Integrating Bird and Marine Mammal Monitoring into Offshore Wind Energy Development Infrastructure and Operations

Final Workshop Report

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Technology Solutions to Mitigate Use Conflicts: Technology Needs for Scientifically Robust Wildlife Monitoring and Adaptive Management

Task 4.4

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Table of Contents

List of Tables

Acronyms and Abbreviations

ADLS	Aircraft detection lighting systems
AUV	Autonomous underwater vehicle
BRI	Biodiversity Research Institute
GPS	Global positioning system
IMU	Inertial Measurement Unit
Motus	Motus Wildlife Tracking System
MUSE	Multi-Sensor Bird Detection
NOAA	National Oceanic and Atmospheric Administration
NOWRDC	National Offshore Wind Research and Development Consortium
OSW	Offshore wind
PAB	Project Advisory Board
PAM	Passive acoustic monitoring
R&D	Research and development
SCADA	Supervisory Control and Data Acquisition
SME	Subject-matter expert
UAS	Unoccupied aerial system
VHF	Very high frequency

Glossary

Autonomous underwater vehicle (AUV) – AUVs are programmable, robotic vehicles that, depending on their design, can drift, drive, or glide through the ocean without real-time control by human operators. Some AUVs communicate with operators periodically or continuously through satellite signals or underwater acoustic beacons to permit some level of control.

Blade – Blades capture the wind's energy and convert it into mechanical energy.

Buoy – Floating device which can be anchored or drift with the currents which can be equipped with various sensors and instruments to record data

Cables - The electrical transmission infrastructure that carries the generated electricity from the wind turbines to the onshore grid or distribution network

Camera - Thermal IR cameras detect temperature by capturing different levels of infrared light and can detect surfacing marine mammals

Drone – A flying robot that can be remotely controlled or fly autonomously using software-controlled flight plans in its embedded systems, can capture images and video along transect (fixed-wing system) or over individuals (multi-rotor system)

Foundation – Secures the tower and above-water turbine components to the sea floor. A variety of technologies are available, including jackets, monopiles, and gravity-based foundations.

Glider - an autonomous, unmanned underwater vehicle used for ocean science, such as for monitoring marine mammal presence and behavior.

Hub – The hub supports the blades and houses the pitch system, which optimizes blade angle and rotation speed.

Maintenance Vessel – A specialized ship or boat designed and equipped for the maintenance, repair, and logistical support of offshore wind farms

Mooring Lines – The cables or lines that secure floating wind turbines or other offshore structures to the seabed

Nacelle – The nacelle houses the components that convert mechanical energy to electrical energy.

Offshore Substation – The offshore substation collects and stabilizes the power generated by the turbines, preparing it for transmission to shore.

Passive Acoustics (Birds) - Microphone and recorder that capture sounds in environment, including bird calls

Passive Acoustics (Marine Mammals) Records acoustic signals continuously or triggered by events (towed array or bottom-mounted)

Platform - A structure or area that provides support for the various components of the turbine. It serves as a foundation for the turbine tower and other necessary equipment.

SCADA system – Control system that manages turbine operations

Secondary entanglement - The occurrence of marine life becoming entangled with marine debris, such as derelict fishing gear, that is snagged on a mooring line or inter-array cable.

Substation - Serves as a central hub for the wind farm's electrical infrastructure and performs several important functions, including power collection, power transformation, grid connection, as well as control and protection of electricity flow.

Supply Vessel – A specialized ship or boat that is primarily used for providing logistical support and transportation of personnel, equipment, and supplies to offshore wind farms

Tags - GPS locations (satellite and archival tags), as well as possible video, acoustic, depth, and movement data (archival tags)

Tertiary entanglement - Where marine debris or active fishing gear already entangling an animal becomes caught on the infrastructure and anchors the animal.

Tower – The tall structure that supports the nacelle, hub, and blades of a wind turbine above the water surface.

Radar – A technology that uses radio waves to detect and track objects, including the presence of marine mammals on or near the water’s surface.

Unoccupied aerial system (UAS) – aerial drone (including multi-rotor and fixed-wing models)

Wind loading – The forces and stresses exerted on the turbine structure and its components due to the action of the wind

Executive Summary

The project, “Technology Solutions to Mitigate Use Conflicts: Technology Needs for Scientifically Robust Wildlife Monitoring and Adaptive Management,” is identifying research and development needs for wildlife monitoring technologies for birds and marine mammals at offshore wind (OSW) farms. This includes a specific focus on developing technologies to 1) achieve statistically robust studies that can inform understanding of the effects of OSW energy development on birds and marine mammals, as well as informing mitigation and adaptive management of observed effects; and 2) become integrated into OSW infrastructure and operations.

Two virtual workshops were held in February and March of 2023 to discuss the limitations and opportunities for deploying and integrating wildlife monitoring technologies into OSW structures and platforms, as well as integrating the deployment and maintenance of these technologies into standard OSW operational procedures. Thirty-five subject matter experts, including research scientists, resource managers, turbine engineers, technology developers, and OSW operations and maintenance specialists, participated in this discussion.

Workshop participants discussed a range of barriers to integration of bird and marine mammal monitoring technologies into OSW activities including human safety concerns, limited physical access and space for desired technology deployment locations on offshore infrastructure, complications relating to durable attachment of monitoring technologies to OSW infrastructure, and issues associated with providing power and other resources for monitoring technologies. Discussion also included data security concerns associated with incorporating wildlife monitoring technologies into OSW data networks, and challenges caused by the timing of different planning activities during the OSW development process, which can make it difficult to integrate wildlife monitoring plans into the designs of OSW farms.

Workshop participants identified a variety of research and development opportunities that could help to address key deployment and operational limitations and better integrate wildlife monitoring systems into OSW infrastructure and operations. These included opportunities to deploy technologies on a range of different platforms, improve remote data access, standardize the external resources needed by wildlife monitoring technologies (e.g., power, data transfer, physical space, etc.), and adjust the design of offshore structures to better support these standardized wildlife monitoring systems. Continued discussions among multidisciplinary teams of OSW engineers, technology developers, wildlife biologists, regulators, operations and maintenance specialists, and other experts will be needed to ensure that technologies are safely and effectively integrated into OSW development. Further discussion of these opportunities and final project recommendations will be included in the final report of this project.

1 Introduction

1.1 Objectives

Data collection and monitoring for offshore wind (OSW) energy development should be question-driven and scientifically robust; otherwise, funding spent on wildlife monitoring may not meaningfully inform future environmental assessments and adaptive management decisions (Wilding et al. 2017). The existing Tethys WREN resources oversees the open access "Wind Energy Monitoring and Mitigation Technologies Tool” database, and includes monitoring tools for land and offshore wind projects for a variety of receptors, However, there is currently no comprehensive synthesis of the technologies available to collect statistically robust wildlife data at OSW facilities, inform adaptive management, and reduce precautionary mitigation. Similarly, there is currently no comprehensive evaluation of the capacity of monitoring technologies to be integrated into normal operations and maintenance of windfarms. This project, “Technology Solutions to Mitigate Use Conflicts: Technology Needs for Scientifically Robust Wildlife Monitoring and Adaptive Management,” aims to inform technology development relative to the following:

- Achieving statistically robust studies that can inform understanding of the effects of OSW energy development on birds and marine mammals, as well as mitigation and adaptive management of observed effects; and
- Integrating monitoring technologies into OSW operations.

The project incorporates input from a wide range of stakeholders via an expert Project Advisory Board (PAB), as well as workshops and individual expert engagement efforts with research scientists, resource managers, turbine engineers, technology developers, and OSW operation and maintenance specialists.

The first task of this project was to write a memo to compile the most up-to-date information on priority conflicts that are likely to become barriers to OSW progress as environmental compliance issues or stakeholder concerns. This assessment was written by Advisian, Worley Group in collaboration with Biodiversity Research Institute and focused on:

- Identifying areas of potential conflict for bird and marine mammal species in the U.S. Pacific, Atlantic, Gulf of Mexico, and Great Lakes regions.
- Species of marine mammals and birds that could be impacted by OSW development, along with the known issues where data gaps exist, proxies are not available, or there is significant uncertainty.
- Providing an overview of potential OSW cumulative effects on marine mammals and birds; and
- Identifying research topics that have been highlighted by experts as priorities for research and monitoring as the industry progresses.

Based on the findings of this memo, priority questions were identified and used to guide the discussion during two workshops with subject matter experts (SMEs). The workshops focused on identifying:

- The technologies and methods (including sample size and scale considerations) needed to answer priority research questions;
- Factors influencing the level of uncertainty in results produced by these technologies;
- Major bottlenecks and limitations of available methods/technologies that additional research and development (R&D) could address; and
- Ideas to streamline bottlenecks.

The goals of the integration operations workshops were to identify the following:

- Limitations to, and opportunities for, integrating bird and marine mammal monitoring technologies into offshore infrastructure, particularly wind turbines; and
- Identification of operational integration opportunities to allow for robust, effective bird and marine mammal monitoring during OSW activities (in all development phases) without interfering with or substantially changing existing activities and procedures.

This report focuses on summarizing the results of workshops held jointly with OSW and research platform developers as well as SMEs focused on marine mammal and bird monitoring, to identify limitations and opportunities for integrating monitoring technologies into OSW infrastructure and operational procedures. Subsequent project activities will focus on documenting the technical specifications and capabilities of existing monitoring technologies, identifying limitations and opportunities for integrating monitoring technologies into OSW infrastructure and operational procedures, and synthesizing findings into a final project report with targeted recommendations for R&D of bird and marine mammal monitoring technologies. Additionally, it is worth noting that our goal is to make our project findings easily integrated into existing efforts, such as the Tethys database.

1.2 Workshop Details

1.2.1 Format

The technology integration workshops were conducted in two sessions (2.5 hours each) in February and March 2023 using video conferencing and a Mural virtual whiteboard (www.mural.co). The Mural whiteboard remained open for the participants to add comments and suggestions for an additional week following each session. Prior to the workshop, SMEs received 1) a brief summary of workshop objectives and the elicitation process to be used during workshop sessions and 2) a brief compilation of the types of wildlife monitoring technologies that could be deployed at offshore wind farms for marine mammals and birds. The Mural virtual whiteboard was organized to help facilitate discussion during workshop sessions and to capture participant ideas in a collaborative format.

After a brief introduction to the project and Mural platform, attendees were invited to contribute ideas focused on limitations of deploying or integrating wildlife monitoring technologies on structures and platforms expected to be used in OSW and potential opportunities for integration of these wildlife monitoring technology and OSW structures (in the first meeting). Identified platforms for potential deployment of monitoring technology included: Hub and Nacelle, Blades, Drone, Tower and Platform, Buoy, Foundation, Substation, Supply or Maintenance Vessel, Mooring Lines, Cables, and Autonomous Vehicles/Gliders (definitions for these platforms are included in the Glossary, above).

The second meeting focused on several case studies for potential technology integration that were collaboratively investigated using a combination of group discussion and written feedback via the Mural platform.

1.2.2 Participants

In addition to project personnel, a total of 34 SMEs (Table 1) participated in one or both of the technology integration workshop sessions. SMEs had expertise in a variety of wildlife monitoring methods, OSW structures and platforms, and OSW development and operations, and represented academia, non-profit organizations, the offshore wind industry, environmental and technical consultants, technology development companies, and government agencies.

Although the workshop participants comprised a diverse group of subject matter experts, it is worth acknowledging there were some expertise gaps in the passive acoustic monitoring and engine turbine engineering fields. Additionally, the workshop facilitators faced the challenge of finding the optimal balance between specialized and broad expertise, with certain participants expressing concerns about the significance of their contributions.

Table 1. List of Technology Workshop Participants

Name	Affiliation
Tom Barracca	Stony Brook University
Brittiny Bennett	EPI Group
Dorian Brefort	Exponent Consulting
Mark Baumgartner	Woods Hole Oceanographic Institution
Ethan Butler	Ocean Power Technologies
Elizabeth Clarke	National Oceanic and Atmospheric Administration
Matthew Kowalczyk	Ocean Floor Geophysics
Scott Croft	Terrasond
Michael Crowley	Rutgers University

Name	Affiliation
David Demer	National Oceanic and Atmospheric Administration
Robb Diehl	U.S. Geological Survey
David Goldstein	Ocean Power Technologies
Chris Hein	National Renewable Energy Laboratory
Roger Hewitt	National Oceanic and Atmospheric Administration
Stephen Hillier	Worley
Andrew Gilbert	BRI
Michael Jones	Subsea Sail
Michael King	Ocean Infinity
Jochanan Kollwitz	Ørsted
Naomi Lewandowski	Department of Energy Wind Energy Technologies Office
Pam Loring	U. S. Fish and Wildlife Service
David McLaurin	Worley
Danny Merritt	Liquid Robotics
Rhonda Moniz	Regional Wildlife Science Collaborative
Kaj Skov Nielsen	Independent Consultant
Kim Peters	Ørsted
Jon Ritter	Wildlife Imaging Systems
Mel Schultz	National Offshore Wind Research & Development Consortium
Nick Sisson	National Oceanic and Atmospheric Administration
Seth Stansbury	Ocean Power Technologies
Jennifer Stucker	WEST Inc.

2 Integration Limitations and Solutions

Workshop participants discussed a range of barriers to integration of bird and marine mammal monitoring technologies into OSW activities, including human safety concerns, limited physical access and space for desired technology deployment locations on offshore infrastructure, complications relating to durable attachment of monitoring technologies to OSW infrastructure, and issues associated with providing power and other resources for monitoring technologies. Discussion also touched on acoustic and other interference caused by OSW infrastructure, which can hamper some types of data collection, and challenges caused by the timing of different planning activities during the OSW development process, which can make it difficult to integrate wildlife monitoring plans into the designs of OSW farms.

2.1 Physical Access

2.1.1 Limitations

Workshop participants described physical access constraints for different platforms, including the hub and nacelle, the tower, and the turbine blades. Discussion about monitoring technology access for integration onto the hub and nacelle primarily focused on deployment of camera technologies. There were concerns that cameras collect a large amount of data and that physical access for data download, as well as system maintenance, may be difficult and expensive. Remote access to the camera data would likely be a requirement for camera installations on the hub and nacelle, especially if real-time or near-real-time data access is needed. Workshop participants also identified that deployment of monitoring technologies on towers and blades is technically difficult and would have access issues. Lastly, subsurface or submerged structures are generally difficult to physically access, for example sensors attached to subsurface cables or moorings would likely be difficult to access. One workshop participant also indicated that some OSW developers are moving toward automated operational and maintenance activities, so on-site visits or access may not occur regularly.

2.1.2 Solutions

Proposed solutions for physical access issues primarily focused on remote data access, including options such as very high frequency transmission, satellite communications, and line-of-sight transmission of data. A solution that was repeatedly suggested was using a mobile platform such as an unoccupied aerial system (UAS) or autonomous underwater vehicle (AUV) to communicate with multiple types of wildlife monitoring systems to conduct wireless data transfers. In addition, the use of UAS and AUV technologies to conduct routine surveys of the OSW structures could also provide opportunities for possible remote data transfer using these platforms. There was also discussion about the potential to transfer data via fiber optics in cables or within operations data systems, with further discussion around the data security needed to use such systems.

2.2 Attachments

2.2.3 Limitations

There were concerns identified with both above-water and subsurface attachment locations for wildlife monitoring technologies. One participant noted that no structural modifications should be made to the tower structures, such as drilling into watertight housings, and that any attached technologies would need to be attached using magnets. In addition, mounting technologies on turbine blades pose risk due to lightning and mechanical issues. Attachments of Motus station structures on turbine platforms are recommended to include a physical connection to the platform itself, not just the railing, to withstand any loads placed on the equipment. Lastly, installing sensors on submerged structures is extremely challenging, and it was suggested that this would only be possible via retrofitting after the structures are installed. It was also noted that subsurface installations are at risk of damage from fishing activities, including activities such as trawling as well as interaction with lost or abandoned fishing gear or other marine debris.

2.2.4 Solutions

The primary proposed solution to mitigate attachment limitations was to create a standardized attachment system that can be deployed on the platform. This solution is described in greater detail in the case study section focused on standard platform development (Section 3.3).

2.3 Space and Equipment Size

2.3.5 Limitations

The space available on certain platforms is limited and the size of some monitoring technologies may be too large or cumbersome for some platforms. Areas that were identified as limited in space included the hub and nacelle, but future changes to platforms need to be considered as well. For example, it was noted that OSW turbine platforms are getting both higher off the sea surface and smaller in size, which could impact which technologies can be mounted on these important structures. Monitoring technologies such as radars and Motus stations have a large footprint and require substantial space. In addition, if technologies will be deployed from vessels, the vessel space available to carry monitoring platforms such as buoys, passive acoustic monitoring (PAM) systems, drones and operators, and/or gliders could be a limitation for deployment of these systems.

2.3.6 Solutions

Proposed solutions to mitigate platform space and technology size limitations were limited, but participants identified specific locations where technologies could be deployed effectively (e.g., radars on higher portions of substations to reduce obstructions and increase field of view). In addition, some technologies with small footprints were identified, including multi-rotor UAS, which are launched from a small portion of a vessel deck or other platform, and cameras on top of foundations. The development of integrated systems such as camera-radar-thermal systems was also suggested as a possible (partial) solution, as they might have a smaller footprint than those technologies installed individually. In addition, some participants identified the scalability, power supply, and longevity of specific AUVs, such as gliders, which are not appropriate platforms for all technologies but are able to carry multiple sensors with a range of power and physical space options.

2.4 Power Supply

2.4.7 Limitations

Power supply is of particular concern for monitoring technology installations on subsurface platforms. Any installations on subsurface moorings and cables would need to rely on alternative power supplies. Power supply is available, but limited, for autonomous or unoccupied systems including UAS and AUVs, specifically on the scale of minutes to hours for UAS, and days for AUVs. Power supply options include power provided from docking on a vessel or other powered structure. In addition, some AUVs such as surface vessels are able to be powered by wind and solar. An exception to the power limitations of unoccupied systems may be subsurface or surface gliders which can be deployed on longer time scales.

2.4.8 Solutions

Some participants suggested the use of monitoring technologies with very low power requirements (e.g., passive electromagnetic sensors) or the integration of multiple power sources (e.g., a combination of wind, solar, and wave power supply for AUVs and buoys) to support monitoring technologies and provide redundancy in power supply. There may be potential for systems attached to the turbine structure to connect to power systems used powering other operations. Replacement of batteries and power supplies may be achieved for autonomous platforms during routine maintenance activities like vessel surveys for scour.

2.5 Safety

2.5.9 Limitations

Worker safety concerns were primarily focused on sensitive or moving parts of turbines such as the blade, nacelle, and hub. Workshop participants identified that there are higher health and safety risks when humans are working on or near the hub, nacelle, and blades than on the turbine platform. In addition, the hub and nacelle are confined spaces that require specific training and procedures for access.

2.5.10 Solutions

Solutions to safety concerns primarily focused on limiting physical access to structures and using autonomous platforms to conduct maintenance surveys and to meet data access and power needs.

Redundancies and planning around anticipated end-of-life of monitoring equipment that cannot be directly maintained were also discussed.

2.6 Data Storage and Security

2.6.11 Limitations

Data security concerns primarily focused on the opportunities and risks of integrating marine mammal and bird monitoring data streams into the OSW developer's data network. Though options such as cellular networks have been used by wildlife monitoring technologies in other deployment scenarios, this is not a reasonable option for locations far from shore (due to lack of cell service), and even in locations where this is a feasible option, workshop participants identified that many operators would likely be reluctant to incorporate cellular networks into data transfer protocols. Autonomous platforms, such as PAM buoy systems, can transfer data via satellite or data can be directly downloaded from them, though archival data creates data storage limitations. Some workshop participants indicated that it would be a serious security risk to have external connection to equipment on turbine structures to download data. Some workshop participants recommended transferring data through the OSW developer data network, which addresses some security concerns but substantially complicates the ability to retrieve monitoring data. Other participants suggested that integrating wildlife monitoring data into the OSW network is essential, despite the data security risks, and identified the possibility of data storage in an OSW "data lake" such that data could be remotely transferred from the monitoring system but, for security reasons, would then have to be retrieved from the data lake by the developer in order to be provided to researchers. This is particularly complicated if real-time or near-real-time monitoring is needed, as there could be a delay in data transfer.

Storage concerns were primarily related to continuous data collection methods or monitoring technologies that collect large datasets, including acoustic, radar, and camera systems. The storage of all raw video files or continuous acoustic recordings may not be feasible if the sole data retrieval method is through internet or remote access. In addition, if real-time access is required, an internet or remote connection is required.

2.6.12 Solutions

Solutions for security concerns primarily focused on conducting remote or wireless data transfers using communication systems that are external to the OSW data and communications network. Solutions for storage concerns primarily focused on integrating platforms that could remotely access data, such as linking the communication systems of buoys and gliders, or by relying on fiber optic cable that can be made available at multiple platforms including the tower, nacelle, substation, and foundation. It was suggested that OSW developers could have a second data network dedicated to monitoring non-turbine systems, which some wind farms already have, and which would facilitate data transfer and worker safety while also ameliorating security concerns. Alternatively, if there is a desire to integrate data transfer into the OSW developer network, discussions about the security and implementation of this should commence early in the design process.

Edge computing or filtering datasets for detections of wildlife using algorithms could assist with the storage limitations.

2.7 Data Quality Considerations

2.7.13 Limitations

A number of issues were identified by workshop participants concerning negative influences on data quality as a result of deployment near or on OSW structures, including acoustic, visual, and other interference, as well as stabilization requirements. Possible interference in data collection from OSW structures includes influences of OSW structure noise on PAM or active acoustic monitoring efforts that render the data not usable, possible radio energy interference between OSW turbines and radars that can lead to multipath detection, and acoustic interference from electronics and engine noise on vessels if used for monitoring purposes. The field of view for cameras/radars may also be limited by the turbine structures; for example, the field of view of cameras deployed on the hub or nacelle will vary based on the rotation of the hub and nacelle. Similarly, radars may have a substantial shadow from the turbine structure or from sea clutter that masks signals and reduces data quality and/or field of view.

Stabilization requirements were identified for many moving platforms including vessels and buoys, where gyroscopic stabilization of monitoring systems, inertial measurement unit (IMU) positioning data, and video post-processing could all help reduce variability and interference in data collection caused by the lack of a stable platform. Importantly, floating OSW platforms could introduce concerns for stabilization of technologies placed anywhere on the turbine structure, and precise global positioning system (GPS) coordinates may be difficult to obtain as floating platforms experience small positional shifts.

2.7.14 Solutions

Solutions proposed by workshop attendees focused on using novel technologies and methods to account for reductions in data quality. For issues such as noise interference, one workshop participant highlighted that there are filtering mechanisms to improve the quality of acoustic data. For subsurface instruments, antifouling mechanisms can help to maintain the accuracy and longevity of data collection. Some data collection methods could also be broadly improved using novel technology, for example, using UAS to increase the range of observation for protected species during protected species observing.

2.8 Challenges Related to the OSW Planning Process

2.8.15 Limitations

There are several issues relating to the timing of OSW design, planning, and infrastructure deployment that make the deployment of wildlife monitoring technologies challenging. First, the design and planning of OSW farms often happens well before the details of wildlife monitoring plans have been identified. One workshop participant stated that the monitoring requirements from regulators are often not known until late in the design process, which makes the process of modifying or changing the structures to accept required monitoring technologies almost impossible. Discussions about integrating wildlife monitoring data streams and OSW data streams (Section 2.6) likewise need to occur relatively early in the design process, often much earlier than wildlife monitoring plans have been developed. Second, certain platforms may have limited deployment durations, which limits their ability to host wildlife monitoring technologies for prolonged periods. For example, LiDAR buoys are not expected to be deployed and maintained for the duration of OSW projects. Buoys are suitable platforms for some types of technologies during the pre-construction and construction periods but may not be viable platforms during the operational period. In addition, structures and platforms are developed and deployed at different times, so decisions about some monitoring platforms may need to happen earlier in the design process.

2.8.16 Solutions

Standardization of wildlife monitoring technologies and joint deployment of multiple monitoring systems may help to address some of the timing concerns. In particular, workshop participants recommended the development of dedicated platforms designed specifically to host wildlife monitoring equipment, which could be outfitted to accommodate changes in new technology over time and could help to standardize power supply, space, and other resources available to monitoring technologies. Clearly defined wildlife monitoring requirements by regulators, including details such as deployment locations, duration, type of data to be produced, and questions to be answered, would also help OSW developers to better integrate monitoring plans into broader OSW planning efforts.

3 Case Studies

3.1 Background

Five case studies allowed workshop participants to investigate specific integration opportunities in more detail. Each "case study" was a question the workshop organizers posed to the group to explore the potential of different ideas for integrating wildlife monitoring into OSW farm design and operations:

- How can maintenance vessels be used in wildlife monitoring?
- How can we develop a standardized space or platform on turbine structures for wildlife monitoring technology?
- How can autonomous equipment connect into offshore wind infrastructure to transfer data and power?
- How can we deploy a combined radar-camera system on turbine platforms?
- How can we use or modify the detection sensors on cables and mooring lines used for debris fouling detection to detect secondary or tertiary marine mammal entanglements?

Four categories of considerations were discussed for each case study, including the integration of wildlife monitoring with 1) other OSW farm operational procedures, 2) OSW infrastructure design and engineering, 3) worker safety considerations, and 4) data security considerations. Participants were asked to indicate challenges and potential opportunities for each of these four topic areas.

3.2 How can maintenance vessels be used in wildlife monitoring?

3.2.1 Operational Considerations

Operational challenges identified when using maintenance vessels for wildlife monitoring focused on communication between interested parties, especially concerning the prioritization and timing of tasks. Communication between relevant parties was highlighted as a key consideration for operational planning to avoid possible discrepancies between the scope and timeline of operations and maintenance for OSW structures and the scope and timeline of those activities required for wildlife monitoring. There is also prioritization of the operations and maintenance requirements of the OSW structures compared to the tasks required for wildlife monitoring. One workshop participant noted OSW vessels are unlikely to do extra work in addition to what is required which could result in the need for additional staff on OSW vessels. In addition, there were some concerns over the ability to obtain necessary data from the ship's instruments such as GPS and IMU where GPS tracks of vessels would need to be made available post-trip. Ensuring there is clear communication about data offload and data sharing needs between vessel operators and researchers after the trip is important for efficient data quality and processing.

Potential opportunities and solutions identified for maintenance vessels and wildlife monitoring included utilizing remote technology systems for accessing wildlife data and maintaining monitoring systems to reduce the need for additional specialists' presence on OSW vessels. Remote technologies could include robotics, UASs, gliders, and AUVs. OSW maintenance vessels could also provide opportunities to manually retrieve and deploy any equipment needed for monitoring, given that the crew members receive appropriate training on deployment and retrieval methods. To date, both AUVs and UASs have been deployed successfully from OSW maintenance and supply vessels.

3.2.2 Engineering Considerations

In order to be used for wildlife monitoring efforts, maintenance vessels need to have sufficient space on deck or below deck for storage and deployment of the monitoring technology. For some larger systems such as PAM systems, space on board may be limited. In addition to deck space, maintenance vessels would be required to have appropriate lifting gear such as A-frames and cranes to deploy monitoring equipment. Any monitoring systems that will be deployed on vessels will also need to be carefully waterproofed if not already a feature of the equipment.

A workshop participant noted the layout of the OSW farm itself may not be appropriate in scale, size, or spatial resolution for marine mammal or bird monitoring efforts. Ultimately, the design of the OSW farm will prioritize power generation over sampling design for wildlife monitoring.

Solutions and opportunities included the possible development of wireless-enabled systems that can send and receive data when proximate to turbine structures. It was also suggested that OSW farms that are not currently under construction could be built with different communications systems to ensure better transfer of data and information. This solution would also be applicable to operational considerations once developed.

3.2.3 Safety Considerations

Safety challenges include the requirement for substantial training for any personnel boarding and working on an OSW supply or maintenance vessel. As a result, wildlife biologists are unlikely to be the personnel deploying or maintaining wildlife monitoring systems unless onboard to direct the vessel crew. Alternatively, wildlife biologists could train vessel crew on the equipment they are servicing and create easy-to-use documentation to guide maintenance and data download processes. Remote data transfer via autonomous systems (such as described above) could also help to reduce reliance on vessel crews that are unfamiliar with deployment and maintenance of wildlife monitoring technologies reducing offshore exposure hours. One participant noted it is safer to have personnel on a vessel than transferring from a vessel to an OSW turbine structure. In addition, the development of autonomous systems may be able to reduce the human-hours that are spent in the offshore environment, thereby further reducing safety risk to OSW operations crews.

There are also additional safety considerations for the deployment of certain types of wildlife monitoring technologies in the vicinity of floating OSW farms, as the increased amount of cabling in the water column will limit or prevent the use of some technologies, such as towed PAM arrays.

3.2.4 Security Considerations

There is an opportunity to develop wireless data transfer practices when OSW vessels are in close proximity to turbines or other OSW structures, but there are challenges associated with the security of data transfer in this way. It is likely, due to bandwidth limitations, only subsets of the data would be able to be transmitted via cloud services, and any redundancy or data backups would not be transmittable using remote access.

3.2.5 Other Considerations

One workshop participant noted the relatively small market for offshore wildlife monitoring technologies has hindered their development to date. It was suggested that an expanded market for wildlife monitoring technology (e.g., as the OSW industry continues to develop globally) would support improvements to these technologies, as well as to the process of their deployment on vessels, while reducing overall cost.

3.3 How can we develop a standardized space or platform on turbine structures for wildlife monitoring technology?

3.3.6 Operational Considerations

There is a temporal mismatch between the timing of the turbine design process and most ecological monitoring decisions, which complicates the design and implementation of wildlife monitoring activities. Incorporation of a standardized platform/location for wildlife monitoring could help to address this mismatch by building resources and capacity into turbine designs early in the development process. A major concern with this approach, from a wildlife monitoring perspective, is how to decide which monitoring equipment is prioritized, as the platform space will be limited. The development of a standardized space or platform would also require an adaptive plan that can be modified over time, as platform configurations (specifically size and available space) will change over time, as will the size and weight of monitoring technologies. Ideally, there would be space included to test novel technology, and adaptive monitoring plans would be implemented to review and update technology as appropriate. More specifically, there were operational concerns about interference from electrical signals, as well as the process to store and transfer data. Of note, some turbine brands have already dedicated fiber optic lines for non-supervisory control and data acquisition (SCADA) uses, but this is optional and not required.

3.3.7 Engineering Considerations

The development of a standardized platform for wildlife monitoring on turbines elicited concerns regarding technology-specific deployment needs, longevity, and physical access:

- Multiple standardized platforms may need to be developed depending on the monitoring technology, including developing above- or below-surface platforms. Some monitoring technologies also require specific configurations or mounting needs, such as Motus, which needs to be mounted on a railing or platform as far from the turbine tower as possible. Importantly, the direction of attachment (relative to a compass heading) may not be adjustable or may need to be decided prior to deployment. Thermal cameras mounted to turbine platforms would require an unobstructed view and would have power requirements.
- The possibility of sensors to detect marine mammals on underwater cabling was mentioned. Engineering considerations for this form of monitoring technology would have to involve issues such as loss of equipment due to marine debris and additional strain on underwater cables.
- The longevity of the monitoring technology must be considered, as the life span is often significantly shorter than that of the turbines. Therefore, equipment connections will need to be relatively simple so they can be changed out over the life span of the project. Participants also mentioned concerns about corrosion control as well as wind loading for anything that is mounted on turbine structures. Wind loading concerns were thought to be particularly relevant for monitoring systems deployed at the nacelle and for floating OSW structures.
- Physical access concerns focused on technology deployment on towers and blades, which can be important for monitoring and mitigation (e.g., strike detection systems and blade-mounted deterrents), but lead to access and safety concerns for maintenance and data downloads.

Ultimately, it was felt that a standard way to access data remotely would be necessary, as would a standardized mounting design and potentially a direct power source. However, the development of this standardized wildlife monitoring technology platform on turbines would allow for novel combinations of technologies and help to ensure wildlife monitoring can be effectively conducted in a more standardized way.

3.3.8 Safety Considerations

To ensure worker safety, the platform location on the turbine would need to allow for safe access by crew, and the equipment would need to be easy enough to install for regular maintenance personnel to handle it. Any sort of plug-and-play option for installation is the safest option. In addition, platforms can only be mounted on a railing if the railings are dual-purpose for both safety and gear mounting (e.g., taking both human safety and gear loading into consideration). It will be important to discuss with turbine designers whether there are specifications for railing designs and/or latch-on points that should be considered when designing a monitoring platform in this location. Safety for people engaging with equipment and platforms may be affected by any ability of the platform to create a place birds or pinnipeds may access for perching/hauling out.

3.3.9 Security Considerations

One participant highlighted the security of the installed technology could be a concern (e.g., the internet protocol [IP] version used by a specific technology), while another mentioned the importance of maintaining regulatory security requirements and standards. There was a suggestion that it would be helpful to develop some kind of standardized interface for data to be transferred using turbine fiber connections, which could also simplify changeover of equipment in the future.

3.4 How can autonomous equipment connect into offshore wind infrastructure to transfer data and power?

3.4.10 Operations, Safety, and Security Considerations

Workshop participants expressed concerns that docking an external uncrewed surface vessel, AUV, or UAS to a turbine platform or substation could lead to liability issues. There may likewise be liability concerns with the launching of UASs in airspace proximate to the OSW farm. Participants also mentioned there may be a temporal mismatch between necessary manual inspection or handling of autonomous vehicles and the strict operational schedules required for OSW farms. However, some AUVs have significant onboard storage capacity, which could help to coordinate these schedules at least with regard to data storage. It was suggested any transmission of data over wireless systems could be a security concern, as some wind turbine manufacturers and developers do not allow wireless capability.

The use of aerial drones in connection with UAVs was discussed as some drones are able to be launched from UAVs. However, multiple concerns were brought up around this concerning limitations of drone operators as well as regulatory concerns.

3.4.11 Engineering Considerations

Workshop participants indicated AUVs or uncrewed surface vehicles that harvest energy and are powered could likely dock on a platform or substation, while non-energy harvesting vehicles that are more reliant on currents likely could not dock and would be unsafe in close proximity to OSW structures. Some AUVs that are surface vehicles are specifically able to rely on solar power which could extend the battery life and reduce the need to connect to physical power transfer points.

For powered autonomous vehicles, workshop participants mentioned further concerns about the lack of standardization for UASs and AUVs, which makes it difficult to develop the types of standardized connections, transfer stations, and communication networks that would be required to autonomously connect to OSW structures. In addition, there were specific concerns about connecting autonomous equipment to floating OSW structures; workshop participants indicated substations for floating OSW may be located under the sea surface, which could limit the opportunities for integration with UASs and some AUVs. Some AUVs have the capability to use multiple communication methods, which could address some of these concerns. For example, wave gliders and other AUVs can deliver data using multiple methods including radio communications that can integrate with the data stream of the OSW network.

3.5 How can we deploy a combined radar-camera system on turbine platforms?

3.5.12 General considerations

Recent tests of the MUSE radar-camera system (Tjørnløv et al. 2023) have helped to validate this system for use in monitoring birds and bats at OSW farms. This system can operate year-round and is a commercially available product that has been deployed on a number of projects. However, there are several concerns and challenges regarding safety; in addition to safety risks associated with simply accessing an OSW turbine (e.g., for systems deployment and maintenance), the spinning units in the marine radar system may represent an added danger on turbine platforms, especially in the winter where there is a risk of ice throw from the unit. It was suggested the unit could be situated on a dedicated platform extension on the correct side of the turbine, away from the hoist. There were also concerns with data transfer and validation. Multiple opportunities to expand this combined data system were discussed, including integrating radar from aircraft detection lighting systems (ADLS) with cameras on turbines, integrating mitigation techniques like stop-on-demand, and possibly combining additional systems such as thermal cameras to assist with detections of bats and marine mammals.

3.6 How can we use or modify the detection sensors on cables and mooring lines used for debris fouling detection to detect secondary or tertiary marine mammal entanglements?

3.6.13 General Considerations

From the perspective of technology sensitivity and gear testing, it is important to first determine whether the debris fouling detection technology is capable of differentiating between debris fouling and secondary or tertiary entanglement. If entanglement detection is possible, then the next question becomes the timeline on which this information could be transmitted. It would be important to define the timeline for identifying a potential entanglement problem, as well as the timeline of expected response (e.g., mounting a disentanglement effort via ship or plane). Prior to technology development, it would be important to determine whether any specialist fibers are required to be integrated into the cable, as well as the method of data storage and transfer, especially if the data access is required to be real time or near-real time.

4 Additional Comments from Project Advisory Board

The PAB for this project includes experts from OSW companies, non-governmental organizations, and state and federal agencies. PAB feedback on the above workshop results included:

- There are recent tenders, particularly in the Netherlands, that include wildlife monitoring technology requirements within bids (capabilities, numbers, and ranges, not requirements to use specific systems). Including requirements in tenders is one way to drive development and adoption of new technologies targeted toward answering key research questions.
- There may be some existing tech that can be altered to meet new needs.
- We do not currently have a standard pathway to technology verification, or a defined point at which Department of Energy, Bureau of Ocean Energy Management, or other agencies say a certain technology is a verified system. This makes it difficult to create sufficient investment in new technologies as well as integrating them into monitoring plans.
- With the US developing OSW at such a large commercial scale, we have an opportunity to develop the monitoring tech at scale as well, especially when thinking about cumulative impacts. This will be key to ensure technology development and production is economically viable.
- A success story was shared regarding the IdentiFlight technology for detecting eagles at terrestrial wind farms. A key component to the success was that industry was looking for solution – there was a desire from industry to conduct this research.
- A group such as the new Technology Subcommittee of the Regional Wildlife Science Collaborative might be a good platform to continue these conversations. Other discussion fora brought up by PAB members included the Western Governors Association and the West Coast Ocean Alliance.

5 Conclusions

There are a variety of opportunities to better integrate wildlife monitoring technologies into OSW farm design and operations. This integration will require concerted effort by OSW developers to pursue these wildlife monitoring activities and by technology developers to better address existing technological and operational limitations. **Continued discussions among multidisciplinary teams of OSW engineers, technology developers, wildlife biologists, regulators, operations and maintenance specialists, and other experts will be needed to ensure technologies are safely and effectively integrated into OSW development.** Specific issues discussed during the workshop included the following:

The different timelines on which OSW design/planning and wildlife monitoring planning are conducted. This temporal mismatch in planning processes creates an enormous challenge for integration. Clearly defined wildlife monitoring requirements by regulators, including details such as deployment locations, duration, type of data to be produced, and questions to be answered, would help OSW developers to better integrate monitoring plans into broader OSW planning efforts. Additionally, OSW developers and turbine engineers could set aside designated resources (physical space, power and fiber connections, etc.) for wildlife monitoring systems on turbines, even if the exact systems/models are identified much later in the OSW development process. Additional collaborative effort to define standards for these designated resources could help OSW developers as well as wildlife biologists and regulators to define what resources are needed and are feasible to engineer into OSW design plans.

Tradeoffs between data security and human safety. Many OSW developers are reluctant to allow wildlife monitoring systems to use turbine fiber connections for data transfer. There are very real data security issues associated with turbine SCADA systems. However, without remote data access, wildlife monitoring systems require physical access for downloading data, which introduces clear safety concerns for OSW crews, especially when systems are deployed on turbines. Concerted effort to create a separate fiber network for non-SCADA data, or to develop other remote data transfer options such as via UASs/AUVs, would support worker safety. Remote data access is also strongly preferable from a wildlife monitoring perspective, as biologists are better able to determine when systems may need maintenance and can analyze data in something closer to real time rather than waiting months or years to access data from offshore systems.

Ensuring wildlife monitoring technologies do not impact OSW performance. Installation of additional technologies on OSW platforms, and potential for resulting wear/corrosion or additional wind loading, are concerns that will need to be addressed and carefully monitored as systems are deployed. There are particular issues with drilling into structures, using safety structures such as railings for deployment purposes, and the effects of wind/weather on heavy and potentially vulnerable technology. Developers of wildlife monitoring technologies should carefully consider these limitations and design their systems to minimize risk to OSW structures and performance.

As identified during workshop discussions, there are a range of research and development opportunities that could help to address key deployment and operational limitations and better integrate wildlife monitoring systems into OSW farms. Further exploration of these opportunities, and recommendations to improve operational integration, will be included in the final report for this project.

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