OCEANTIC NETWORK

OFFSHORE WIND REPORT:

BUILDING A COLLABORATIVE DATA STRATEGY FOR THE U.S. OFFSHORE WIND INDUSTRY

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Executive Summary

The United States has reached a turning point in its offshore wind energy journey. With steel in the water, dozens of projects in the pipeline and a federal goal of 30 GW deployed by 2030, the industry and its stakeholders must work together to ensure success by thinking beyond individual project implementation and considering offshore wind as a collective critical energy infrastructure system.

This collaborative approach can be further strengthened through the development of a strategy to collect, synthesize, and share data to help U.S. offshore wind develop the frameworks and tools necessary to support a high-value, sustainable industry for decades to come.

Historically, the offshore wind industry has collected environmental data – including metocean, geophysical, geotechnical, and ecological data – primarily to meet requirements for siting and development. Such data have significant proprietary commercial value to offshore wind project developers and other parties. As a result, the current operating culture is one in which data are often held close to the vest. Such data have immediate value in establishing facts at a moment in time, but more critically, they provide the basis for long-term, industry-wide learning, problem solving, and future analysis. Recent efforts to launch shared or public databases have begun to gain momentum. However, to truly capitalize on the potential of data sharing, the industry must embrace a leadership role to collaborate on the creation of a comprehensive data sharing strategy or otherwise be passively affected by one that will inevitably be imposed on it.

To better understand the existing data landscape and advance next steps, the Oceantic Network engaged its Data & Digitalization Working Group to catalyze a strategic, industry-wide approach to the utilization of data in offshore wind. This briefing paper both summarizes and illustrates the steps taken by the working group on this topic to-date and highlights new and emerging opportunities that the U.S. industry must consider to successfully employ offshore wind energy in an economically viable and timely fashion.

Addressing this need for a collaborative data strategy comes as the U.S. market is shifting from a scarce and uncertain landscape into an entirely new challenge – a fast-paced commercial deployment schedule. New investments are being driven by a desire to contribute to climate change mitigation, capitalize on building a more equitable and sustainable energy economy, and reap the economic and job creation benefits of a domestic supply chain, all while supporting the health of coastal communities and marine ecosystems.

Developing the Tools We Need: It Starts with Raw Data

It is imperative the U.S. offshore wind industry consider the data-driven tools it will need to continue lowering costs, supporting essential research, and responding to lessons learned during the deployment period here and abroad – especially as the 30 GW target has unleashed a pent-up appetite for investment in a U.S. offshore wind market. And recent industry headwinds, including economic inflation driving up project costs, have not deterred the industry's forward momentum.

Data is capable of fueling U.S. offshore wind innovation, problem-solving, stakeholder confidence, and commercial opportunities. Baseline data and individual research collected for individual project design as well as regulatory permitting and monitoring requirements have the potential to drive significant innovation and increase permitting efficiency. However, a failure to share such information will limit acceleration of the cumulative learning the U.S. industry requires.

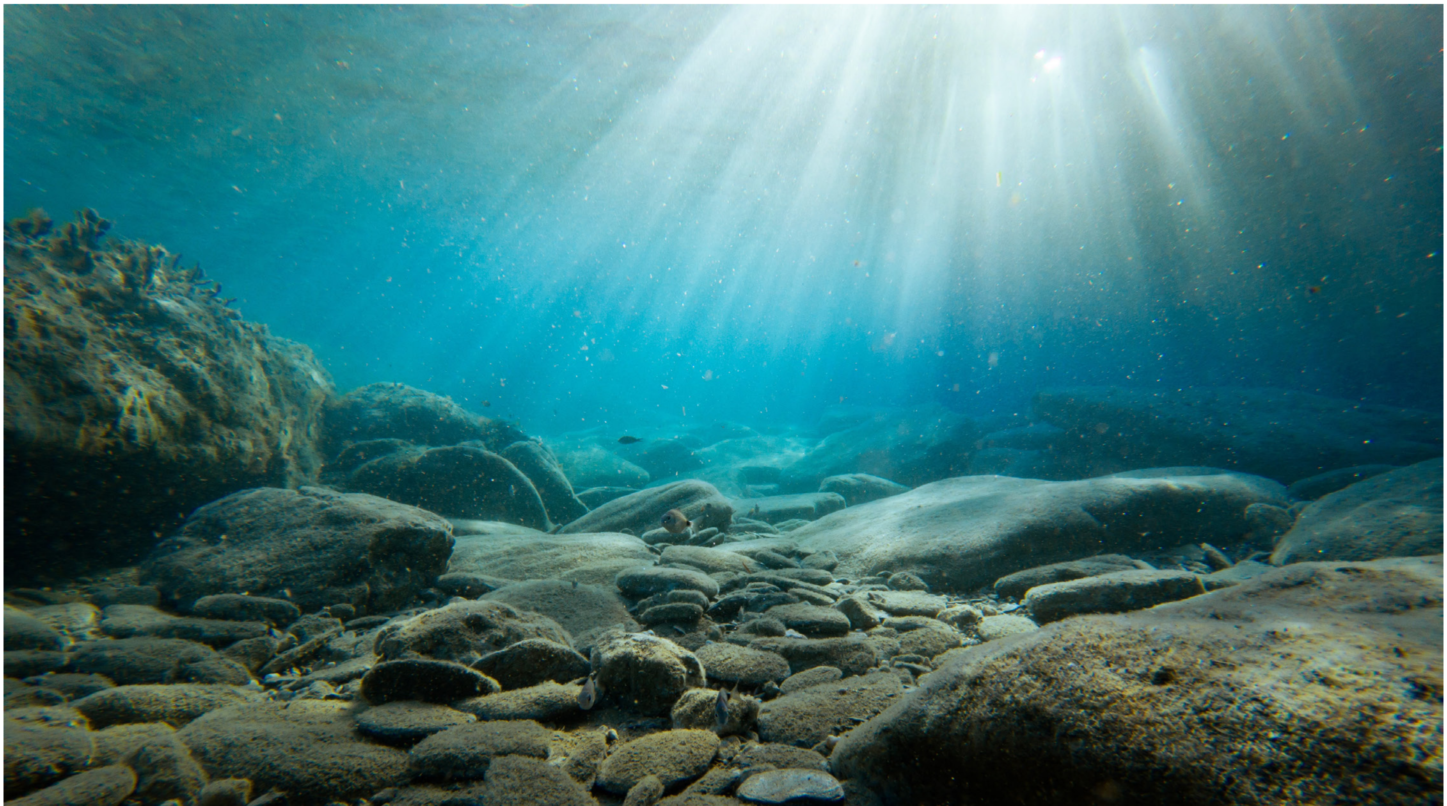
The industry now has the ability to preserve and extend the value of data, making it work for the long-term, especially amid recent advances in;

- Big data management and storage
- Development of algorithms to extract information from extremely large data sets
- Real-time sensing, transfer, and storage of data in the cloud
- Utility of data lakes
- Frameworks and portals for data access and analysis in the U.S. and other countries

But it can be difficult to separate proprietary data from data that can be publicly disseminated, especially in the hyper-competitive U.S. market where offshore wind project developers and other parties, such as academic institutions, government agencies, and businesses that sell data and data products, hold such information close to the vest.

Collaborating with researchers can bring valuable expertise but is simultaneously restricting if agreements between industry and researchers require keeping data access limited to a particular academic institution or contractor. As a result, researchers and consultants working on the environmental or engineering parameters of projects cannot easily integrate data from other developments to build a regional ecosystem profile, for example. Collection protocols and data standards are negotiated on a project-by-project basis, subject to restrictive agreements, and the investment needed to make data sets with different protocols compatible for aggregation after data collection is significant (see Appendix C). This issue is not endemic to the U.S. offshore wind sector – the critical need for benchmark offshore wind turbine condition monitoring data sets is important to the global offshore wind sector.[i] Observing how the decades-old European market has wrestled with this challenge can help provide guidance to the U.S., as well as reciprocal learning and information sharing with other countries early in their development journey, such as Australia, Brazil, Canada, Colombia, Japan, Taiwan, Uruguay and Vietnam.[ii]

The Bureau of Ocean Energy Management (BOEM) and certain U.S. states are investing significantly in environmental data collection to de-risk identification of wind energy areas and address stakeholder concerns. But the need is growing for a larger umbrella system that can store, manage, and package data and ultimately apply it to tools such as validated models, geographic information systems, machine learning, and artificial intelligence.



Offshore Wind Data Collection: What is Recorded and How is it Used?

Siting data collected by offshore wind developers and other parties typically includes information about the environment or the external conditions of a project.

- Metocean, geotechnical, and geophysical data lay the groundwork for engineering design, financial modeling, and assessment of insurance risk, as well as undergirding an understanding of the drivers of ecological systems.
- Ecological data (such as animal distributions and use patterns, habitat mapping, and animal behavior in response to stressors) are used to inform design constraints and mitigation efforts as required by regulation, and to address public interests.

There is a trend in the industry to start collecting critical observational data ahead of the lease auction so that developers can enhance their bidding strategy. This approach provides more information early in the cycle and helps to accelerate wind energy development post-auction. Once a project is constructed, data collection programs are initiated to track changes in the external conditions that may be affected by the presence of the project.

Data are also collected to track the impact of the external conditions on the installed structures and their operations.

- Studying a project's power generation and structural health can help to optimize construction logistics and inform operations and maintenance.
- Sensor deployment focused on the response and performance of engineered structures informs advances in cybersecurity, digitalization of operations, and inspection automation, and reduces worker safety risks.

The highest value and broadest application of such information and tools can be derived from data that have been vetted, validated, and archived in raw form, prior to being synthesized as data products. Data products are statistical outputs that answer a specific question by analyzing raw data, such as density maps of marine mammals in an area. In contrast, raw data that have undergone quality control and packaging with metadata can be used in combination with other raw data sets to develop new data products as new questions arise. Data managed in this way can help address crucial future questions that we don't know enough about to ask now.

Developing better tools for offshore wind doesn't just come from collecting more data. The industry needs to ask the right questions so that the right data can be collected in an interoperable format, made accessible to stakeholders, and used to answer those questions.

Stakeholder Input: Making the Case for Data Standardization, Aggregation, and Sharing

The Oceantic Network's Data & Digitalization Working Group first convened in May 2021 around a shared interest in advancing a more strategic approach to the utilization of data in the offshore wind space. The group was launched with a mission to catalyze an industry-wide approach to data acquisition, accessibility, and analysis aimed at: driving down the cost of permitting, construction, O&M, and logistics; increasing financial return; and supporting a global offshore wind community to achieve breakthrough advances. Because "data" is an immense topic with numerous angles in the offshore wind context – and with different emphasis and implications during each phase of project development – the working group's first year focused on exploring and understanding the context and current state of data usage and concerns in the different phases of the development cycle (see Appendix A).

From its initial sessions, the working group identified environmental and siting data as the topic most relevant to the U.S. industry's current state of progress and the topic that was of most immediate interest to working group members and participants. Therefore, the following year of working group activities further explored the data issues relevant to the earlier phases of offshore wind development. The Data & Digitalization Working Group recognizes there are parties advancing work to address these issues around data – including the Regional Wildlife Science Collaborative for Offshore Wind (RWSC) [iii], the Responsible Offshore Science Alliance (ROSA), the National Centers for Coastal Ocean Science (NCCOS), and others – and considers these to be important benchmarks and building blocks toward taking a more strategic approach to managing external conditions data in order to support offshore wind development efficiencies (see Appendix B). This briefing paper reflects the working group's discussions on this topic to date, using examples from the East Coast to illustrate key points.

Data that reveal the interactions between a wind project and its environment are essential to meeting stakeholder needs as well as regulatory compliance.[iv] ***Minimizing environmental impact and ensuring mitigation of stakeholder concerns through data transparency and effective communication must be a collective goal for the U.S. offshore wind industry, rather than a target for competitive advantage.*** As a mature industry, U.S. offshore wind will be held accountable for collective impact and therefore, to achieve successful build-out and operations, must encourage a rapid understanding of environmental interactions and industry best practices.

The emergence of the offshore wind industry in the U.S. has been a significant catalyst for marine data collection by states interested in renewable energy development off their shores, and by BOEM as it looks to de-risk the identification of wind energy areas (WEAs) and leases. For example, offshore wind energy developers selling power to New York State are required to make non-proprietary environmental data publicly available "as soon after collection [as] is practicable for use by third parties in decision-making around adaptive management."[v] However, there is no consistent requirement by other states potentially being served from the same New York Bight WEA. The Northeast Regional Ocean Council (NROC) conducted a pilot project with several developers around marine habitat data access.[vi] Ørsted and National Oceanic and Atmospheric Administration (NOAA) have a bespoke data sharing agreement.[vii] These efforts are a good start for securing robust marine databases around offshore wind deployment, but the unsystematic approach to data management, storage, and sharing represents a missed opportunity to build a consistent long-term framework. Such an approach will support the offshore wind industry, ocean managers, and other maritime users as all sectors adapt to new conditions spurred by climate change.

Although clearly challenging, at this point in the sector's development, the U.S. offshore wind industry should embrace a collective strategic approach to data packaging, storage, sharing, management, and standards. The industry-wide value of aggregating project-scale data assets should not be left on the table.

One well-established benchmark for environmental data integration is the United Kingdom's Marine Data Exchange (MDE),[viii] governed by The Crown Estate. The MDE is a dedicated data management system that is used to store, quality check, and publish environmental survey data, including all survey data associated with The Crown Estate's commercial offshore leases, including for offshore wind, mineral extraction, and marine hydrokinetic development. While not necessarily a template for U.S. governance, the principles and approach to mitigating the inherent resistance to data sharing are instructive.

For example, all developers seeking leases for renewable energy development on the seabed around the U.K., which is managed by The Crown Estate, are contractually obligated to submit their data for archiving throughout the lifecycle of the project, thereby eliminating any loss of competitive advantage in voluntarily providing the data; and issues related to commercial proprietary value are addressed through a system of timed public release of the data, which was created collaboratively among the developers and managers of the MDE. See Appendix C for more information about the MDE as a benchmark for U.S. industry consideration.

One lesson learned from the MDE that is applicable to U.S. offshore wind development is the importance of data standardization at the time of data collection. This was not done in the U.K. and as a result the MDE holds data in varying formats. To improve the interoperability and reusability of the data within the MDE, and to ultimately drive efficient evidence-based decision making and to accelerate the deployment of offshore wind in the U.K., the MDE is undertaking significant developments that utilize cutting edge digital tools to retrospectively standardize and manipulate the data holding, for more effective aggregation and analysis. The usefulness of the data on the MDE is limited until the standardization work is complete.[ix] BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) have essential historic data collection and dissemination knowledge for assisting in the development of data standards and guidelines for offshore wind. The agencies provide developers with guidance documents on various engineering parameters produced by the U.S. Offshore Wind Standards Initiative led by the National Renewable Energy Laboratory (NREL), BOEM, BSEE, Department of Energy (DOE), American Clean Power (ACP), American National Standards Institute (ANSI), and the Oceantic Network. Employing different standards means the offshore wind industry is missing out on the opportunity to combine survey and monitoring data across studies to inform the development of better models, regional data products, support future lease area identification, and capture learnings from the first offshore wind development cycle. If in the future, the industry seeks the value that these aggregated data sets will provide, there will be a significant upfront cost to standardizing the data after the fact.

The pursuit of evidence-based solutions starts with asking the right questions, and development of methods for conducting studies will differ depending on those questions. For example, the frequencies, duty cycles, and distribution of hydrophones with which data are collected by a passive acoustic monitoring system may differ depending on the question (e.g. are right whales present? How far do harbor porpoise disperse from pile driving activities? Is ambient noise significantly affected by wind energy project operations? Are fish spawning near turbine areas at lower or higher rates than outside turbine areas?). The goal is not to have a single methodology for studies, but rather to have standards by which data undergo quality control, have metadata connected to them, and are packaged, shared, and managed. Data management cannot substitute for collaborative efforts to develop studies at regional scales for compatibility in data analysis, but they can make data more accessible, useable, and integrable for long-term value. They can also ensure data are not lost when employees leave, companies change hands, or companies sell projects to other companies.

Individual offshore wind projects currently under review by BOEM supply their wildlife and fisheries data during the regulatory process as data products in a variety of analog forms, such as reports, maps and tables. However, the underlying data sets are only typically made available on a bilateral basis, for specific purposes to limited audiences. This makes it difficult to compare projects over time, look at regional interactions, and consider multiple projects within a single lease area or across lease areas.

This is also acutely applicable to academic data collection. An academic institution usually negotiates multi-year proprietary data agreements. Consultants who act as scientific researchers also do this. One potential solution is for the industry to collectively develop a protocol that allows for the necessary ability to publish "first" while still making data available quickly for other studies.

There is a strong consensus among U.S. offshore wind stakeholders that the industry has not been getting the maximum return on public and private investment in environmental surveys. Significant progress is being made around discrete topics with the support of offshore wind leaseholders. The RWSC, according to its website, supports research and monitoring on wildlife and offshore wind and is working to ensure that better, more appropriate data and standards are in place to support their science priorities.[x] ROSA, which collaborates with offshore wind and fisheries stakeholders on research at the intersection of the two industries, published Offshore Wind Project Monitoring Framework and Guidelines (March 2021),[xi] created a regional framework database to aid research prioritization, synthesis, and gaps,[xii] and handled peer review of the recently published NOAA Technical Memorandum Fisheries and Offshore Wind Interactions: Synthesis of the Science (March 2023)[xiii], building on guidance already established by BOEM to improve the interface between fisheries data collected as part of project permitting with data from state and federally sponsored studies.

Benefits of a Coordinated Environmental Data Strategy:

PERMITTING EFFICIENCY

While developer hesitancy to disclose intellectual property has led to sequestration of data, regulators, on the other hand, have the benefit of seeing all data –– but how that transparency translates to regulatory adaptation is largely unclear. If one project uses one strategy to assess an area of impact and a second project does it differently, is there a means by which to communicate the preferred methodology to the industry other than through project calls and meetings? If not, establishing this would be beneficial. Updates to guidance documents are published periodically, but what about smaller scale changes that may not require such comprehensive measures? This type of industry and regulator communication would benefit both the efficiency of the permitting process and project proponents in equal measure. This approach bolsters the health of the industry and will be especially critical as the initial projects are permitted and built.

The full impacts associated with permitting efficiency from the New York Bight Programmatic Environmental Impact Statement (PEIS) remain unknown. The potential for this process to execute impact assessments on behalf of all N.Y. Bight projects and create efficiencies is real. Many of the leases in the N.Y. Bight are adjacent to one another and some assessments will not be materially different from one project to the most proximate of their neighbors. This process might also set the stage for assessing cumulative impacts as well.

In the future, it will be key to determine how much post-construction compliance data will be made available to the public and how much will be treated as confidential. There are efficiencies associated with post-construction data and sharing it could significantly benefit the development of successful regional maintenance strategies. For example, successful strategies associated with keeping export cables buried to their proper depths in mobile seabed in New England may also benefit projects in the mid-Atlantic that feature mobile seabed. Additionally, each developer will address the regulatory obligations that allow for latitude differently. Nature-inclusive solutions, for example, are an area where each project will likely deploy unique approaches in different scenarios. Communicating which of these are most effective across the industry would be beneficial to both the industry and the environment.

STAKEHOLDER CONFIDENCE

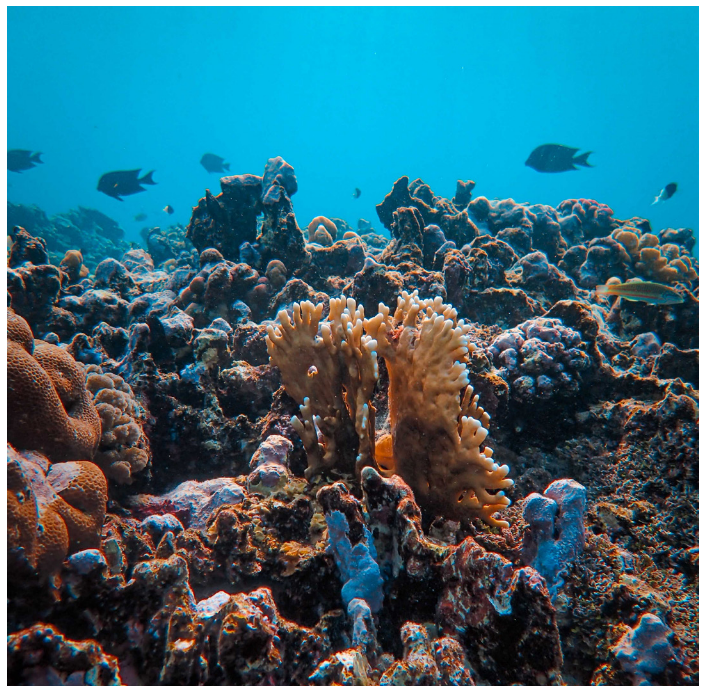
A 2019 survey of stakeholders, state and federal agency representatives, and offshore wind interests gave high praise for the effectiveness the Northeast Ocean Data Portal[xiv] as a trusted and effective provider of data products to support the review of offshore wind projects. Despite existing sources of metocean and marine ecosystem data, understanding the physical and biological processes in marine environments is still, in many ways, frontier science. The work of ROSA and RWSC representing the interests of fisheries and wildlife advocates demonstrates the desire for consistency. Having a mechanism to manage, protect, aggregate, and share data will be important for the long-term prospects of the offshore wind learning enterprise.

There are three main uses for environmental data in offshore wind development:

1. Identifying, prioritizing, and addressing potential biological impacts of offshore wind
2. Addressing stakeholder concerns, even if the concerns are not biologically important
3. Achieving regulatory compliance

These three applications require the collection of baseline and post-construction data sets. In particular, having the statistical power to identify a change and attribute that change to a particular stressor, such as a wind project, is a significant challenge, particularly in remote ocean environments where data collection is costly, logistically challenging, and can pose safety risks. It is imperative for researchers to have access to large, long-term data sets that have standardized formats, quality control procedures, metadata, and compatibility to the fullest extent possible. Using data in this way will help the industry achieve more certainty, leading to shorter timelines for regulator and stakeholder acceptance of projects and minimization of impacts to the environment.

Ideally, the offshore wind industry and other commercial interests take a lead in developing such systems in collaboration with researchers, agencies, and stakeholders to ensure the approach is practicable and achieves the maximum potential risk reduction for industry. Agencies use conservative models and the precautionary principal in authorization and consultation processes when there are few data to inform decisions. In general, the industry will benefit from data and data products that provide more information to regulators and the public and allow for prioritization of genuine biological concerns and warranted mitigation choices. Thus, it is in the industry's interest to contribute as much as possible to the body of data and knowledge around offshore wind impacts through standardized data sharing efforts.



QUANTIFYING INSURANCE RISK

One significant risk during the operational life of offshore wind developments is the potential for damage from hurricanes or other extreme weather events. Wind projects typically require adequate and affordable insurance coverage for such risks and costs can vary from year to year, based on the conditions of the insurance and reinsurance markets.

Property casualty insurance markets behave cyclically. They have both hard and soft periods dictated by loss events. Currently, insurance needs for operational wind developments are modest in size and are encountering a soft market. Insurance terms and coverage during these periods can be beneficial to insureds. Catastrophic losses such as those that occurred in 2022 could result in changes to insurance markets going forward.

Insurers and reinsurers utilize their own proprietary catastrophe software for pricing and risk aggregation. These systems are not designed to incorporate and appropriately model the risks faced by U.S. offshore wind developments. The models have limited wind characterization in the offshore domain, and they model wind perils but not the combined wind and wave perils faced by wind turbines. And, because the offshore wind turbines are different from residential and commercial building structures, these models have no ability to incorporate their vulnerability into the loss modeling.

Bespoke hurricane risk studies have been performed for individual offshore wind developments, but the insurance industry does not generally have the ability to model and price the cost of hurricane exposures for the industry as a whole. This means that in a hard insurance environment, insurers will tend to make "ad-hoc" and often conservative assumptions about hurricane risks, which will be reflected in premiums and insurance capacity available to the industry.

A similar hurricane risk modeling problem was recognized in the U.S. offshore oil and gas industry in the 2000s. After extensive damage to infrastructure in the Gulf of Mexico from Hurricanes Gustav, Katrina, Lili, and Rita hurricane insurance in the Gulf of Mexico became an industry problem. Hurricane catastrophe models for the specialized offshore oil and gas platforms and pipelines were developed that allowed insurers to model and quantify risk for large portfolios of insured assets. This was accomplished through the participation of insurance catastrophe modelers and engineering consultants familiar with the design and risk faced by these assets and supported in part by BOEM funding. Replicating this kind of industry effort could allow the offshore wind industry to anticipate a similar situation where hurricane insurance cannot be quantified by the insurance industry and hurricane coverages are not available or are prohibitively expensive.

MODEL VALIDATION

An important value-add of long-term data sets from offshore wind developments are validating and ground-truthing models and predictions and adjusting to account for new understandings. There are different scientific approaches to answering a question. Once a question has become prioritized – for example, "does offshore wind affect migratory patterns of right whales?" – researchers must determine what data are needed to answer this question and whether it can be reasonably collected in the context of time, safety, logistics, and expense to achieve a statistically robust outcome that reduces the current level of uncertainty. If there is such a method, a direct study may be implemented, and statistical models will be applied to the data to assess the probability of various answers to the question. If there is no such method, the next consideration is what data may provide proxies to address the question and/or allow for predictive modeling that can be iteratively improved with more data over time.

The statistical power of directed studies can be improved gradually with new data, and additional data sets can also indicate trends over time. For example, large-scale, 25-year data sets have informed marine mammal density maps on the U.S. East Coast, allowing for predictions of animal distributions for species for which few sightings (data points) are collected on a seasonal or annual basis. However, annual and seasonal trends in distribution can be assessed for some species based on these same data sets but analyzed in a different way. A good example of the use of proxies in models are animal movement models, like those used in many construction and operations plans, which assume movement parameters of many species based on studies of a similar species. These movement models have a predictive component but are mainly hindcast in nature. Forecast models will seek to predict something in the future, such as the distribution of right whales in ten years based on environmental changes associated with climate change. These must rely on historical associations, such as right whale dynamic habitat preferences, but are meant to predict the future. Models of all types can benefit from systematic, compatible data collection that can be used to refine and ground truth model outcomes over time and adapt management and mitigation accordingly. A set number of years of data collection is popular with agencies that have a limited ability to require long-term monitoring, but the reality is that the number of years does not matter as much as the amount of time needed to collect sufficient data for reduction of uncertainty in the statistical analysis or model. Ecosystem-based modeling efforts are data hungry and connect complex processes, requiring that data from physical environmental modeling be coupled in time and space with biological information. For example, if a study only focuses on where right whales are distributed and finds that their feeding locations have shifted out of wind energy development areas, without environmental data connected to this information, it is impossible to know whether the environmental conditions affecting their prey distribution is driving this change, or if wind projects are causing the disruption.

The assumptions made in modelling and the conservative nature of those assumptions to avoid unexpected impacts can drive mitigation measures and increase industry costs and timelines. Continued refinement of models in a manner that replaces assumptions with data over years will be important to develop our understanding of actual impacts and how to address them and reduce risk to industry as a whole.

BIODIVERSITY AND NATURE-INCLUSIVE DESIGN

It is well known from the long history of oil and gas infrastructure in the Gulf, as well as decades of offshore wind project installations across the globe, that new, hard structures introduced into the marine environment provide surface areas where habitats develop and attract new types of marine life. As a result, oil rigs in the Gulf and the Block Island Wind Farm off Rhode Island's coast serve as popular recreational fishing areas. Questions arise, however, around the specific attributes and interactions resulting from this new habitat.

There is growing attention on the potential for offshore wind to contribute positively to ocean biodiversity, in addition to playing a major role in decarbonizing the energy economy.[xv] As these ecosystem dynamics are better understood, offshore wind foundation designers, developers, eNGOs, and academic partners are developing the knowledge base to channel engineering, siting, and materials selection to support nature inclusive design aimed at increasing marine ecosystem services, as well as new economic opportunities such as mariculture.[xvi] Sharing and aggregating external conditions data across multiple wind projects in a lease area, and at the larger ecosystem scale, will be critical to advancing innovation of these offshore wind collaborative endeavors. The ability to quantify the ecosystem services provided by offshore wind substructures will become an operational expense benefit and perhaps eventually, a requirement.[xvii]

As the industry grows, so too will the need to be transparent about environmental interactions and their cumulative implications to help advance best practices over time. ***Industry must take the lead in defining how this will happen in a pragmatic way.*** Additionally, contributing to the science behind climate impacts on marine ecosystems while promoting biodiversity enhancement amplifies the industry's position as a key climate change mitigation tool.

How to Move Forward: An Environmental Data Strategy for the U.S. Offshore Wind Industry

Offshore wind industry trends both domestically and globally suggest progress toward regional approaches to grid integration,[xviii] supply chain development,[xix] and ecosystem interactions.[xx] The industry must embrace a leadership role in data sharing and collaboration or otherwise be passively affected by it. One way to do this is to advocate for a collaborative, internal process between government, academia, and stakeholders to envision a robust, sustainable U.S. offshore wind environmental data strategy.

Collectively, the presentations and ensuing conversation at the 2023 IPF Data & Digitalization Working Group meeting highlighted the existing wealth of initiatives, experience, and accomplishments to build on when considering how to better leverage marine environmental data assets within the offshore wind development enterprise (see Appendices D and E). Among them, environmental standardization initiatives targeting particular parameters; state incentives/requirements for data sharing; regional data integration initiatives; platforms housing marine data (IOOS, NROC, and other regional Data Portals, Marine Cadastre); and other analytics tools. There was significant consensus around needing to pull these and other relevant pieces together into a more comprehensive, integrated strategic environmental data framework, as well as clarifying the key challenges we face in accomplishing this in the context of the U.S. offshore wind industry. There was also general consensus that BOEM is in the best position to establish a forum for advancing the necessary multi-sector collaborative convening.

The Network appreciates BOEM's support for such a forum and its expressed objective of informing the agenda for a BOEM-/BSEE-convened action-planning meeting.

WORKING GROUP TOPICS FOR INDUSTRY CONSIDERATION

The 2023 IPF Data & Digitalization Working Group discussion surfaced both general and specific points to be considered in setting the agenda going forward.

Establishing Realistic Priorities: There are many different data types, making it overwhelming to approach with a data strategy in mind. What are the main data types to manage? What data streams need immediate attention to enable permitting efficiencies and refinement of mitigation requirements?

To answer these questions, industry must look to known, regional, collaborative data management processes for decision-making guidance that may include mapping high-impact, short-term, and long-term priorities, including identifying long lead-time actions that should start immediately.

Data Acquisition: Good science is question-driven; to the extent possible, it is important to identify key questions to address and set up the system accordingly. However, sometimes pertinent and unavoidable questions that require data to answer don't emerge until years later – so protecting the data now is imperative. As the U.S. offshore wind industry enters the initial, accelerated deployment phase, project siting and permitting is already generating terabytes of data.

It is to the sector's benefit to prioritize instituting a process for capturing that data and holding it securely while undertaking the process of determining protocols for making it publicly available, similar to the evolution of the U.K. MDE.

Data Management Architecture: It is generally viewed as unlikely that the U.S. will develop a unified platform similar to the U.K. MDE because there are currently numerous high-quality marine data management systems in the U.S. serving different purposes. BOEM has not had a U.K. MDE-type system in the past but is working with BSEE to identify long-term information technology needs. The question then arises of where data from the offshore wind development process should be housed and who should store it.

It may become necessary to map existing assets that might be appropriate for different data streams and collaborate with these data experts or inform the development of procedures for what data should be stored, by whom, for how long, how others can access it, and guidelines for data backups. The question that must then be addressed is how can the industry enhance the ability to integrate across different data platforms? Terabytes of data must be housed and managed in order to be used for the advantage of new technologies and analytics tools to address currently unknown challenges.

Standards and Interoperability of Data: Determining what should be standardized – metadata, definition of terms, collection methods, etc. – is a high priority and a foundational component of an effective data management system or network. The longer the industry waits to develop a metadata system for offshore wind development data, the harder it will be to integrate later. When different data sets are merged, data loss is imminent, therefore, one needs to be able to parse and separate data streams through the metadata and trace back to where the data originated. Basic definitional standards are also needed. For example, ROSA found no consistency in how fisheries data are collected; for example, the basic coding of fish species and even the way date and time are recorded differs across states and agencies.

It's a challenge to work within the accelerated offshore wind development timeline to achieve standardization, so the industry must consider prioritizing long-term actions that it needs to start on now.[xxi]

Role of Requirements/Best Practices for Developers: There are various responses to those seeking data that developers are willing to share – from "it's too hard to pull that data out because it's in the form of a map or report," to "no problem, here's the readily accessible link." Many developers don't think about stakeholder requests for data and the work it will take to respond if data is not packaged for efficient delivery in advance, which is a key benefit of the U.K. MDE. Stakeholders' data requests are directed to the MDE to access the validated data.

Data standards and metadata requirements need to be clear and articulated early in the development cycle so they can be contractually incorporated into the supply chain procurement process for execution. Standards are valuable, but can also limit innovation; how can flexibility be incorporated? Collaborative engagement with government, industry, and science is needed to identify priorities and define the terms of engagement. Specific data standards are more efficient and lead to fewer redundancies because regulators are not dealing with fresh systems for every project. Capacity-building and learning across project reviews leads to a more efficient review process and permitting pipeline.

Proprietary Interests in Data: Confidentiality protocols are needed to govern who has access to data, when, and for what purpose. How can stakeholders increase data sharing by all parties, including states and academia?

A potential starting point is to look at MDE milestones for release of proprietary developers' data. Collaborative negotiation is required to determine a reasonable shelf life for the proprietary value of data. There is a reasonable concern about misuse of data and litigation. There are lessons to be learned from ROSA about concerns around fisheries data and similar concerns around sharing tribal data. There is a need to maintain some control over how the data is exposed.

Data Validation: Vetted or validated data is essential to mitigating litigation risk. Third-party validation and management of developers' data increases stakeholder confidence. There is a role for citizen science, but it needs to be clear about what it is and how it is used.

Data Use for Decision-Making: NCCOS set a standard for spatial planning and lease area identification by engaging science, industry knowledge, and data analysts along with regulators in interpreting data. A similar approach is needed at the permitting and decision-making level (e.g. mitigation) to create a clear framework for applying the data.

Risks of Inaction: Although data sharing feels risky, the real risk for developers and industry is not having the data. More assertive mitigation measures can be implemented when supported by data, enabling a fact-based and less restrictive approach, often resulting in lower project impacts than initially feared. Some short- and long-term risks associated with industry inaction include;

- Data that has disappeared because it was housed on someone's server or in the Cloud and the person who generated it is no longer involved.
- A lack of a clear pathway back to the data when industry has a collective need for it to address a shared concern (e.g. the recent controversy about whale mortality).
- Loss of opportunity to look at cumulative impacts, or lack thereof, as the industry scales.

Developers are creating a tremendous depth and breadth of data in areas where there were no resources to do this before. This is an opportunity to fill gaps and track changes, including changes due to ocean warming.

As part of the development of a U.S. offshore wind industry environmental data strategy, the following can and should be considered and addressed collectively by stakeholders:

1. Data from studies ranging from physical, to ecological, to operational, can be packaged in a manner that follows specific data standardization and metadata protocols to allow for use and integration of raw data across scientific studies.

2. Data can be shared with appropriate data housing and management services in a manner that allows for long-term use and releases propriety data when it becomes non-proprietary (i.e., it would no longer affect competitive advantage to release it).

3. Data can be recognized as a tool for improving offshore wind development, lowering costs and time to development, and avoiding use of environmental compliance and social license as a context for competition among developers. Making compliance a source of competition tends to cause delays and setbacks for industries as a whole.

4. Data sharing agreements can ensure accessibility to data for many researchers and regulators and do not limit access based on limited agreements or publication dates.

5. Recognition that data and data products are different and that both are important to offshore wind development and for addressing concerns around environmental impacts and long-term monitoring.

6. Recognition that long-term and regional studies require collaboration and integration of data sets across projects to benefit the industry as a whole.

7. A system should be developed for storing, sharing, and managing data and data products that improves availability speed and access, quality of available data, and the ability to synthesize data across data collection efforts.

8. It is unlikely that there will be one single data portal or access point, but systematic standardization, sharing, and serving of data can be applied across applicable data portals to significantly improve the value and use of data to support the success and adaptive management of offshore wind in the U.S.

Conclusion and Next Steps

With steel entering the water for the first time on a commercial scale, the U.S. offshore wind industry has a rare window of opportunity to create enduring frameworks of cooperation that will ensure clean energy benefits are spread across society. Greater sharing of data can forecast future industry challenges and solutions, as well as reduce permitting timelines. These steps will build a stronger supply chain, reduce operational costs, and bolster public confidence in the industry's environmental benefits.

Through this paper, the Network has attempted to lay out the challenges and opportunities around broader data sharing, as identified by its Data & Digitalization Working Group and workshops. Through these collaborative sessions, it's apparent that even with its existing hurdles, building a path to a U.S. offshore wind data sharing strategy is possible, and the industry and the public sector should immediately explore next steps to achieve this critical system. That work begins with industry stakeholders – namely government agencies, academia, private industry experts and other organizations currently engaged in marine data collection – convening to determine which strategies best suit the collective group, and then developing a roadmap to build and implement them. The Network will continue to support this work through its own research and by engaging key industry players in future discussions around building a collaborative offshore wind data strategy.

Acknowledgements

The authors were assisted with substantial contributions to this paper by several members of the Data & Digitalization Working Group including Sarah Courbis of Advisian, Joel Whitman of Foss Offshore Wind, Scott Eichelberger of TGS, and Nick Welz of Tetra Tech, as well as Chelsea Bradbury and John Mitchell of The Crown Estate. We would also like to thank representatives of ROSA and RWSC, BOEM and BSEE staff, and others for their contributions to the working group activities and IPF discussion, which made this paper possible.

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Appendix A
Oceantic Network's Data & Digitalization Working Group Session Topics

The Data & Digitalization Working Group (DDWG) held sessions starting in July 2021 on the topics of:

- Environmental and permitting data, where Nick Napoli, Manager of the Northeast Regional Ocean Council (NROC) and Mid-Atlantic Regional Council on the Ocean (MARCO) data portals, was invited to participate as a key resource in understanding the current state-of-play around marine data availability on the east coast.
- Digitalization and operations, where Crowley Marine Services provided a baseline of challenges and opportunities related to digitalization of the offshore wind industry, and insight into Crowley's approach to marine coordination.
- The U.K.'s Marine Data Exchange (MDE), where Chelsea Bradbury, Senior Marine Data and Evidence Manager at The Crown Estate and lead for the MDE, discussed the U.K. experience and some lessons learned regarding offshore wind-related environmental data collection, standardization, and management, providing a valuable baseline understanding of European practices to benchmark US options.
- Regulatory compliance, where Nick Welz, Research Director of Tetra Tech, provided insight into the way offshore wind construction and operations and maintenance regulatory compliance is currently navigated as well as considerations for compliance regarding environmental monitoring, cable installation, and more.
- Cybersecurity, where Mark McKinney, Director of Cyber and Physical Security at Tetra Tech, made an illuminating and compelling presentation on security trends and considerations for offshore wind operations.
- Data standards, where National Renewable Energy Laboratory (NREL) Principal Engineer and Offshore Wind Research Lead Walt Musial spoke about the US Offshore Wind Standards Initiative facilitated by American Clean Power (ACP) and the Oceantic Network under American National Standards Institute (ANSI) rules to navigate existing offshore wind standards and guidelines and the benefits of data standardization.
- Insurance and risk, presented by a panel consisting of Ben Roberts, Senior Vice President and US Offshore Wind Lead for Marsh USA, Scott Eichelberger, Chief Scientist at TGS, Steven Harris, Senior Consultant at American Bureau of Shipping (ABS), and Olivier Rodriguez, MWS Manager for Renewables at Global Maritime.

A stakeholder meeting was also convened at The Network's 2023 International Partnering Forum (IPF) in Baltimore, MD which included the following speakers: Sarah Courbis, Marine Protected Species and Regulatory Specialist at Advisian; Emily Shunchenia, Director of Regional Wildlife Science Collaborative (RWSC); James Morris, Marine Ecologist at National Centers for Coastal Ocean Science (NCCOS); Lyndie Hice-Dunton, Executive Director of National Offshore Wind Research and Development Consortium (NOWRDC); Greg Lampman, Director of Offshore Wind at New York State Energy Research and Development Authority (NYSERDA); John Mitchell, Marine Data Advisor at the MDE; and Jim Bennett, former Senior Advisor at Bureau of Ocean Energy Management (BOEM). Other participants include additional parties from BOEM, Bureau of Safety and Environmental Enforcement (BSEE), NREL, state regulatory agencies, DDWG members, and offshore wind leaseholders/developer members of the Oceantic Network (see Appendices D and E).

Appendix B
Existing Efforts Underway to Advance Solutions Related to Offshore Wind Environmental Data

Regional Wildlife Science Collaborative (RWSC) was cooperatively established and funded two years ago at the request of four sectors that comprise its leadership — federal agencies, Atlantic coastal states, offshore wind leaseholders, and environmental non-government organizations (e-NGOs). RWSC, hosted by NROC and MARCO, facilitates data collection standardization and sharing. The four RWSC sectors have collaborated with scientific experts in several taxa-based subcommittees to develop the Draft Science Plan, which was released on July 1 and available for comment until September 30[1].

For example:

- Passive Acoustic Monitoring (PAM) Best Practices[2]
- Standards for sharing geo-tech and other sea floor data[3]

RWSC also recently engaged consultants to map pain points and important milestones in the data lifecycle to identify priorities for future focus.

National Center for Coastal and Ocean Science (NCCOS) is part of National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce, with broad blue economy and conservation mandates. NCCOS promotes the sharing of validated, high-quality ocean data through the Marine Cadastre[4] regional ocean data portal. NCCOS also develops curated products like Ocean Reports[5] to enhance the utility of available data for particular ocean-use purposes. Over the last couple of years, NCCOS has segued into marine spatial planning — developing suitability models to answer the question, "where is the best place to pursue specific ocean uses and why?" NCCOS is currently bolstering the marine spatial planning capacity of BOEM, supporting the identification of deconflicted wind energy lease areas in the Gulf of Mexico and Gulf of Maine.

The Carbon Trust and The International Energy Agency (IEA) have developed recommended practices[6] and standards[7] for floating LiDAR observation system data.

[1]https://rwsc.org/science-plan/#chapters
[2]https://rwscollab.github.io/pam-data-mgmt/
[3]Initial analysis funded by Rhode Island DEM, Massachusetts CEC and BOEM, handed over to WRSC for further development
[4]https://marinecadastre.gov/
[5]https://coastalscience.noaa.gov/products/ocean-reports/
[6]https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/owa-floating-lidar-recommended-practice
[7]https://iea-wind.org/wp-content/uploads/2020/12/IEA-Wind-RP-18-Floating-Lidar-Systems-fnl1.pdf

Appendix C

The U.K. Marine Data Exchange: A Benchmark for Consideration[8]

The driver for data sharing by offshore wind developers in the U.K. is the Data Clause included in all offshore renewable energy lease agreements issued by The Crown Estate since 2003 (between U.K. Round 1 & 2 leasing). The Data Clause requires leaseholders to provide their offshore survey data collected throughout the lifetime of a project to:

- Safeguard the retention of data and information for industry and future research.
- Ensure that the best available evidence is accessible for sustainable decision making.
- Provide developers with access to data and information that enhances development opportunities.
- Work with developers to promote best practice data management.
- Provide information to aid The Crown Estate, industry, and public understanding of the marine estate.
- Facilitate collaboration and research for the benefit of stakeholder industries.
- Provide support for development programs in the event of future development opportunities.

The motivation for developing this data management framework is straightforward: The Crown Estate did not want to risk losing the investment in data collection or missing opportunities to maximize public benefit in pursuit of commercial development on its offshore public lands.

For the first 10 years of working with the Data Clause, until 2013, The Crown Estate did not have a robust system of data management, and for most of those 10 years, the MDE was focused on first acquiring the required data. While the fact that all developers are compelled to abide by the same requirements and standards for providing data was helpful in gaining support, there was concern in the development community about the appropriate protection of proprietary information – for example, who could access the data and critically, when. In response, the MDE was established to ensure transparency and confidentiality and control how and when the data would become publicly available. These standards and processes were developed jointly with the industry.

Developers do not want to share data in a way that will disadvantage them against their competitors. The data requirement, along with agreed-upon standards for protecting data when it can be considered commercially sensitive, removes the business advantage of limiting data accessibility. In the U.K., the developers actively showcase their data via the MDE with stakeholders to demonstrate that they are meeting their survey obligations as verified by a third party. Additionally, developers field many data requests by researchers, or from Freedom of Information Act requests. Rather than responding to these individually, they can point stakeholders to the MDE.

The MDE has learned from its first eight years of data acquisition and the retrospective lessons from this data collection process that began a decade after the establishment of U.K. offshore wind. To ensure the data is as accessible and easy to use as possible, the MDE upgraded its platform in recent years and is focused on improving user experience to increase the overall efficacy of the database. As big data becomes more prevalent in the industry, the MDE focuses on improving the discoverability of data and resulting data products.

(Continued on page 19)

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[8]Information from Data & Digitalization Working Group Presentation & Discussion with Chelsea Bradbury, U.K MDE Manager, Dec. 2021

Appendix C (cont.)
The U.K. Marine Data Exchange: A Benchmark for Consideration[8] (cont).

Addressing Propriety Value

- In general, data must be submitted to the MDE within six months of acquisition.
    - *Environmental Data is held confidential until consent.*
    - *Site investigation data (e.g. geotechnical and geophysical) is confidential until Final Investment Decision (FID).*
- Wind Resource Data is held confidential until FID or two years from the date of collection, in the case of fixed offshore wind.
- Each can renegotiate these terms based on particular circumstances. It is a very cooperative process and this collaboration is key to the success of the MDE.
- The system itself builds trust: all developers are putting in the same effort, the playing field is level, and everyone (including the public) benefits.

Looking ahead, the MDE is developing case studies on how the data are being used by researchers and The Crown Estate to inform and de-risk future offshore wind leasing and understand cumulative impacts, as well as creating new ways of making data more accessible to stakeholders as they review proposed projects. These are new priorities for the MDE. For example, there is great interest in the kind of Geographic Information System-based products developed by the Northeast and Mid-Atlantic Ocean Data Portals in the US. In general, MDE leadership see a deep need for new skills and workforce development in data science to support offshore wind in developing apps to support virtual operations and maintenance, automate operations, and employ virtual reality and artificial intelligence, etc.

BOEM likely cannot simply replicate The Crown Estate's data sharing practices. Unlike BOEM, which is both a public lands management agency and regulator within the Executive Branch, The Crown Estate is an apolitical, independent commercial business. Those differences in structure may have implications for BOEM's execution of a similar approach. The US will likely need a different, purpose-built solution to accomplish the same.

Appendix D

2023 IPF Data & Digitalization Working Group Meeting Agenda

IPF 2023, Baltimore, MD | March 28, 1 – 3:30 p.m.

Session Goal: Identify priorities related to development of an environmental data strategy for the US offshore wind industry.

Building an Environmental Data Strategy for the US Offshore Wind Industry
Data are fuel for innovation, problem solving, commercial opportunity, and stakeholder confidence. Data strategies are about asking the right questions and the interoperability of data. Researchers working on individual projects cannot easily incorporate data from different projects to build regional ecosystem profiles or validate models. Additional investment to make datasets compatible after the fact is significant. Although challenging, the US offshore wind industry should embrace a collective strategic approach to data packaging, storage, sharing, and management. The industry-wide value of aggregating project-scale data assets is clear.

1:00 – **Welcome & Intro**
Fara Courtney & Aybala Sen

1:15 – **Benchmark Offshore Wind Data Strategy:** The U.K. Marine Data Exchange
John Mitchell (The Crown Estate)

1:30 – **Discussion: MDE**

1:45 – **Panel: Where We Are Now**
5-minute opening statements followed by 20 minutes of facilitated discussion.

- This panel presented lessons learned from early collaborations, needs for aggregated datasets for modeling, key opportunities for shared data, and efforts underway to develop data standardization and sharing protocols.

Panelists:

- Sarah Courbis (Advisan and Panel Moderator)
- Emily Shumchenia (RWSC)
- James Morris (NCCOS)
- Lyndie Dice-Hutton (NOWRDC)
- Greg Lampman (NYSERDA)

2:30 – **Discussion: Developer Perspectives**
Short opening statements followed by 20 minutes of facilitated discussion.

- This discussion provided perspectives about how the US industry and stakeholders can best leverage the private and public sector investment in data to support innovation, public acceptance and permitting efficiency.

3:15 – **Wrap Up & Next Steps**

Appendix E

List of Participants at 2023 IPF Data & Digitalization Working Group Meeting

Sarah Courbis, Advisian
Dianna Phu, Advisian
Deanne Hargrave, Atlantic Shores
Atma Khalsa, Avangrid
Jim Bennet, BOEM
Greg Fulling, BOEM
Arianna Honeycutt, BOEM
Brandon Jensen, BOEM
Annette Moore, BOEM
Renee Richards, BOEM
John Cushing, BSEE
Tara Shifflett, BSEE
Judy Triche, BSEE
Elizabeth Barminski, CEC
John Mitchell, The Crown Estate
Jeff Andreini, Crowley
Meghan Balling, CSS, Inc./NOAA
Dustin Van Liew, EnerGeo
Jennifer Dupont, Equinor
Joel Whitman, Foss Offshore Wind
Kathryn Rovang, Fugro
Rada Khadijinova, Fugro
James Morris, NCCOS
Katy Bland, NERACOOS/NHSG
Lyndie Hice-Dunton, NOWRDC
George Hagerman, NREL
Greg Lampman, NYSERDA
Sharon Whitesell, Orsted
Sam Athey, Partrac
Kevin Black, Partrac
Jeff Williamson, Proserv
Emily Shumchenia, RWSC
Ruth Perry, Shell
Chris Rhymes, Shell
Katja Akentieva, TGS
Scott Eichelberger, TGS
Altay Sansal, TGS

Appendix F
Oceantic Network
Data & Digitalization Working Group Members

FOSS OFFSHORE WIND

Joel Whitman

DDWG Chair

Foss Offshore Wind is a leading provider of installation, laydown, supply, and transportation services to the US offshore wind industry. The company boasts ownership of a dedicated fleet comprising highly specialized vessels, a core competency for project management services in offshore work, and a strategic presence in the Port of New Bedford, Massachusetts, where it maintains a dedicated shore base to support its operations. Based in Seattle, Washington, Foss offers a complete range of maritime transportation and logistics services as well as engineering and shipbuilding services. Whether it's solving transportation challenges in remote parts of the world or efficiently handling everyday harbor jobs, Foss prides itself on always offering customers safe and innovative solutions.

ABS GROUP

Vastan Tchokoev

ABS Group is a leading safety and risk management advisor driven by its mission to be a leading global provider of technical services that better enable its clients to operate safely, reliably, efficiently and in compliance with applicable regulations and standards. Safety, risk and integrity management are at the core of the company's work which aims to add value to the global industries it serves. ABS Group began providing non-classification marine technical services in 1971. Over the decades, its range of services expanded to support the diverse industrial and government clients that power, fuel and regulate our world.

ADVISIAN

Sarah Courbis

Advisian is a community of consultants, scientists, strategists, and engineers all dedicated to solving the world's critical infrastructure, environmental, energy, and resource challenges. Advisian leverages the practical expertise and technical proficiency of its consultants to assist organizations in adapting to evolving global conditions, ensuring that businesses are well-prepared to meet future challenges. Specializing in serving asset-intensive industries within the Infrastructure, Hydrocarbons, Minerals and Metals, and Chemicals sectors, Advisian is committed to delivering tailored solutions by assembling the most qualified teams with the requisite experience and capabilities for clients across the globe.

BURNS & MCDONNELL

Jim Bennett *(Formerly BOEM)*

Ian Voparil

Burns & McDonnell is a full-service engineering, architecture, construction, environmental and consulting solutions firm based in Kansas City, Missouri. It brings together the expertise of 13,500 engineers, architects, construction professionals, planners, estimators, economists, technicians and scientists, representing virtually all design disciplines. With an integrated construction and design approach, Burns & McDonnell plans, designs, permits, constructs and manages facilities all over the world thanks to the full-service capabilities of its 100% employee-owned team.

Appendix F (cont.)

Oceantic Network
Data & Digitalization Working Group Members

CROWLEY WIND SERVICES

Mark Coplen

Crowley, established in 1892, is a privately-held American logistics, marine, and energy solutions company, headquartered in Jacksonville, Florida. Serving both commercial and government clients worldwide, the company operates through five core business units: Crowley Logistics, Crowley (Government) Solutions, Crowley Shipping, Crowley Fuels, and Crowley Wind Services. In addition to maintaining an extensive range of land-based assetts such as port terminals, warehouses, specialized vehicles and more, Crowley possesses, operates, and manages a diverse fleet of over 200 vessels, including RO/RO (roll-on-roll-off) vessels, LO/LO (lift-on-lift-off) vessels, articulated tug-barges (ATBs), LNG-powered container/roll-on, roll-off ships (ConRos), and multipurpose tugboats and barges. As a U.S.-based global marine services provider, Crowley boasts U.S. Jones Act-qualified vessels to support offshore energy projects, offering project management and marine engineering services. Additionally, they are a trusted 3PL logistics and terminal services provider and have extensive experience planning the Cape Wind project.

MARSH USA

Benjamin Roberts

For over 150 years, Marsh's purpose has been to enable possibility. Marsh seeks better ways to manage risk and define more effective paths to the right outcome. The company goes beyond risk to rewards for its clients, company, colleagues, and the communities it serves. With offices in more than 130 countries, Marsh is the world's leading insurance broker and risk advisor. It offers industry-focused brokerage, consulting, and claims advocacy services, leveraging data, technology, and analytics to help reduce the total cost of risk for its clients. Marsh also offers local expertise with over 45,000 colleagues worldwide, providing its commercial and individual clients with insights, advice, and support in the local markets in which they operate or where their business may face risks. Marsh helps its clients understand coverage nuances, regulatory developments, and risk trends, and works together with its clients on placement, mitigating risk, and optimizing risk spend.

NATIONAL RENEWABLE ENERGY LABORATORY (NREL)

George Hagerman

Walt Musial

The National Renewable Energy Laboratory (NREL) is transforming energy through research, development, commercialization, and deployment of renewable energy and energy efficiency technologies. NREL advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provides the knowledge to integrate and optimize energy systems. With 16 research programs, thousands of published scientific and technical materials, more than 1,046 active partnerships, and 688 patents issued for NREL technologies, NREL is on the forefront of industry research and development.

Appendix F (cont.)

Oceantic Network
Data & Digitalization Working Group Members

TERRADEPTH

Siri de Lange

Discovering the last unexplored frontier on Earth, Terradepth is using unmanned submersibles to generate the first holistic picture of the subsea environment. Collecting comprehensive, high-resolution ocean data empowers society with information and knowledge crucial to the sustainable advancement of a variety of key industries such as global telecom, clean energy, national security and more. Terradepth's unique unmanned submersible technology will enable cost-effective, detailed data-capture that, when paired with big data analytics and machine learning, will offer new insights into our oceans. By continuously populating Terradepth's cloud-based information portal, the company aims to enhance humanity's relationship with the ocean, its ecosystems and marine life. Rekindling humanity's connection to the sea, Terradepth aims to empower the protection of our planet and advance the sustainable future of our climate.

TGS

Katja Akentieva

Scott Eichelberger

TGS is a leading energy data and intelligence company known for its asset-light, multi-client business model and global data collection. TGS offers the most complete and intuitive data and insights platforms for offshore wind development, raising the bar in wind data and intelligence. Its primary business provides energy data and intelligence to companies and investors across energy markets, offering the world's largest global energy data library, including seismic data, magnetic and gravity data, multi-beam and coring, digital well log and production data, wind energy data, data to identify CCS opportunities, and other types of renewable data. In addition, TGS also offers specialized services such as advanced processing and analytics, data management and cloud-based data applications and solutions, and with the recent acquisition of Magseis Fairfield, is now also the world's leading ocean bottom node provider.