Technology Gaps for Marine Mammal Monitoring in Relation to Offshore Wind Development

Final Workshop Report

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

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Acronyms and Abbreviations

AI	Artificial intelligence
ASV	Autonomous surface vehicle
AUV	Autonomous underwater vehicle
BOEM	Bureau of Ocean Energy Management
eDNA	Environmental DNA
OSW	Offshore wind
PAM	Passive acoustic monitoring
R&D	Research and development
SME	subject-matter expert

Executive Summary

In recent years, the expansion and development of the offshore wind (OSW) industry has generated an interest in identifying the risk factors to wildlife associated with the construction, operation, and maintenance of fixed and floating OSW turbines. Wildlife monitoring for OSW energy development should be question-driven, scientifically robust, and integrated into OSW development and operation procedures; otherwise, funding spent on wildlife monitoring may not meaningfully inform future environmental assessments and adaptive management decisions. A variety of technologies are available for wildlife monitoring, but there is currently no comprehensive assessment of the capacity of available technologies to collect statistically robust wildlife data at OSW facilities, inform adaptive management, and reduce precautionary mitigation.

As part of an effort to develop targeted recommendations for research and development (R&D) of bird and marine mammal monitoring technologies, subject matter experts (SMEs) were invited to two workshops in the autumn of 2022 to provide input on the technology types, limitations, and possible improvements to technologies that are used or have potential to be used to monitor marine mammals in relation to OSW energy development. This report summarizes discussions from these workshops, including:

- 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 R&D could address; and
- Ideas to streamline bottlenecks.

Workshop participants identified a broad range of technologies used to monitor marine mammals and OSW development, as well as the limitations inherent in those technologies. Strategies to address these limitations included investments in further R&D to improve specific technologies. For example, SMEs suggested investment in further R&D to improve and standardize specific technologies, integration of complementary monitoring technologies. For instance, SMEs strongly recommended more R&D for tag development to optimize hardware reliability and accuracy as well as to ensure rapid hardware integration and modification. Tag access and production were highlighted as a current limitation as there is currently no mass production of these devices. Improved battery life and data storage were considered priorities particularly for offshore environment where hardware maintenance and data offloading will be challenging.

SMEs indicated that improving the engagement and communication between the research community and wind energy projects and turbine manufacturers is important to streamline and facilitate the monitoring at OSW sites. It was also suggested that the development of government requirements for data sharing protocols, standards, or platforms could help to drive collaboration and innovation. Ultimately, a combination of focused R&D, cross-sector coordination and streamlining, and acceleration of development and testing timelines were recommended to improve marine mammal monitoring technologies.

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). 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, 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 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 R&D could address; and
- Ideas to streamline bottlenecks.

This report focuses on marine mammal monitoring and the findings from the marine mammal SME workshop. A similar workshop was conducted for birds and findings are reported in a separate document, titled “Technology Gaps for Bird Monitoring in Relation to Offshore Wind Development.” 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. This report summarizes the predominant technologies, uncertainties, bottlenecks, and potential solutions that were identified by marine mammal SMEs as part of the Task #2 workshops.

1.2 Workshop Details

1.2.1 Format

The marine mammal workshops were conducted in two sessions (2.5 hours each) in October 2022 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 condensed version of the Task #1 priority memo summarizing priority questions on which workshop discussions would focus and 2) a brief summary of workshop objectives and the elicitation process to be used during workshop sessions.

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 specific technologies and uncertainties around those technologies (in the first meeting), and bottlenecks and potential solutions (in the second meeting) via discussion and comments on the Mural platform.

1.2.2 Participants

In addition to project personnel, a total of 14 SMEs (Table 1) participated in one or both of the marine mammal workshop sessions. SMEs had expertise in a variety of marine mammal taxa and monitoring methods and represented academia, nonprofit organizations, the offshore wind industry, environmental consultants, and government agencies.

Table 1. List of Marine Mammal Workshop Participants

Name	Affiliation
Lars Bejder	University of Hawaii at Manoa
Douglas Nowacek	Duke University
Daniel Costa	University of California Santa Cruz
Cormac Booth	Sea Mammal Research Unit Consulting
Greg Fulling	Bureau of Ocean Energy Management
Craig Reiser	Smultea Sciences
Dominic Tollit	Sea Mammal Research Unit Consulting
Saana Isojunno	University of Saint Andrews
Sofie van Parijs	National Oceanic and Atmospheric Administration
Len Thomas	University of Saint Andrews
Brandon Southall	Southall Environmental Associates
Jeff Moore	National Oceanic and Atmospheric Administration
Christine Sloan	NOWRDC
Naomi Lewandowski	Department of Energy

1.2.3 Priorities for Marine Mammal Monitoring

The memo written to meet the objectives of Task #1 identified the following goals for marine mammal research and monitoring efforts in relation to offshore wind facilities in the United States, categorized into four main topic areas (after Southall et al. 2021a). These topic areas were used to organize workshop discussions during the first session.

1.2.3.1 Occurrence

The priority for research associated with understanding marine mammal occurrence encompasses the basic information on species' distribution, abundance, and temporal habitat use. This includes seasonal and interannual variability, as well as elements of behavioral, movement, and acoustic ecology.

- Estimate habitat use, distribution, and abundance in OSW development areas by season, and identify dynamic environmental variables driving these patterns. Establish individual baseline movements and behavioral patterns (foraging, diving, reproduction) specific to OSW development areas. Determine spatially and temporally explicit species presence in OSW development areas.

1.2.3.2 Conditions/Stimuli

This category includes information on OSW activities and their characteristics that may affect marine mammals. These include sound, vessel collision, electromagnetic fields, modifications of the environmental conditions, as well as changes in the food web structure.

- Evaluate ambient sound levels in OSW development areas prior to development activities as well as during development phases. Evaluate changes in ecosystem and prey conditions in OSW development areas from the pre-construction to operational periods.

1.2.3.3 Response

This category encompasses how animals may react to an external stressor on various time scales. The actual responses can include measurable changes in behavior, communication range, abilities to navigate/migrate and/or the animal's physical condition. For these variables to be robustly measured, it is important to first obtain baseline information on the animal's behavior.

- Identify acoustic exposure and contextual conditions associated with potential acute response to OSW stressors to support development and refinement of risk and consequence assessment; and
- Evaluate relative threat of mortality/injury from vessel collision and entanglement (floating wind) associated with OSW and non-OSW activities.

1.2.3.4 Consequences and Long-term Research Priorities

Cumulative impacts were defined "as interacting or compounding effects across spatiotemporal scales, caused by anthropogenic activities relating to the development and operation of multiple offshore wind energy facilities, that collectively affect wildlife populations or ecosystems" (Southall et al. 2021b).

1.2.3.5 Data Standardization

Generally, the continuous effort to better inform the research priorities related to OSW has highlighted the need to have datasets that can be easily integrated in larger research enterprise, framework, and modelling efforts (Kraus et al. 2019; NYSERDA 2021). The emphasis on cohesive, transparent, and collaborative research efforts to better inform management and industry was also highlighted by Bureau of Ocean Energy Management (BOEM 2017). Data standardization and transparency are thus considered a research priority in this document to ensure that there is longitudinal data availability for a region and robust methodologies and frameworks to implement. The aggregation and standardization of data will ensure that the incorporation of the various datasets into population modeling frameworks can occur (Kraus et al

2019; Booth et al. 2020). The standardization of methodology and data availability were identified as essential for future cumulative modeling efforts and opportunities to compare geographical locations and OSW technologies (Lindeboom et al. 2015; Van Parijs et al. 2021; Wall et al. 2021).

2 Technologies and Uncertainties

2.1 General Description of Technologies and Structure of Findings

The discussion was originally centered around priority questions. SMEs rapidly identified that technologies could answer several research priority questions simultaneously. The format of the discussion shifted and became centered around these technologies to avoid redundancy and to capture the overall trends and challenges for each of these tools.

Once identified by the SMEs, the technologies were then reorganized under major categories and the rest of the discussion follows this structure. For each technology, a brief description of the current tools available is provided along with the uncertainties and bottlenecks the SMEs considered substantial and likely to limit their efficacy in the context of OSW wildlife monitoring.

2.2 Sensors

2.2.1 Visual Sensing

2.2.1.1 Platform Description

Visual sensors encompass a wide variety of tools which have different degrees of development and precision. The following technologies were identified:

Infrared Imaging: This technology captures images of objects or animals emitting infrared radiation. Generally, the amount of radiation emitted by an object increases with temperature. As marine mammals are warm blooded and their exhale is generally hotter than the water surface, this technology has been used to detect marine mammals.

Lidar stands for Light detection and ranging. Similar to a sonar system, Lidar is a method to estimate range using a laser that measures the time it takes for the reflected ray to hit back the light source. Lidar technology is regularly used with drone system to get accurate measurements of altitude in order to extrapolate animal body size.

Radar stands for Radio Detection and Ranging, similar to Lidar or Sonar system, it uses radio waves in the microwave range to estimate range. The time of arrival of the returning ray provides an estimate of distance. Radar systems can be used to track animals.

Satellite imaging refers to high definition images taken from satellite platforms to identify the presence of large whales. This type of technology relies on advanced analytical tools to review and classify images that could contain marine mammals.

Digital Aerial surveillance methodologies are similar to satellite imaging but rely on images collected at much lower altitudes, generally from a drone or an airplane.

2.2.1.2 Uncertainties and Bottlenecks

Generally, there were many similarities regarding the bottlenecks associated with these technologies. **Image resolution** was brought up as being problematic for satellite and digital aerial imaging. Ultimately resolution will affect the ability to detect and identify animals at the species level lessening the robustness of these methods. Poor image resolution can result in low detection or inaccurate classification of marine mammals. Once an animal has been accurately detected, it is still currently difficult to identify individuals at the species level. This is particularly problematic in the case of endangered species that might be more relevant to accurately identify. Besides resolution, **correction and availability factors** are not always available for imaging. Knowing how often a specific species spends on average at the surface is important to integrate into correction factors to ensure one is accurately counting and sampling animals. Depending on animal behavior, surfacing may vary greatly and thus the availability of the animals to be actually sampled can also vary for all the technologies relying on surfacing.

It was noted that imaging technologies generally yield an important amount of data where storage limitation and processing can be problematic. Data storage can be problematic for some of these technologies. Similarly processing and analyzing requires a significant amount of computer power that is not readily available. There are currently no standards in imaging data collection which makes comparisons across sites and regions very difficult. The SMEs noted that for some technologies (such as satellite imaging), there are sometimes difficulties to access the data as they might only be shared within the US or with specific partners. Data availability and sharing were considered important for the proper development and standardization of these technologies.

General environmental conditions can have a strong impact on the efficacy of imaging technologies. Sea State and cloud coverage can yield a higher false positive rate or completely prevent the detection of marine mammals. Wind conditions can also affect aerial survey.

Finally, for certain technologies such as Lidar, the SMEs noted that there are reliability issues and the degree of maturity of these sensors, particularly in harsh conditions such as offshore marine environments can cause unforeseen issues.

2.2.2 Acoustics

2.2.2.1 Platform Description

Acoustic studies usually refer to the use of sound (actively or passively) to infer the presence of marine life. Three types of acoustic technologies or tools were identified by the SMEs and are defined further below.

Active acoustic methods refer to the projection of sound underwater and listening to the echo to infer on the presence of objects or biomass in the water. A similar technology is used with fish finder and a variety of frequencies and levels can be used depending on the species of interest as well as the depth that one would like to sample.

Passive acoustic monitoring (PAM) (Mobile/real time) refers to a hydrophone or an array of hydrophones that will pick up the acoustic energy of calls produced by marine mammals. These can be deployed behind a vessel or can transmit data in real time such as acoustic recorders aboard gliders. When several hydrophones record simultaneously, a bearing and distance can be potentially obtained from looking at the different times of arrival.

Finally, **passive acoustics (fixed)** referred to either permanently bottom mounted hydrophones connected to shore via cables or to archival acoustic recorders that will be deployed for weeks/months and collect data continuously or on a duty cycle.

2.2.2.2 Uncertainties and Bottlenecks

Acoustic related technologies generally had a few bottlenecks that were common across methods. First, in terms of analysis, there is still **a lack of standards** and annotated database that can serve as a training dataset for AI algorithms. Generally, species level identification is still problematic with a lot of false positives and species identification requires human validation. The lack of comprehensive and validated analysis tools makes extracting data from these technologies relatively challenging. In areas with strong currents or winds, flow noise can become problematic to accurately detect animals.

Extrapolating density from acoustic data has been the focus of recent research effort. However, to accurately derive this type of data, ancillary information is required. Cue rates or how often an individual produces a call provides important data to infer the size of a group or the presence of non-acoustically active individuals.

The SMEs noted that access to the stored data either from the archival tools or by streaming is generally difficult. Improving data access and storage of the large amount of data is still a bottleneck for passive acoustic tools. Live feeds are generally decimated so only a small portion of the data is truly available for real time analysis.

It was noted that some of the current passive acoustic recorders have some **reliability issues** such as battery, electrical or leakage issues which can be problematic as an entire deployment can be lost if the equipment fails. While there is a need for these types of recorders, there is no mass-production of these tools yet and the majority of them are custom built.

When multiple hydrophones are deployed, localization of animals can be achieved. However, this requires synchronization of the recorders, which can be problematic and would require more robust internal clocks. Depending on the platform, the research question and the area of interest, multiple acoustic sensors would be necessary. In the case of real time acoustics or even fixed PAM, the costs associated with deploying multiple sensors can rapidly become challenging.

For active acoustics, it was noted that the projected sound could be harmful to marine life and cause behavioral disruption or physiological damage. In addition, the specifications (source level and frequency bands) of active acoustic instruments are generally not sufficient for permitting and require additional measurements. The temporal and spatial coverage of this technology is also relatively limited and does not provide detailed information about prey species diversity.

2.2.3 Satellite Tags

2.2.3.1 Description of the Technology

A satellite tag contains a small transmitter that connects to a satellite system. The tags are generally minimally invasive and implanted either in the blubber or in the dorsal fin of cetaceans. For pinnipeds, attachment is commonly on the fur of the animal via a mesh epoxy attachment. The system can be easily retrieved by cutting cable ties and the remaining minimal gear will fall with the annual molt. Satellite position is transmitted when the tag is out of the water, generally when the animal surfaces, giving researchers a better understanding of their movement, habitat use and potential response to anthropogenic activities.

2.2.3.2 Uncertainties and Bottlenecks

Generally, the bottlenecks associated with this technology mirror other tools used in this field. Battery life and size continue to be a challenge as longer deployments and smaller tags would be preferred. Attachment improvements are considered a high priority to minimize any impact on the animals. Data access via satellite can be challenging due to limited transmission bandwidth or in the case of cellphone tags, access to close to shore cellular network. Finally, data compression was considered a challenge and satellite coverage/accuracy continues to be challenging.

2.2.4 eDNA

2.2.4.1 Description of the technology

Environmental DNA (eDNA) refers to DNA released by animals in the water column. eDNA can come from skin shedding, fecal matter, mucous or gametes. In the water column, eDNA can be detected for several days but is heavily dependent on environmental conditions (acidity, heat, radiation; Foote et al. 2012; Gargan et al. 2017).

2.2.4.2 Uncertainties and Bottlenecks

Generally, this method is not considered at a stage where it can be easily implemented for monitoring purposes. While the development of eDNA is promising, an SME cautioned about the current implementation as a marine mammal survey tool. In particular, the lack of reference database, sensitivity analysis, time and space factors in detection make this tool currently unlikely to be ready for deployment. While it might be promising in the future, several important data gaps need to be addressed first.

2.3 Platforms

2.3.1 Unmanned Aerial Systems

2.3.1.1 Description of the Technology

Unmanned Aerial Systems (UAS) encompass both fixed wing and multirotor systems. Some systems can be equipped with Lidar system to obtain photogrammetry data. Generally, UAS are used to monitor animal behavior for relatively short periods of time (order of 30 minutes maximum) for multirotor. Abundance and animal detection using fixed wing systems could be achieved but are limited due to Federal Aviation Administration regulations. Generally, these platforms are increasingly being used to monitor and quantify animal movement and health.

2.3.1.2 Uncertainties and Bottlenecks

UASs provide a reliable platform and multiple studies have validated the results obtained with these tools. SMEs acknowledged that some of the bottlenecks are related to permitting issues where some of the more reliable UAS brands are non-US based which prevents researchers from using them when applying with federal funding. These cost effective and reliable platforms do not currently have US-based equivalent which ultimately slows down the development of the tools and researchers derived from these platforms. Another bottleneck identified by SMEs was the current FAA regulation where UASs must be operated within ‘line of sight.’ Under this regulation, UASs have to be visible at all times even though they have the capacity to operate at much greater distances. With the rapid development of these tools, SMEs also noted that there is a need for standardization across data collection platforms. Battery life was identified as a major limitation for these technologies. The maximum payload a UAS can handle will be the ultimate limitation as far as how battery power can be optimized. Flight time will be directly dependent on battery capacity along with distance of the animals from the pilot (distance for the drone to travel which can be several kilometers) and weather conditions.

2.3.2 Tags

2.3.2.1 Description of the Technology

Tags refer to retrieval platforms where a suite of sensors can be integrated. Unlike satellite tags, these are generally temporarily mounted on the animal via suction cup or mesh/epoxy. Currently archival tags with tri-axial accelerometer, acoustic and video sensors are commonly used. Other non-invasive physiology tags such as near infrared sensors can provide additional information about blood flow, heart rate and other relevant physiological measurements. This type of tag is still in its early stages and requires considerable ground truthing.

2.3.2.2 Uncertainties and bottlenecks

Battery life is currently a significant limitation for tags as there is a trade-off between the size and weight of the tag (archival or satellite) and the maximum battery size it can support. Batteries are also generally waterproof and not easily accessible or changeable and access to power sources or ease to swap batteries were often mentioned as issues. Many technologies discussed currently rely on wireless powering that is not only time consuming but also limiting as battery life and charge diminish overtime. Lithium batteries tend to overheat and swell up making a tag inoperable.

Data access and offloading is still challenging as a significant amount of data is collected via the various sensors. Time to offload data is of the order of hours and potentially days. SMEs highlighted data access and the potential for transferring data via satellite when the tag has come off. Tag attachment is sometimes problematic and species-specific but could benefit from further R&D as it becomes a limiting factor if the tag comes off too early. Similarly, certain sensors are less reliable if positioned on the 'wrong' portion of the animal body. For instance, accelerometer data might be more challenging to extrapolate if the tag is too far from the fluke and the muscles associated with swimming. Tags are highly customizable, and some can tolerate large pressure changes, having reliable 'deep' tags would help researchers better understand how deep divers could be impacted by OSW within the water column for instance.

Tag access was highlighted as a challenge as some tags are available by lease while others are by purchase only. While both approaches have advantages, there is still a lack of mass production of these tools that would not only minimize the time to obtain the tags (production can take several months) and ensure that quality control, consistency and testing are conducted before the tags are actually available to the scientific community. SMEs gave a comparison of activity watches that are very reliable as they are manufactured at a large scale. Mass production will ensure availability, reliability, transparency, continued R&D while minimizing costs and unit availability.

Near infrared sensor tags and other physiological measurements such as blood sampling are currently in a developmental phase compared to other archival tags and need still further proof of concept studies along with ways to address certain challenges such as blubber thickness and access to muscles.

2.3.3 Autonomous Underwater Vehicles and Autonomous Surface Vehicles

2.3.3.1 Description of the Technology

Both Autonomous Underwater Vehicles (AUV) and Autonomous Surface Vehicles (ASV) can be used for population monitoring, mitigation monitoring or even focal follows and can be deployed for several months. There are several ways AUV or ASV can navigate: with a propeller driven underwater, powered at the surface (with an engine), self-powered or underwater buoyancy or unpowered.

2.3.3.2 Uncertainties and Bottlenecks

Generally, the SMEs agreed that the noise generated by some AUVs or ASVs can be problematic for acoustic detection and is mainly dependent on the method of propulsion (self-noise from the pump on the ascent phase for instance). Similarly, some AUVs and ASVs have other sensors that might introduce active acoustics or underwater noise, which could negatively impact marine mammals.

These platforms are also relatively slow and while they provide a long-term platform that can stream data in real time, they need to have increased maneuverability and be more accessible financially to the research community.

2.4 Software

2.4.3.1 Description of the Technology

Machine learning and artificial intelligence software were discussed broadly. Automated processing for photo ID, digital aerial imaging as well as acoustic data processing were generally discussed. SMEs also discussed citizen science and how it could benefit from integrated analysis tools.

2.4.3.2 Uncertainties and bottlenecks

The major bottleneck identified for these types of tools was related to standardization. Many efforts are currently being conducted in parallel but without a cohesive approach that would allow for quality control and comparisons across algorithms. Training datasets are also not readily available but are necessary to ensure that the machine learned the ‘correct’ task. Quantifying error is still challenging because of the infancy of these tools for marine mammal research.

Software should be both customizable while maintaining standardized data collection processes. One of the recommendations was also to have user-friendly interface.

SMEs discussed the value of integrating citizen science into current research effort to maximize overlap between researchers’ effort and the general public. In particular, the SME highlighted the need to better integrate various data streams. The example of bird applications used by the general public that have helped researchers' efforts was cited. Ideally, an app should be accessible, transferrable and relatable to ensure the maximum buy-in from the public.

2.5 Data Integration and Optimization

2.5.3.1 Description of the Technology

Large scale effort to integrate multiple data streams was identified as a major technological challenge. Apart from the logistical aspect of ensuring the researchers have the training to collect and analyze these various sources of data collection, it is important to ensure that the sampling regime, temporal and geographical scales are comparable across datasets. Remotely sense oceanography relies on aerial and satellite imaging to obtain sea surface information such as chlorophyll-A and sea surface temperature.

Other modelling tools include integrated population modelling as well as habitat modelling which can help assess the trajectory a population is going to take based on long term datasets.

2.5.3.2 Uncertainties and Bottlenecks

For the majority of data integration and optimization tools, robust datasets are needed to feed into the modelling. For habitat model for instance, it was suggested to integrate PAM data along with visual survey to optimize detection. Incorporating strong environmental datasets beyond sea surface temperature is also important as most marine mammal species might not respond directly to sea surface changes but rather chlorophyll-A, eddies or sea surface height. Generally, all these models rely on a good quality of data inputs to ensure the model is going to be sensitive enough to predict changes. Data standardization was highlighted as a major bottleneck to these tools as there are currently no standards. Suggestions to overcome these limitations included meta-analyses of currently available data which in the short term could better help inform adaptive management decisions.

For remotely sensed oceanography, the SMEs noted that there is a need to better integrate oceanographers with biologists to interpret these data. Access to data and transfer/storage was often noted as an issue for this type of data stream. Finally, tools to go beyond surface condition monitoring and that would not be dependent on cloud coverage would be preferred.

2.6 Methodologies and Their Bottlenecks

As part of the technology identification, SMEs listed several methodologies. These include visual surveys, focal follow, behavioral observations, photo ID, diet analysis, exhale sampling, physiological measurements, stranding and vet assessment, biopsy sampling, oceanographic measurements, prey monitoring and vessel AIS. While these tools are key components of the current marine mammal research effort, they are not necessarily associated with technologies per se. Based on the discussion of the SMEs, these data streams tend to feed into some of the larger scale effort related to data integration and optimization. Some of these methodologies have improved with the use of new technologies. For instance, behavioral observations and focal follows have greatly benefited from new platforms such as UAV.

2.7 Parking Lot

A section of the Mural was dedicated to ideas, comments and points that did not directly fit within the structure of the workshop but were relevant to the overall discussion. While these points are not discussed in many details in the context of identifying technological gaps, they are provided below for consideration.

It was noted that the level of maturity of technology (stage/readiness etc.) and how it is likely to evolve within 5-10 years should be considered. Long-term goals should be considered while establishing some of the technology gaps. Other data streams could be considered such as existing PSO data to help inform some of the monitoring questions. Similarly, existing technologies such as the fiber optic cables could be used to monitor species presence and transfer data back to shore. Data integration was a recurring comment during the workshop. SMEs highlighted how various projects in the same area and potentially the same species might not collaborate or integrate their respective results into a larger scale study. There was an example for specific questions that could be answers to better help inform some of the PCoD effort highlighting that the research community is still trying to assess distance and levels where disturbance might occur. Similarly, a SME commented that technologies should also be considered for multiple monitoring questions at different scales or for various species.

3 Potential Solutions

3.1 Hardware Improvements

While the conversation was centered around tags, the SMEs agreed that a lot of discussion also applied to other technologies. In particular, SMEs suggested that non-invasive and long-term tags would be helpful to better understand some of the life history processes that cannot be quantified with other methods. Better attachment and research on various glues and mechanical designs would for instance assist with the limitations associated with tag deployment duration.

Cheaper and more accessible tags would also benefit the research community. As mentioned in the tag section, mass production of these tools would ensure more reliability. Maintaining some of the customization of the tags while improving the manufacturing was highlighted during the discussion. SMEs also discussed the different constraints associated with a leasing program vs. a purchasing program when it comes to tags, yet they did not come to consensus regarding which method would yield the most streamlined acquisition of new tags. One suggestion that was brought up was to encourage more companies to look into developing tags. Currently a handful of companies are capable to design and manufacture tags for marine mammals and a financial support to encourage new companies to investigate these technologies would help expedite some of the current issues the scientific and technology communities are facing.

3.2 Battery

As mentioned throughout this document, battery life is a recurring issue across technologies. Finding new power solution or relying on more efficient batteries would greatly benefit the many technologies used for marine mammal monitoring. Within the context of OSW, it is important to understand that equipment will not be serviced as often as it would be in a coastal environment. It is therefore important to ensure that the equipment can be either powered externally or has sufficient power to continuously collect data.

3.3 Data Standardization/Analysis Tool

As part of a larger effort to collect valuable scientific and monitoring data, the SMEs agreed that there is a strong need for data standardization in terms of data collection, storage, reporting and access. In the case of infrared technology for instance, there is no standard in terms of height, sampling regime and detection threshold. Normalizing some of these aspects of data collection would ensure the technology is used in the most advantageous way to answer monitoring questions.

Similarly, there are many analysis tools available but there is often a lack of transparency in terms of the algorithms and assumptions made. Providing open access analysis tools for the suite of technologies used during monitoring efforts would help support larger scale effort and allow for comparisons across regions.

3.4 Better Communication

Generally, the SMEs agreed that monitoring is often decoupled from research and a large communication gap exists between industry/management and the research community. A stronger plan to enhance this exchange and to optimize monitoring so all the data is collected to ensure compliance and the data is available for long term comparisons.

3.5 Data Fusion

Faster data transfer and the ability to bring various data streams together was considered an important path to promote data integration into modeling. Currently it is often difficult to integrate various time and spatial scale datasets into animal behavior or photogrammetry measurements for instance. Additional considerations that could assist in accelerating data fusion include open access data storage and guidance on how to collect and integrate data in terms of sampling rate, scope, temporal and spatial scales etc.)

4 Conclusions and Next Steps

Workshop discussions highlighted a wide range of marine mammal monitoring technologies, methods, and tools that are available to monitor marine mammals in relation to OSW development. All available technologies and methods have limitations for answering certain types of questions. SMEs provided valuable feedback on these limitations as well as strategies to address them, including recommendations to 1) invest in further R&D to improve and standardize specific technologies, 2) integrate complementary monitoring technologies, and 3) standardize the integration of wildlife monitoring capacity into offshore wind turbine designs.

The next steps for this project include the development of a technology database, as suggested by SMEs during this workshop, and conducting an additional workshop with turbine engineers, operations and maintenance specialists, and developers of wildlife monitoring technologies to further explore options to integrate monitoring technology with OSW infrastructure and operations. Following these activities, a final report will synthesize project findings and make recommendations for targeted R&D and innovation to improve the efficacy and integration of marine mammal monitoring technologies at offshore wind facilities.

5 References

[BOEM] Bureau of Ocean Energy Management. 2017. Best Management Practices Workshop for Atlantic Offshore Wind Facilities and Marine Protected Species. Summary Report BOEM 2018-015, Washington, DC: Kearns & West.

Booth, C.G., R.R. Sinclair, and J. Harwood. 2020. Methods for monitoring for the population consequences of disturbance in marine mammals: a review. Frontiers in Marine Science. 7:115.

Foote, A.D., P.F. Thomsen, S. Sveegaard, M. Wahlberg, J. Kielgast, L.A. Kyhn, A.B. Sailing, A. Galatius, L. Orlando, and M.T.P. Gilbert. 2012. Investigating the potential use of environmental DNA (eDNA) for genetic monitoring of marine mammals. PLOS ONE. 7(8):e41781. doi:10.1371/journal.pone.0041781.

Gargan, L.M., T. Morato, C.K. Pham, J.A. Finarelli, J.E. Carlsson, and J. Carlsson. 2017. Development of a sensitive detection method to survey pelagic biodiversity using eDNA and quantitative PCR: a case study of devil ray at seamounts. Marine Biology. 164(5):1-9.

Kraus, S.D., R.D. Kenney, and L. Thomas. 2019. A framework for studying the effects of offshore wind development on marine mammals and turtles. Report prepared for the Massachusetts Clean Energy Center, Boston, MA, 2110.

Lindeboom, H., S. Degraer, J. Dannheim, A.B. Gill, and D. Wilhelmsson. 2015. Offshore wind park monitoring programmes, lessons learned and recommendations for the future. Hydrobiologia. 756(1):169-180.

[NYSERDA] New York State Energy and Research Development Authority. 2021. Wildlife Data Standardization and Sharing: Environmental Data Transparency for New York State Offshore Wind Energy. NYSERDA Report 21-11. Prepared by E Jenkins and K Williams, Biodiversity Research Institute, Portland ME. nyserda.ny.gov/publications.

Southall, B., L. Morse, K.A. Williams, and E. Jenkins. 2021a. Marine Mammals Workgroup Report for the State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: Cumulative Impacts. Report to the New York State Energy Research and Development Authority (NYSERDA). Albany, NY. 50 pp. Available at https://www.nyetwg.com/2020-workgroups.

Southall B, W. Ellison, C. Clark, D. Tollit, and J. Amaral. 2021b. Marine Mammal Risk Assessment for New England Offshore Windfarm Construction and Operational Scenarios. Sterling (VA): US Department of the Interior, Bureau of Ocean Energy Management. 104 p. Report No.: OCS Study BOEM 2021-080

Van Parijs, S.M., K. Baker, J. Carduner, J. Daly, G.E. Davis, C. Esch, S. Guan, A. Scholik-Schlomer, N.B. Sisson and E. Staaterman. 2021. NOAA and BOEM Minimum Recommendations for Use of Passive Acoustic Listening Systems in Offshore Wind Energy Development Monitoring and Mitigation Programs. Frontiers in Marine Science. 8: https://doi.org/10.3389/fmars.2021.760840.

Wall, C.C., S.M. Haver, L.T. Hatch, J. Miksis-Olds, R. Bochenek, R.P. Dziak, and J. Gedamke. 2021. The next wave of passive acoustic data management: How centralized access can enhance science. Frontiers in Marine Science. 8: https://doi.org/10.3389/fmars.2021.703682.

Wilding, T.A., A.B. Gill, A. Boon, E. Sheehan, J.C. Dauvin, J.P. Pezy, F. O'beirn, U. Janas, L. Rostin, and I. De Mesel. 2017. Turning off the DRIP ('Data-rich, information-poor')–rationalising monitoring with a focus on marine renewable energy developments and the benthos. Renewable and Sustainable Energy Reviews. 74:848-859.