry and increasing uncertainty due to climate change create challenges in defining evidence baselines. Decisions are made using the best-available data, but the growing volume of data and evolving environmental conditions will make integrating evidence into guidance more complex. Consistency in advice is important, but new evidence can create pressure for change. Some findings, such as gannet displacement rates, show consistency and yet their transferability across different UK regions remains uncertain. Workshops and symposiums are valuable for knowledge exchange across the industry, providing opportunities to learn from experts and researchers. However, there are challenges as new findings can raise further questions including around additional uncertainty.

The feedback and findings from this workshop were fed into the development of a set of recommendations and a roadmap for closing the loop to incorporate PCM data back into the assessment process (**Closing the Loop – Recommendations & roadmap (D05)** report). Despite resource challenges, workshop participants were keen that changes can be made to improve current processes. Discussions during the workshop emphasised the need for project outputs to be resilient into the future, accounting for increasing data volumes, technological advancements, and changing environmental impacts.

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Appendix 1: Organisations represented at the workshop

Crown Estate Scotland

Cyfoeth Naturiol Cymru

Department for Environment, Food and Rural Affairs (DEFRA)

Joint Nature Conservation Committee (JNCC)

Marine Management Organisation

MacArthur Green

Natural England

Nature Scot

Renewable UK

Scottish Government

The Crown Estate

UK Centre for Ecology & Hydrology

Appendix 2: Interview consent form

Please delete any lines below to which you do not give your consent:

[Email]

[Telephone]

By participating in the "Closing the Loop" project workshop, I confirm that:

- I have read and understand the information sheet for "Closing the Loop." I have had the opportunity to ask questions, and these have been answered.
- I understand that my participation is voluntary, and I am free to withdraw at any time, without providing any reason, and without my legal rights being affected.
- I understand the study is conducted by researchers from The James Hutton Institute and partner organisations, funded through The Carbon Trust/Offshore Renewables Joint Industry Programme (ORJIP).
- I understand taking part will involve participating in co-production/stakeholder engagement activity that is recorded on MS Teams, and the recording will be transcribed (without names) for notetaking purposes.
- I understand my words may be quoted in publications, reports, and other research outputs in anonymised format (e.g. 'an industry representative' 'SNCB representative').
- I agree my organisation's name can be included in a 'list of participants' in any workshop outputs.
- I agree my personal contact details can be retained in a secure database so that the researchers can contact me for future studies.
- I agree to being contacted in the future in relation to this or other relevant studies.
- I have read and understood the privacy notice (below).

Privacy Notice

The James Hutton Institute ("Hutton", "us" or "we") will use your personal data for the purposes of the research undertaken in the project 'Closing the Loop in accordance with our privacy notice at https://www.hutton.ac.uk/privacy-notice. The James Hutton Institute is a data controller for the data collected in this study.

Please note that your personal data may be shared with project partners and subcontractors participating in the research

team. These parties are data controllers on their own right and will handle your personal data in accordance with their respective privacy policies. In some instances our subcontractors may be processing your personal data under our instructions and/or our behalf, in which case they act as data processors. We have put in place appropriate contractual clauses to ensure that your data is protected adequately by data processors. Where this is possible, we will only share anonymised or aggregated data.

This project is part of a project funded by the Carbon Trust/Offshore Renewables Joint Industry Programme.

Personal data will be retained for a period after the completion of the project to allow further contact in relation to this and future relevant projects. Our main privacy notice will explain what we do with personal data in more detail as well as your rights.

If you have any queries about your personal data, you can contact our Data Protection Officer [email]

Appendix 3: Information sheet

CLOSING THE LOOP: PARTICIPANT INFORMATION SHEET

Feasibility study to determine a feedback approach for post-consent monitoring to reduce consent monitoring risk in future assessments

You are invited to take part in research about the barriers and potential solutions for incorporating post-consent monitoring data back into the consenting process for offshore renewable developments, thereby 'closing the loop' as part of the wider adaptative management paradigm.

RESEARCH AIMS

As part of a project to understand the institutional, technical, scientific and statistical challenges to 'closing the loop' of post-consent monitoring data, we are undertaking research with key institutions in the consenting process and in establishing requirements and standards in relation to post-consent monitoring data.

Discussions held as part of this research will be part of co-producing a strategic approach, relevant across devolved administrations, for improving the use of post-consent monitoring data, and will lead to recommendations identifying and resolving barriers to the use of post-consent monitoring data to improve assessments, thereby reducing consent risk.

This research is funded by ORJIP – the Offshore Renewables Joint Industry Programme through the Carbon Trust.

WHO IS INVOLVED?

The project team is led by [name], Strategy & Development Lead for Offshore Renewables at BioSS, and includes colleagues from the James Hutton Institute, UKCEH, ABPMer, SMRU Consulting, the University of St Andrews and SEFARI Gateway. The lead researcher for this part of the study is [name], Senior Social Scientist at the James Hutton Institute.

STAKEHOLDER ENGAGEMENT & COPRODUCTION

You have been invited to take part as a representative of an organisation with a key role in the consenting process of offshore wind in the UK. We acknowledge that we cannot cover everyone or everything, but are keen to engage a wide range of stakeholder organisations.

No preparation work will be necessary. This will be an online workshop, with opportunity to provide feedback on findings from the study to date, and to feed into the development of the strategic framework for closing the loop.

The workshop will be video recorded (in MS Teams) to allow the research team to focus on the conversation and ensure an accurate record of the discussion. The recording will only be available to the research team and a professional transcriber, all of whom are bound by relevant data privacy and confidentiality agreements.

We will not use your name in any outputs or reporting. With your consent, we would like to have the option to list the organisations represented in the workshop (by organisation name) in the final workshop report.

HOW WILL MY DATA BE STORED?

Any personal information will be confidential and will only be seen by the research team and transcriber. The data gathered will be used to inform our research and develop presentations, reports and academic publications. Your information will be stored securely on Hutton systems for the purposes of this and potential relevant future contact on this topic.

DO I HAVE TO TAKE PART?

No. Participation is voluntary and you can withdraw from the study at any point without giving reasons and without any negative consequences.

How can I withdraw from the study?

If you wish to withdraw from the study, please contact [name, email] within one week of the workshop if you do wish to withdraw from the study.

ETHICAL REVIEW

The project has been reviewed by the Research Ethics Committee of the James Hutton Institute. If you have any concerns about the way in which the project has been conducted, or you wish to make a complaint, please contact [email].

FURTHER INFORMATION

If you have any further questions, please contact [name, email].

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