Environmental Stratification Workgroup Report

State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: Cumulative Impacts

Prepared for:

New York State Energy Research and Development Authority

Albany, NY

Kate McClellan Press
Project Manager

Prepared by:

Jeff Carpenter, Helmholtz-Zentrum Hereon, Geesthacht

Kate Williams, Biodiversity Research Institute

Edward Jenkins, Biodiversity Research Institute

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

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Biodiversity Research Institute
innovative wildlife science

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Additional Information

This report is one outcome from a broader effort to review the state of knowledge regarding offshore wind energy development's effects on wildlife and identify short-term research priorities to improve our understanding of cumulative biological impacts as the offshore wind industry develops in the eastern United States. This effort, titled *State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: Cumulative Impacts*, included a week of plenary presentation sessions and contributed talks in November 2020, as well as the formation of six other workgroups similar to the environmental change workgroup that met over the winter of 2020-2021. This report, and those from the six other workgroups, are available on the workshop website at https://www.nyetwg.com/2020-workgroups.

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Contents

Background

The 2020 State of the Science Workshop, hosted by the New York State Energy Research and Development Authority (NYSERDA), was held virtually from November 16-20, 2020. This workshop brought together over 430 stakeholders engaged with environmental and wildlife research relevant to offshore wind energy development. The aim of the workshop was to assess the state of the knowledge regarding offshore wind development's potential cumulative impacts on wildlife populations and ecosystems. **For this effort, 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** (see call-out box for definitions of "effects" and "impacts").[1] Attendees included a wide range of stakeholders from offshore industry, government agencies, non-profit organizations, and academia. More information can be found at http://nyetwg.com/2020-workshop.

Following the plenary sessions in November, workshop attendees formed seven taxon-specific workgroups focusing on benthos, fishes and mobile invertebrates, birds, bats, marine mammals, sea turtles, and environmental change. Workgroups, under the guidance of lead technical experts, met virtually in late 2020 and early 2021 to identify scientific research, monitoring, and coordination needs to improve our understanding of cumulative impacts from offshore wind energy development. **The goal for each group was to identify a list of studies that could be implemented in the next five years to position the stakeholder community to better understand potential cumulative biological impacts as the offshore wind industry develops in the eastern U.S.**

The intended audience for this report encompasses a range of stakeholders including researchers, state and federal agencies, offshore wind energy developers, regional science entities, and other potential funding entities that could potentially target these priorities for future funding. The priorities identified below should not be interpreted as research that must occur prior to any development activity. Rather, these priorities are intended to further inform environmentally-responsible development and minimize cumulative impacts over the long term, and many of these research needs are specifically directed at understanding and measuring effects as the industry progresses.

The environmental change workgroup was led by Jeff Carpenter (Department Head of Small-scale Physics and Turbulence, Institute of Coastal Ocean Dynamics, Helmholtz-Zentrum Hereon, Geesthacht, Germany), with technical and logistical support from Kate Williams and Edward Jenkins (Biodiversity Research Institute) and Ashley Arayas and others (Cadmus Group). The workgroup consisted of 29 members who met virtually twice in the winter and spring of 2020-2021

Defining Impacts vs. Effects (from Hawkins et al. 2020)

Effect: a change caused by an exposure to an anthropogenic activity that is a departure from a prior state, condition, or situation, which is called the "baseline" condition.

Impact: a biologically significant effect that reflects a change whose direction, magnitude and/or duration is sufficient to have consequences for the fitness of individuals or populations.

[1] This effort was focused on better understanding effects specifically from offshore wind energy development. This was not intended to imply that offshore wind is causing greater impacts than other stressors. Cumulative impact estimates for offshore wind energy development will be useful in broader cumulative impact frameworks that include impacts from multiple types of anthropogenic activities.

(Appendix A). Workgroup members represented a wide range of perspectives from offshore wind developers, the fishing industry, government agencies, non-profit organizations, and academia, and provided key input based on their respective specialties. Workgroup meetings included presentations as well as small and large group discussions to identify and prioritize key topics of interest. Workgroup members also provided input on the relative priority of different topics via live polls during meetings and/or online surveys between meetings. All workgroup documents were shared with workgroup members via a document collaboration platform (e.g., Google Drive, Microsoft Teams), and workgroup members had multiple opportunities over the course of several months to provide written input on earlier drafts of this report. The report indicates a general consensus among workgroup members, unless otherwise noted; where there was stated disagreement among workgroup members on a recommendation in this report, this disagreement is noted in the text. Despite the substantial input and influence of workgroup members on the workgroup reports, final report content was determined by the technical leads, in some cases with support from an additional small subgroup of experts within the workgroup. More information about the workgroups can be found at https://www.nyetwg.com/2020-workgroups.

Introduction and Methods

Past large-scale infrastructure developments such as the railroad, telegraph, and highway networks, have had profound effects on the landscape and subsequent patterns of anthropogenic activities. Offshore wind (OSW) development in the U.S. is set to increase dramatically in the next few years, with wind farms in various planning stages along much of the east coast. As research from Europe has shown, OSW structures affect physical processes, which may have knock-on effects on wildlife and other oceanographic and anthropogenic processes in the marine environment.

The collection and coupling of oceanographic and biological data have been ongoing across the region since the 1970s. However, OSW development is predicted to alter the local physical environment through changes in stratification (Carpenter et al. 2016; Floeter et al. 2017; Schultze et al. 2020), turbulence (Schultze et al. 2017; ,2020), suspended sediment (Vanhellemont & Ruddick 2014; Baeye & Fettweis 2015), and wind- and ocean-wake effects (Platis et al. 2018; Djath et al. 2018; Schultze et al. 2020). A good overview of the effects of OSW on hydrodynamics with implications for fisheries can be found in a recent special issue of *Oceanography* (van Berkel et al. 2021). Given these potential changes to the local physical environment, there is a need to not only design approaches to understand the cumulative oceanographic impacts of OSW in the U.S., but to adjust previous monitoring strategies to continue building on long-term datasets. It is also important to consider that while OSW development may have some negative effects on the environment, it may also have positive effects including tackling climate change and providing "artificial reef" effects.

Following discussions at the initial environmental change breakout group meeting in November 2020, the workgroup's broad initial scope was refined to focus particularly on changes in stratification and the other topics listed below in relation to offshore wind energy development. In line with this focus, the workgroup suggested six specific priorities for improving our understanding of OSW effects on physical and oceanographic conditions in the eastern U.S. in the coming years (below).

Following development of these topic ideas, workgroup members (n=19) participated in an online survey and ranked the topics in order from highest to lowest priority. Given the goals of this workgroup, members were asked to consider the following criteria when identifying priorities:

- Urgency of information need. Objectives should be prioritized that will most effectively improve our understanding of cumulative impacts and inform decision making.
- Sequencing of objectives. If the results of Study #1 are needed to inform the design of Study #2, the former should be designated higher priority in the short term.
- Ability to inform cumulative impact models. Studies should be prioritized that will improve our ability to model cumulative impacts to populations or ecosystems.
- Effectiveness at addressing one or more key societal concerns, as identified through multi-stakeholder engagement processes.

The below research topics are listed in order of priority according to these survey responses, with the highest-priority topic listed first. For each topic, information is included on the study goal, potential methods, and existing data and/or related information with relevance to the proposed study (for example, other ongoing studies or coordination efforts with which a proposed study should be coordinated).

Short-term Priorities

1. Develop a methods and metrics document to define what monitoring should be done and how

Goal: Develop a strategy for short- and long-term monitoring strategies (including pre- and post-construction periods) that can span a range of spatial and temporal scales and differentiate OSW effects from natural and climate variability.

Potential methods:

- Important variables on which to focus this guidance document include: stratification, currents, suspended sediment concentrations, pH, turbulence, and chlorophyll.
- Pre-construction methods should build from previous survey/modeling efforts, and extend data collection using autonomous gliders (which are already active in several regions of interest).
- Post-construction methods should include the use of smaller vessels that can maneuver within OSW areas, mounting instruments on foundation structures, and using new high-resolution satellites to examine wakes. Larger-scale effects, such as wind wakes, should be examined both upstream and downstream of OSW farms for comparison purposes.
- Monitoring strategies should include a focus on successful methodological transition, including maintaining long-term time series (obtained using traditional methods) while also incorporating new techniques.

Existing data: None provided.

Related information: The importance of differentiating the effects of OSW from natural and climate variability was recognized by multiple State of the Science workgroups including those focused on benthos (Degraer et al. 2021), sea turtles (Gitschlag et al. 2021) and birds (Cook et al. 2021). Differentiating the oceanographic influences of OSW from other stressors can help inform our understanding of potential effects on these higher trophic levels. A need for methodological and data standardization and transparency was also noted in other State of the Science workgroups, including those focused on the benthos (Degraer et al. 2021), marine mammals (Southall et al. 2021), fishes and aquatic invertebrates (Popper et al. 2021), bats (Hein et al. 2021), and birds (Cook et al. 2021).

Guidelines have recently been released by the Responsible Offshore Science Alliance (ROSA)[2] and are forthcoming from the Rutgers University Center for Ocean Observing Leadership (RUCOOL) 2021 Partners in Science Workshop[3]. The ROSA guidelines are more generally focused on pre- and post-construction monitoring in relation to fish populations, while the RUCOOL workshop was more specifically focused on the identification of oceanographic variables to be measured (workshop report in progress). It will be important to build off of the next steps and further needs identified in these efforts, particularly the RUCOOL workshop; some areas discussed at this recent workshop had a fair amount of consensus from participants, while others will require additional discussion.

2. Link the physical effects of offshore wind energy development to biological effects

Goal: Develop strategies for linking the physical effects of OSW to biological effects at all trophic levels.

Potential methods: Using an interdisciplinary approach, assess mechanisms that link physical processes to biology. Direct and indirect effects should both be considered, including drivers of prey production, distribution, and availability. Modeling efforts are likely to form a significant aspect of the methodology.

- The indirect effects of OSW on other human activities (e.g., fishing) should be considered, as changes could have implications for individual species and cascading effects on food webs. As turbines will be more widely spaced in the U.S. than Europe, it is unclear how fishing activity will change once structures are in the water. It may be necessary to wait until OSW farms have been built to see what fishing practices actually occur in OSW areas; there are several current approaches for measuring these changes, though they are not comprehensive (e.g., vessel monitoring systems data, automatic identification systems data) and some states are also considering new approaches for how to measure fishing activity in OSW farms post-construction.
- Fisheries management will also change over time independently of OSW development, and this represents a potential confounding variable that must be considered (i.e., closures may change biodiversity in an area).

[2] ROSA Offshore Wind Project Monitoring Framework and Guidelines, March 2021. Available at https://www.rosascience.org/resources

[3] Rutgers University Centre for Ocean Observing Leadership Partners in Science Workshop: Identifying Ecological Metrics and Sampling Strategies for Baseline Monitoring During Offshore Wind Development. January 28, 2021. Agenda available: https://drive.google.com/file/d/1SSoi5O_I6Paig1iz0rDVyq-Yv1klbPiS/view

Existing data:

- Existing integrated modeling may be applicable in this context, in which our knowledge about physical process and associated biological process is captured in modeling frameworks.
- WhaleSafe[4] includes a whale habitat model that uses oceanographic information to predict Blue Whale (*Balaenoptera musculus*) presence likelihood in the Santa Barbara Channel, California.
- The Ecosystem and Passive Acoustic Monitoring (ECO-PAM) project[5] is focused on North Atlantic Right Whale (*Eubalaena glacialis*) habitat predictive modeling, and in 2021 will also begin measuring phytoplankton concentrations and turbidity in the water column.
- Some information is available on changes in fishing practices at European OSW farms where fishing is allowed; however, results may not be transferable to the U.S. context due to differences in turbine size/spacing etc.
- Existing marine use data on the Ocean Portals[6] can also help to examine trends in activity over time, though we will need to continue gathering information for longer-term comparisons.
- Substantial amounts of data are gathered by Protected Species Observers (PSOs; also known as Marine Mammal Observers) while performing mitigation work. While data collection protocols have varied, PSO data may include detailed environmental data, passive acoustics monitoring, visual sightings (both day and night via infrared cameras), and behavioral recording of marine mammals, sea turtles and in some cases seabirds. While not generally gathered under strict line transect survey protocols, it is possible that these data could still be leveraged for a wide array of scientific studies. The National Marine Fisheries Service and New England Aquarium are currently conducting a study to assess the utility of PSO data in a conservation and management context[7].

Related information: This linkage of physical and biological effects, particularly as it relates to the drivers of prey distributions, was of interest across all State of the Science workgroups, including those focused on birds (Cook et al. 2021), marine mammals (Southall et al. 2021), and benthos (Degraer et al. 2021).

3. Coordinate existing efforts to maximize utility of available resources and expand scale of inference

Goal: Formalize coordination and collaboration among small-scale efforts to maximize the utility of datasets and funding, bring together different ideas, and develop standardized methods and new techniques.

Potential methods: Develop a platform for researchers to come together to pool different types of data and advance larger modeling efforts across spatial and temporal scales. Coordination will be very important to bring together local-scale efforts, allow researchers to discover available datasets they

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[4] WhaleSafe https://whalesafe.com/
[5] The Ørsted Ecosystem and Passive Acoustic Monitoring (ECO-PAM) project https://orsted-eco-pam-web-portal.srv.axds.co/
[6] Northeast Ocean Data Portal https://www.northeastoceandata.org/, Mid-Atlantic Ocean Data Portal https://portal.midatlanticocean.org/
[7] Evaluating the utility of Protected Species Observer data to address cetacean management and conservation. https://www.mmc.gov/grants-and-research-survey/grant-awards/2020-grant-awards/

could use in new ways, and share ideas. Funding tends to be more local in focus, but regular coordination would help contribute to something bigger by bringing together existing efforts. This process could be formalized to varying degrees depending on available funding, from regular Zoom calls to an annual meeting or development of a research consortium.

Existing data: None provided.

Related information: Various teams are working on modeling efforts related to oceanographic processes and OSW, but there is a need to collate data. Existing examples of this type of coordination include the International Council for the Exploration of the Sea (ICES) working groups and Middle Atlantic Bight Physical Oceanography and Meteorology (MABPOM) meetings.

4. Conduct feasibility studies to identify the types and scale of potential effects and focus research in the eastern U.S.

Goal: Use existing data from different industries or OSW locations to design and conduct "transfer" studies to better understand possible environmental effects of OSW development and operations in the eastern U.S.

Potential methods: Much can be done in the short term using existing oceanographic knowledge for the eastern U.S. and OSW-related studies in different regions (e.g., Europe). Feasibility studies should be designed using information from Europe to predict, given various variables, what could be observed in the U.S. and to help determine the variables, parameters, and scales on which to focus U.S. research. There are also lessons to be learned regarding measurement strategies, though there is no well-organized, planned long-term measurement strategy in Europe to our knowledge.

Existing data: The van Berkel et al. review (2021) is a good summary of existing knowledge. Other specific sources of information for different OSW areas or industries include:

- Research from existing offshore oil and gas projects, including studies in the Gulf of Mexico and California
- The Bureau of Ocean Energy Management (BOEM) Realtime Opportunity for Development Environmental Observations (RODEO) project[8]
- Ørsted ECO-PAM Project
- The U.S. Integrated Ocean Observing System (IOOS) including the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)[9] and the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)[10]

Related information: The Department of Energy is in the process of funding Woods Hole Oceanographic Institution to deploy platforms and sensors to characterize marine boundary layers around wind farm lease areas as part of DOE's Wind Forecast Improvement Project (WFIP). Planned sensors for

[8] BOEM Realtime Opportunity for Development Environmental Observations (RODEO) Project https://www.boem.gov/rodeo
[9] Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) https://maracoos.org/
[10] Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS) http://www.neracoos.org/

deployment south of Martha's Vineyard, in the area monitored by WHOI's Martha's Vineyard Coastal Observatory (MVCO[11]), include a ship-based meteorological tower, rawinsonde (balloon) launches, LiDAR buoys, and others.

5. Examine effects of offshore wind energy development on ocean stratification

Goal: Understand and quantify the possible effects from OSW structures on stratification, including structure-caused aquatic turbulence and wind stress alterations that affect both mixing and upwelling/downwelling ocean responses. The cascading effects that result from these changes, such as altered primary production, possible plankton blooms, and changes in predator foraging behavior, are addressed in Topic #2 above.

Potential methods: Utilize oceanographic data and models from the region to define the spatial extent to be examined, both inside and outside the OSW areas. Monitoring methodologies should be at the relevant scale of the variable in question (e.g., ocean wakes from OSW are small but can be felt at broad scales). Methods also need to separate OSW-related effects from natural variability and climate change-induced effects, if possible. Satellites may be useful for observing wind-wake effects, which could happen at larger scales than turbulence and other physical variables in close proximity to foundations; however, satellites can only provide surface data on certain variables under specific conditions.

We must improve our understanding of small-scale physical processes at an individual turbine structure (e.g., small-scale turbulence modeling) before it would be useful for predicting effects at a more regional scale. This is exacerbated by the variety of foundation designs. Care will need to be taken in considering how to parameterize and incorporate realistic physical, oceanographic, and meteorological structure wake effects into models at different scales. An important task for this research topic is to be able to assess OSW effects, including cumulative impacts of multiple wind farms, through the development and implementation of numerical models of various types. However, this must be done in conjunction with observational studies.

Existing data: None provided.

Related information:

- Atmospheric effects are important not just for effects on ocean mixing but also for aerofauna, meteorology/storms, etc. Some parameterization of OSW effects on wind speeds, etc. in the atmosphere are ongoing, but it is currently unclear whether OSW build-out areas are large enough to affect large-scale circulation.
- Floating wind turbines will be substantially different than traditional foundations in their effects on ocean wakes. The proposed Gulf of Maine research array, Aqua Ventus turbine, or proposed floating test turbine at the Mayflower Wind Project may be useful test cases.
- Understanding the potential effect of OSW development on stratification was also identified by the State of the Science workgroup focused on benthos (Degraer et al. 2021), recognizing the

[11] WHOI Martha's Vineyard Coastal Observatory (MVCO) https://mvco.whoi.edu/

close connection to benthic processes, as well as by the marine mammal workgroup (Southall et al. 2021) as it relates to possible effects on prey species.

6. Assess changes in light conditions

Goal: To understand and quantify changing light conditions due to the suspension of sediment and possible changes in primary production within OSW areas.

Potential methods: Some members suggested that this may be more of a cabling issue during construction, rather than an operational phase issue. Others felt that, as installation activities are local and short-term, it may be worth focusing more on the degree of resuspension of sediment that occurs in the operational period. Previous work on the topic in European seas has suggested that this could be an important effect (Baeye and Fetteis 2015), but the bed composition and conditions are expected to be very different on the U.S. east coast.

Existing data: The BOEM RODEO project examined sediment resuspension and did not find it to be a major issue. Workgroup members varied in their opinions of the importance of this topic, but overall ranked it by far the lowest of the six priorities.

Related information: The degree of potential effects will be highly dependent on sediment class. Many OSW areas and cabling areas in the eastern U.S. are sandy with naturally high sediment suspension, natural bedload sediment transport, and turbidity. There is also ongoing disturbance from commercial dredging. Thus, though it has been observed in the North Sea, this could be a non-issue in some areas of the eastern U.S.

Conclusions

Workgroup members felt strongly that long-term, broad-scale monitoring, including coordination of existing long-term monitoring efforts with site-specific studies at offshore wind development locations, will be essential to understand changes in physical oceanographic processes in relation to both offshore wind energy development and climate change. The highest priority topics identified in this report included a mix of efforts that were felt to address issues of key ecological importance and those that would serve to set the stage for needed research (such as developing appropriate methods and metrics). Coordination of research and data collection at a range of spatiotemporal scales will allow for an improved understanding of how offshore wind energy structures affect physical processes and in turn affect wildlife and their habitats.

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Appendix A. Workgroup Participants

Table A1. Workgroup members who attended one or more workgroup meetings and/or provided written comments on research priorities included (listed in alphabetical order by first name).

Name	Affiliation
Andrew Gilbert	Biodiversity Research Institute
Andrew Rella	ECOncrete Inc.
Carter Craft	Consulate General of the Netherlands in New York
Craig Reiser	Smultea Sciences
Damien Kirby	MarineSpace
Dave Steckler	Mysticetus
Dusty Miller	Black & Veatch
Edward Jenkins	Biodiversity Research Institute
Emily Rochon	Vineyard Wind
Emily Shumchenia	Northeast Regional Ocean Council
Grace Chang	Integral Consulting Inc.
Ian Slayton	Bureau of Ocean Energy Management
Jan Vanaverbeke	Royal Belgian Institute of Natural Sciences
Jeff Carpenter	Helmholtz-Zentrum Hereon
Jennifer Draher	Bureau of Ocean Energy Management
Jennifer McCann	University of Rhode Island
Joseph Brodie	Rutgers University
Josh Kohut	Rutgers University
Julia Lewis	Equinor
June Mire	Tetra Tech
Kate McClellan Press	New York State Energy Research and Development Authority
Kate Williams	Biodiversity Research Institute
Kim Fitzgibbons	Kleinschmidt Associates
Laura Morse	Ørsted
Liz Gowell	Ørsted
Maureen Dunn	Seatuck Environmental Association
Nils Bolgen	Massachusetts Clean Energy Center
Nick Sisson	National Oceanic and Atmospheric Administration
Patrick Halpin	Duke University
Paula Fratanoni	National Oceanic and Atmospheric Administration
Richard Zeroka	RPS Group
Susan Bates	The Nature Conservancy