


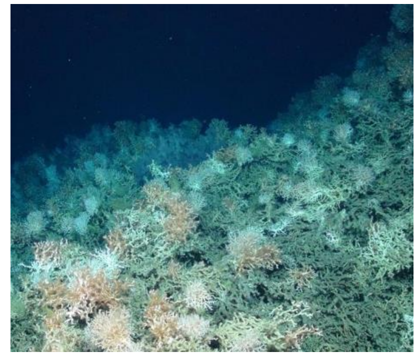

The State of the Science on Wildlife and Offshore Wind Energy Development

November 13-14, 2018
Woodbury, New York

Workshop Proceedings

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Disclaimer

Funding for this workshop and report was provided by the New York State Energy Research and Development Authority. Presentations described in the Proceedings of the State of the Science of Wildlife and Offshore Wind Energy Development Meeting may have been peer-reviewed independently from this workshop, but results should be considered preliminary. The views and conclusions contained in this document are those of the presenters or individual meeting participants and do not necessarily represent the views of all meeting participants, the planning committee, the E-TWG, BRI, or NYSERDA.

Additional information

These proceedings are available in PDF format and may be downloaded from the workshop website at www.nyetwg.com/past-workshops. Additional workshop information may also be found at this website.

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Abbreviations

AC – Alternative Current
ADD – Acoustic Deterrent Device
BACI – Before After Control Impact
BAG – Before After Gradient
BOEM – Bureau of Ocean Energy Management
BRI – Biodiversity Research Institute
CEAF – Cumulative Effects Assessment Framework
COP – Construction and Operations Plan
CZMA – Coastal Zone Management Act
DC – Direct Current
DEPONS – Disturbance Effects on the Harbor Porpoise population in the North Sea
DOE – U.S. Department of Energy
DPS – Distinct Population Segment recognized under the Endangered Species Act
DRIP – Data Rich, Information Poor
EIS – Environmental Impact Statement
EMF – Electromagnetic Field
ESA – Endangered Species Act
E-TWG – Environmental Technical Working Group
EU – European Union
GAR – Greater Atlantic Region
GW – Gigawatt
iPCoD – Interim Population Consequences of Disturbance model
ITS – Incidental Take Statement
MDAT – Marine Life Data Analysis Team
MMPA – Marine Mammal Protection Act
MW – Megawatt
NARW – North Atlantic Right Whale
NEAMAP – Northeast Area Monitoring and Assessment Program
NEPA – National Environmental Policy Act
NFWF – National Fish and Wildlife Foundation
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NYSERDA – New York State Energy Research and Development Authority
OCS – Outer Continental Shelf
ORJIP – Offshore Renewables Joint Industry Program
OSW – Offshore Wind
PTS – Permanent Threshold Shift
PCoD – see iPCoD, above
RODEO – Real-Time Opportunity for Development Environmental Observations
SEL- Sound Exposure Level
TRL – Technology Readiness Level
TTS – Temporary Threshold Shift
USFWS – U.S. Fish and Wildlife Service
VHF – Very High Frequency
WEA – Wind Energy Area

Summary

The first State of the Science Workshop on Wildlife and Offshore Wind, hosted by the New York State Energy Research and Development Authority (NYSERDA), allowed researchers, managers, and stakeholders to share knowledge about the impacts to wildlife from offshore wind energy development. Panel presentations and group discussions allowed for a diversity of topics and issues to be identified in relation to: 1) Key advances in our understanding of environmental impacts from offshore wind, 2) Remaining priority data gaps and research needs, and 3) Opportunities for collaboration and regional coordination.

Key Advances in Understanding

Much knowledge has been gained on the impacts of offshore wind on wildlife through the European experience, studies at the Block Island Wind Farm, other offshore industries such as oil and gas, and other research efforts. A substantial body of research from properly designed studies has contributed to our understanding of wildlife impacts from offshore wind in recent years. Impacts from noise and other sensory disturbance, displacement, collisions, and habitat change have been explored for a range of species, largely in Europe. Such impacts must be considered within the context of climate change, including ongoing changes in ocean dynamics.

The importance of properly designed studies has become broadly recognized as the offshore wind industry has developed. Both basic monitoring programs and targeted research must:

- Focus on high-priority, pertinent questions, which involves balancing stakeholder interests and identifying the most relevant and urgent questions for each project based on assessed risk,
- Have a scientifically robust survey design, with a priori consideration of statistical power to detect impacts (in particular, the use of gradient study designs has allowed for more robust analyses of displacement and habitat impacts), and
- Identify the appropriate spatial and temporal scale at which to examine impacts.

Noise and Sensory Disturbance

Studies on the impacts of noise and other sources of sensory disturbance, such as EMF (electromagnetic fields), have contributed to our understanding of behavioral disturbance in marine mammals, sea turtles, and fishes. Main EMF receptors include fishes, aquatic invertebrates, marine mammals, and sea turtles in close proximity to the seabed. Studies on species including eels, lobsters, and skates have shown behavioral responses to EMF from buried cables, but the impacts of these responses remain unclear. Operational noise is not likely an issue for many species; in Europe, for example, this is no longer considered an issue for marine mammals. Concerns do, however, still exist in relation to the impacts of pile driving noise on marine mammals, sea turtles, and fishes. Very close to the noise source, there is potential for physical and physiological effects, while at greater distances, behavioral as well as physiological effects are more likely. However, key advances in noise-reducing technologies can help reduce risk of injury and shrink the behavioral impact zone. Behavioral impacts include displacement, with harbor porpoises and seals in Europe showing displacement up to 20 km from pile driving activities, though individuals usually return quickly to the area once piling ceases. Similarly, several species of fishes and invertebrates were captured less frequently during pile driving at the Block Island Wind Farm, and abundance returned to baseline after construction (though other species apparently remained unaffected). We have improved our understanding of the hearing capabilities of many species of interest, which informs our understanding and prediction of impacts. While hearing capabilities may remain somewhat consistent within broad taxonomic groups, both sound detection and the impacts of underwater sound generated from offshore wind energy development are likely to be species-specific. For example, in the case of fish, with 33,000 species, there is substantial variation in the structure and function of auditory systems.

Population Distributions and Movements
Through a great deal of research and advances in technology, we have improved our understanding of the abundance, movement, and distribution of species including seabirds, marine mammals, and sea turtles. This is a key first step in both understanding and improving collision risk estimates (for aerial species), as well as increasing our understanding of displacement and other impacts. We have developed, and are still developing, a better understanding of wildlife distributions and abundance for taxa along the east coast of the United States such as marine mammals, sea turtles, seabirds, endangered birds such as roseate terns and piping plovers, and commercially important fishes.

Collision Risk and Displacement in Birds
In Europe, studies of seabirds have shown evidence of displacement from entire wind farms for some species, and initial displacement followed by habituation in others. Evidence suggests that risk of displacement and collision in marine birds is not only species-specific, but also dependent on life history and behavior. Recent studies have contributed to improving our understanding of collision risk and avoidance behavior.

Habitat Change
Research from Europe and the Block Island Wind Farm suggest greater fish abundance inside of wind farms than in reference sites, with attraction to structures (turbine foundations) evident in some species such as black sea bass. This can increase local biomass substantially and also lead to changes in community structure and trophic interactions. As with many impacts, this attraction effect likely varies by species and life stage. In addition, benthic habitats are affected during construction activities. These habitats recover over time, though the speed and degree of recovery depends on the severity of impacts, the substrate type, and the type of benthic community, among other factors.

Data Gaps and Research Needs
Despite recent advances in our knowledge of wildlife impacts from offshore wind energy development, several data gaps remain, particularly relating to general ecological conditions, ecosystem and community dynamics, and the combined impacts of climate change, offshore wind development, and other stressors on these systems.

Ecological Drivers of Distribution and Movement Patterns
While we have increased our understanding of the movement, abundance and distribution of

species, data gaps remain for some taxonomic groups, such as sea turtles, and species further offshore remain underrepresented in these data. There is still much to be learned about the drivers of movement patterns and change over time, including oceanographic conditions, animal behavior, and trophic relationships. In many cases we are now able to conclude that species move in relation to wind farms, including temporary and longer-term displacement and attraction, but we do not know what mechanisms are driving these changes.

Sublethal Impacts

Much of the improvement in our understanding of offshore wind impacts has been focused on megafauna in European systems. We still lack information on lower trophic levels and species that are more difficult to study. For instance, little is known about how sea turtles, benthic invertebrates, and fishes that hear through particle motion are affected by underwater noise. Impacts likely vary by species and life history stage. Studies are lacking on pelagic fish species and little is known about how habitat change from offshore wind development might impact spawning activities and behavior or juvenile refuge habitat.

Technological and Methodological Development

Our understanding of baseline distributions, ecosystem dynamics, and offshore wind impacts is currently hampered by several technological and methodological limitations. These include a lack of methodologies for accurate and unbiased abundance estimates (particularly for long-diving species), technology for automated identification of species in photographs, videos, and acoustic recordings, and technology for tracking individuals (size and battery limitations), as well as ways to better detect collision mortality and avoidance in the offshore environment. In addition, there is a need to understand how impacts might change as offshore wind technologies develop, such as increased foundation and turbine size, and mitigation technologies are improved. For example, there may be tradeoffs between spatial reduction and temporal expansion of acoustic disturbance that require further investigation.

Ecosystem and Cumulative Impacts

To date, many studies of offshore wind have focused on wildlife impacts that are limited in temporal and/or spatial scope. While this is a critical first step, we must move from local and structural impacts to understanding impacts on broader ecosystem-wide function, and from understanding impacts during the first few years of wind farm operations to the lifetime of the project, including decommissioning. The population-level and ecosystem-level consequences of individual impacts must be better understood, and we must move towards a better understanding of cumulative effects across multiple developments, and tease apart impacts from offshore wind development and other stressors, including climate change.

Opportunities for Collaboration

Throughout the workshop, opportunities for collaboration were identified relating to research and data sharing, information dissemination, and regional-scale monitoring and research.

Research Opportunities and Combining Data

Combining data from different sources (for example, visual observations, passive acoustics, behavioral data, oceanographic sampling) is key to understanding baseline ecological conditions and the potential for population- and ecosystem-level impacts of offshore wind energy development. Collaboration between the wildlife and oceanographic communities to simultaneously collect physical ocean data (e.g., temperature, salinity, wind speed) and wildlife data can help to improve our understanding of underlying factors that influence species distributions and ecosystem dynamics, and help differentiate impacts of offshore wind from other ecosystem changes. Metocean buoys, for example, that collect oceanographic information can also have passive acoustic monitors to detect wildlife activity, and have been deployed by multiple stakeholders[1]. Research collaborations that allow for the integration of multiple data types help increase our understanding of impacts while addressing existing data gaps.

Data Sharing and Information Dissemination

Information dissemination is important within the wildlife research community as well as between wildlife stakeholders, commercial fisherman, and the general public. There must be a strong focus on data sharing and availability to improve our collective understanding of ecosystems and offshore wind impacts. Data portals are key for ensuring data can be shared across research projects.

Regional Collaboration

There is a need to develop a unified approach to improve our understanding of impacts and their causes. Regional funding and cooperation could go a long way to leverage existing resources and enable us to better answer large-scale, long-term questions. There are examples of such collaborations in Europe, such as the Offshore Renewables Joint Industry Programme (ORJIP) in the UK, which is funded by public and private partners to improve our understanding of the effects of offshore wind across project sites. Momentum is building in the U.S. among developers and other stakeholders for strategic and regional collaboration of this nature. This collaboration could take many forms, from providing funding for regional research efforts, to coordinating among developers to standardize site-specific data collection to allow for broader use, to developing a regional research and monitoring framework to guide the selection and implementation of site-specific studies. Such efforts could help facilitate regional-scale data collection to make assessments across species, communities, and wind farms.

Next Steps

Post-workshop feedback from attendees indicated overwhelming interest in holding additional State of the Science meetings to improve coordination and information dissemination within the offshore wind and wildlife stakeholder community. NYSERDA will host the next State of the

[1] Examples include:

- Wildlife Conservation Society. 2019. BlueYork. Available at: https://blueyork.org/buoy
- NYSERDA. 2019. NYSERDA announces contracts for collecting environmental and metocean data in support of offshore wind energy development. Available at: www.nyserda.ny.gov/About/Newsroom/2019-Announcements/2019-01-31-NYSERDA-Announces-Contracts-for-Collecting-Environmental-and-Metocean-Data-in-Support-of-Offshore-Wind-Energy-Development

Science Workshop in 2020, as well as host webinars and collaborate on discussions around the development of a regional research and funding entity.

Introduction

The Environmental Technical Working Group (E-TWG) serves as a long-term advisory body to the State of New York, providing advice and guidance for the State's efforts to advance offshore wind development in environmentally responsible ways (Appendix A). The objectives of this group include identifying additional research needs, supporting coordination of research activities, and encouraging coordination and dialogue among regional planning bodies, state and federal managers, scientists, and other stakeholders.

The E-TWG has recognized the importance of regional coordination, collaboration, and the sharing of information among stakeholders on topics relating to wildlife impacts from offshore wind energy development in the eastern United States. The first State of the Science Workshop on Wildlife and Offshore Wind was initiated as an opportunity for researchers, managers, and stakeholders to share knowledge about the impacts to wildlife from offshore wind energy development. The workshop was designed to allow for collaborative conversations among stakeholders, ensure awareness of past efforts, and support stakeholders in making informed recommendations to the E-TWG about future work.

NYSERDA hosted the first State of the Science Workshop on Wildlife and Offshore Wind Energy Development on November 13-14, 2018 at the Inn at Fox Hollow in Woodbury, New York. Presentation topics were identified as part of the workshop planning process with a planning committee and other advisors, and were intended to provide a broad review of topics relating to wildlife and offshore wind energy for the east coast of the United States. With over 180 attendees, 32 speakers, and 45 poster presentations, participants from the U.S. and Europe exchanged information and built relationships to better understand the current state of knowledge relating to wildlife and offshore wind energy development. Workshop goals included:

- Engaging and informing interested stakeholders about the state of knowledge regarding wildlife and offshore wind energy development, including ongoing efforts to understand, minimize, and mitigate environmental impacts
- Promoting regional coordination by sharing updates on research studies, guidelines development, and other efforts along the eastern seaboard (Massachusetts to North Carolina)
- Promoting collaboration through expert information exchange and discussion

During the two-day public workshop, stakeholders from offshore industry, government agencies, non-profit organizations, and academia exchanged ideas. Panel topics and group discussions helped address workshop priorities by identifying: 1) key advances in our understanding of environmental impacts from offshore wind, 2) remaining priority data gaps and research needs, and 3) opportunities for collaboration and regional coordination.

The workshop consisted of seven sessions on the following topics: marine systems and the offshore wind energy development process; marine mammals and sea turtles; lower trophic levels; fishes and fish habitats; birds and bats; and ecosystem perspectives (Appendix B). Key areas of conversation included impacts of pile driving noise on marine mammals, sea turtles, and fish; habitat alteration with the introduction of hard substrates (turbine foundations) into the benthic environment; collision and displacement risk; and understanding cumulative impacts. In addition to presentation sessions and question and answer (Q&A) periods, two group discussions were held with all workshop attendees. The first of these group discussions focused on regional coordination strategies and needs, and the second on identifying key advances in our understanding and remaining data gaps and research needs.

The following sections provide summaries of the seven presentation sessions, Q&A and discussion periods. Additional background information on the E-TWG (Appendix A), the workshop agenda (Appendix B), and abstracts for the posters presented at the workshop poster session (Appendix C) are included in report appendices. For presentations that have been made publicly available by presenters, links to the presentation PDFs have been included in presentation titles. In cases where presenters called out one or more of the priority topic areas for the workshop (key advances in our understanding of environmental impacts on wildlife populations; remaining priority data gaps and research needs; and opportunities for collaboration and regional coordination), these have been highlighted in presentation summaries.

Marine Systems and the Offshore Wind Development Process

Session Moderator: Gregory Lampman, NYSERDA

State of the Science Workshop on Wildlife and Offshore Wind: Welcome and Workshop Overview

Gregory Lampman, NYSERDA

The New York Offshore Wind Master Plan[2], released in January 2018, is a comprehensive state roadmap for advancing offshore wind cost-effectively and responsibly. The report recommended the creation of four Technical Working Groups (TWGs) to support the state's efforts. NYSERDA leads the Environmental Technical Working Group, which is focused on the development of wildlife Best Management Practices, coordination for adaptive management, and the identification of research needs, among other topics. E-TWG members include representatives from 1) offshore wind companies with geographically relevant leases (Massachusetts to North Carolina); 2) environmental nongovernmental organizations (eNGOs) with strong scientific grounding and offshore wind/wildlife expertise; 3) a nonpartisan NGO that includes both developers and eNGOs as members; 4) state agency representatives from New York and other

[2] NYSERDA. 2018. New York State Offshore Wind Master Plan: Charting a Course to 2,400 Megawatts of Offshore Wind Energy. Albany, NY. Pp 1-57. Available at: www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Offshore-Wind-in-New-York-State-Overview/NYS-Offshore-Wind-Master-Plan

regional states; and 5) federal agency representatives from agencies that work most directly on offshore wind and wildlife issues.

As one the group's immediate priorities when formed in 2018, the E-TWG identified the need for a conference or workshop to promote regional coordination of research studies and other efforts, allow for information exchange and discussion, and promote public engagement and education. This State of the Science Workshop on Wildlife and Offshore Wind is focused around addressing three priority topic areas: key advances in our understanding of environmental impacts on wildlife populations; remaining priority data gaps and research needs; and opportunities for collaboration and regional coordination.

Resources in a Dynamic Ocean

Kevin Friedland, National Marine Fisheries Service, Narragansett, Rhode Island

Marine systems are highly variable and dynamic. The Northeast Shelf ecoregions include the Scotian Shelf, the Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight, which are experiencing important ecological changes. Temperature is controlled by prevailing winds as well as by the movement of warm surface waters from the Gulf Stream and cold deep water from the Labrador Current. Time-series water temperature data are variable, but show distinct step-wise increases over time, with change points around 1999 and 2011. The intensity of warming due to climate change is strongest in the Arctic, which is causing deformation of the jet stream and increasingly variable weather systems in the Northwest Atlantic Ocean relative to most other oceans in the world[3]. In particular, spring has been arriving earlier since the mid-1900s, with increasing water temperatures over time. Salinity has also increased during this period, and mean annual chlorophyll concentrations have been decreasing since around 2000, though prior to this time, trends were fairly stable. The Northwest Atlantic is projected to continue increasing in temperature faster than the global average as atmospheric carbon dioxide continues to rise[4]. These changes impact species and ecosystem dynamics in a variety of ways. The ecosystem is showing signs of increased productivity and diversity overall. Many species' ranges are increasing (e.g., occupancy area is increasing) in the region and there appears to be greater niche overlap (e.g., shared resource use among species). However, these effects are by no means consistent across all species, with some species such as Atlantic Cod showing strong decreases in occupancy area.

Key advances:

- The Northeast Shelf has warmed significantly in recent decades and will continue to warm with climate change.
- There have been distinct step change increases in temperature in both surface and bottom environments.

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[3] Chen et al. 2015. The Role of Atmospheric Forcing Versus Ocean Advection during the Extreme Warming of the Northeast U.S. Continental Shelf in 2012. Journal of Geophysical Research: Oceans 120(6):4324-4339.

[4] Saba et al. 2016. Enhanced Warming of the Northwest Atlantic Ocean Under Climate Change. Journal of Geophysical Research: Oceans 121(1):118-132.

- Variability in temperature is increasing and thermal phenology is shifting.
- Other physical changes include increased salinity and changes in wind speed and direction.
- The ecosystem is showing signs of increased productivity and diversity and is now supporting increased species occurrence areas with greater niche overlap.

Bureau of Ocean Energy Management: U.S. Outer Continental Shelf Renewable Energy
Mary Boatman, Bureau of Ocean Energy Management (BOEM)

The Outer Continental Shelf (OCS) is recognized as an important national energy resource that should be developed in a way that safeguards and protects the environment[5]. BOEM oversees the offshore wind leasing and development process in federal waters. There is significant wind resource availability and market demand in the Northeast region of the Atlantic Coast. From Massachusetts to South Carolina there are 12 active commercial leases for offshore wind development[6], infrastructure is growing, and there are additional projects in the pipeline. This process is not constrained to the Atlantic, with additional planning activities in Hawaii and California. Current projects are in various stages of development. The renewable energy authorization process includes planning and analysis, leasing, site assessment, and construction and operations. The Construction and Operations Plan (COP) must undergo an environmental review and approval process that includes an Environmental Impact Statement (EIS). This process involves consultations under the Endangered Species Act (ESA) [7], the Coastal Zone Management Act (CZMA)[8] and others, and generally takes two years or longer to complete. BOEM has also invested in an extensive environmental studies program[9] to fund scientific research to inform decision-making and better understand the impacts of renewable energy.

Introduction to Offshore Wind: Development, construction, and operations
Sophie Hartfield, Ørsted

Ørsted has a strong European market and a 25-year track record of operating in Northern Europe, including decommissioning the first offshore wind (OSW) farm in the world and planning to build wind farms that produce more than a gigawatt (GW) of power.

The life cycle of an offshore wind farm includes: 1) development and consent, 2) design and manufacture, 3) construction and installation, and 4) operations and maintenance. In the development stage (~2-4 years), planning involves understanding the environmental impacts to different taxa, social impacts to fisheries, tourism, shipping, and other activities, and the potential for cumulative impacts with other offshore wind facilities, ports, aquaculture, and other marine activities. It also includes preliminary surveys, geotechnical surveys, planning of

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[5] BOEM. 2019. OCS Lands Act History. Available at: www.boem.gov/OCS-Lands-Act-History/
[6] As of November 2018 there were 12 active leases. As of January 2020, there are 15 active leases.
[7] BOEM. 2019. Endangered Species Act (ESA). Available at: www.boem.gov/Environmental-Stewardship/Environmental-Assessment/ESA/index.aspx
[8] BOEM. 2019. Coastal Zone Management Act. Available at: www.boem.gov/Coastal-Zone-Management-Act/
[9] BOEM. 2019. Renewable Energy Research. Available at: www.boem.gov/Renewable-Energy-Environmental-Studies/

cable routes, and the acquisition of permits, resulting in hundreds of documents for submission. Once approved, construction (12-24 months) starts with additional planning, from turbine placement and underwater cables to identifying potential vessel conflicts and environmental restrictions that might impact deadlines. This process requires that developers be flexible, anticipate and avoid unplanned delays, and consider linkages between activities. Construction begins on land with the onshore substation, followed by onshore cable routes and the offshore substation. Next, turbine foundations (monopoles) are installed followed by array and export cables, and then the wind turbines themselves (towers, nacelles, and blades). Offshore components are floated to the site via barge and moved into place using large cranes on installation vessels. Once construction has been finished and sites have been energized and tested, wind farm operations and maintenance begins (25+ years). Maintenance includes monitoring and inspections of foundations, blades, and cables to ensure structural integrity and to identify instances of corrosion or damage.

There are a range of potential challenges during the offshore wind development process in the US, including: 1) shifting regulatory landscapes that make it difficult to work together to manage current information while also looking ahead, 2) resourcing experienced personnel and contractors/suppliers, leading to possible supply chain bottlenecks, 3) a lack of consistency among projects, as what works for one wind farm might not work for the next, 4) a potential lack of awareness of "solved issues" involving environmental impacts, such as electromagnetic fields (EMF), 5) the pressure of lowering energy costs, and 6) additional costs relating to increased distances from shore for new projects. This is still a relatively young industry with a lot to learn from other mature industries such as oil and gas.

Offshore wind also brings opportunities, particularly job growth for environmentally skilled positions, from oceanographers and ecologists to communications positions, acoustics experts, and data management specialists. In the U.K., it is predicted that there will be 260% growth in offshore wind jobs by 2032. In addition, there are opportunities for strategic working groups to address the challenges associated with offshore wind development, including working on wildlife issues (e.g., seal and bird tagging, assessing bird avoidance rates, crustacean monitoring) and working to develop community benefit funds. There is still much to be done, but there is also a lot of research already out there, therefore collaboration is key to this process.

Key advances: Understanding the impacts of EMF.
Knowledge gaps: Understanding mitigation measures and ensuring that mitigation tactics are not unintentionally exacerbating impacts (ex. pile driving noise concerns for marine mammals led to a "soft soft start" followed by a "soft start," which led to higher cumulative noise exposure).
Opportunities for collaboration: European strategic working groups including Offshore Renewables Joint Industry Program (ORJIP), Disturbance Effect on the Harbor Porpoise in the North Sea (DEPONS), Southern North Sea Offshore Wind farm Forum (SNSOWF), and Offshore Wind Programme Board (OWPB) work on many issues with multiple stakeholder groups to address larger questions of pile driving impacts, collision risk, cost reduction strategies and more.

Real-time Opportunity for Development Environmental Observations (RODEO)

Presenter: Mary Boatman, Bureau of Ocean Energy Management

The RODEO project at the Block Island Wind Farm collected real-time measurements of stressors during construction and operations at the first U.S. operational wind farm to better understand environmental effects and inform mitigation strategies. Topics included air quality, sound, seafloor disturbance, visual impacts, testing of monitoring equipment, and evaluation of mitigation equipment.

Underwater acoustic monitoring, using hydrophones of multiple types, and airborne acoustic monitoring was conducted to understand noise emissions, particularly during construction of the jacket foundations. Benthic monitoring around wind turbines and reference sites assessed grain size, organic carbon, and infauna to understand effects of disturbance and growth on hard structures. Seafloor habitats were dynamic, and recovery of these habitats following disturbance was largely dictated by sediment type. Scour monitoring was used to understand sediment transport around turbine foundations. Sampling was done during submarine cable installation to examine sediment plumes, which were minimal. Overall, these studies helped provide real data that can be incorporated into models to improve predictive power when examining possible impacts from offshore wind energy development.

Marine Systems and the Offshore Wind Development Process, Q & A and Panel Discussion

Q: Why are we seeing a decrease in chlorophyll?

A: Friedland: We don’t have answers yet but this is an area of active investigation. It is possible that decreases in chlorophyll may relate to changes in water stratification.

Q: What are the total megawatts and the number of turbines projected by BOEM between 2023 and 2027?

A: Boatman: It depends. There are a significant number of factors that would influence this.

Q: How has assessment and planning for wildlife changed?

A: Hartfield: Over time we have gotten better at collecting data (for example, there has been a shift from boat-based surveys to aerial surveys), though we are not really coming to different answers as a result of these methodological changes. There has been a shift from site-specific data interpretation to more strategic data interpretation, with the understanding that we need bigger-picture information in order to detect trends. However, there is still room for improvement.

Q: Are you thinking about decommissioning moving forward?

A: Boatman: The environmental impact assessment includes decommissioning, and the industry must put up a bond to ensure that turbines can be removed.

Hartfield: In Europe, one project has been decommissioned and there is another that will be decommissioned in a few years. Thus, regulators in the U.K. are looking into it and there will be additional information coming out about these projects in the future. Decommissioning is not necessarily a show-stopper and isn’t something those in the industry are too concerned about.

Q: What about repowering as opposed to decommissioning?

A: Boatman: Repowering is a possibility, depending on the circumstances, though it would require a lease extension.

Q: What are the expected impacts of increasing precipitation in the Northeast and melting of glacial ice sheets?

A: Friedland: The Northeast Shelf is very dependent on water coming up from depths. With a dramatic increase in precipitation, especially off the coast of Maine, we are looking for more runoff data from the National Weather Service to develop new models on what these changes will mean.

Q: What is BOEM's perspective on how the process flow from COP to EIS scoping is working?

A: Boatman: The COP needs to provide information on every aspect of the environment, thus the sequence of flow makes sense from that perspective and I believe this is working well.

Q: Without a good understanding of what total build-out might look like, how can we address cumulative effects on wildlife? What information do we need to collect now?

A: Hartfield: A building block approach has worked well. What this means is looking at a project in the context of what currently exists and what is proposed.

Boatman: You have to examine cumulative impacts as completely as possible during the National Environmental Policy Act (NEPA) process, though there are many unknowns. We are always looking for a better framework for how to consider the next project in the context of what we already know about existing projects.

Q: What are key lessons from the European experience to bring here?

A: Lampman: I think we don't need to understand absolutely everything in great detail. We should be focusing on key species.

Hartfield: We are always learning. It's important not to double-count impacts (for example, if there are overlapping areas of expected displacement from different projects, those should not be double counted in cumulative impact assessments). We are working to mitigate known impacts but must be cautious about trying to mitigate impacts we do not thoroughly understand, as we risk making things worse. If we are not sure, we should monitor and work to understand costs and benefits, not just apply mitigation across the board. We need to look at impacts to the most sensitive species; there may be some species where impacts are not significant, so we need to be realistic and focus on the most important issues.

Q: How does the design envelope work with permitting?

A: Boatman: BOEM did a study to evaluate this. As technology changes quickly and developers need to maintain flexibility, the design envelope approach allows developers to propose a range of designs and have the EIS cover the entirety of this range. The developer cannot do anything outside of the design envelope approved by BOEM (i.e. they cannot have 12MW turbines after proposing either 6MW or 8MW turbines).

Hartfield: Technology is moving incredibly quickly and it is becoming more cost-effective to move to bigger turbines. These may have lower impacts on most receptors. A dynamic design envelope allows projects to learn from one another and have flexibility to amend the process. Additionally, detailed geotechnical and geophysical surveys do not happen until construction, and changes to the local environment such as from significant storm events may require adjustments in building design or techniques.

Q: From a site-specific perspective, a lack of granularity in some types of data can be challenging. How does BOEM consider climate data that's only available at larger scales?

A: Friedland: Climate projection models are continuing to improve in their spatial resolution and the granularity of models will improve as time goes on.
Boatman: BOEM uses the best available science in our analyses. Where information is missing, we identify the gap.
Hartfield: Offshore wind development is challenging to site even without this consideration. It is a valid point, but we're moving towards offshore wind in part because of its benefits as a low-carbon energy source, so this is not necessarily an important question for the future of offshore wind in the U.S.

Q: What is the maximum practical depth of different foundation types?

A: Hartfield: It depends in large part on how much money you are willing to put into it.

Q: How many at-sea substations are needed for projects?

A: Hartfield: It depends on whether electricity is being transferred as AC vs DC. But for example, a 1.2. GW wind farm may need three substations.

Q: Why is it necessary to avoid oil infrastructure when siting offshore wind?

A: Hartfield: Offshore oil operations require helicopter access with landing areas around the platforms. Depending on the type of activities, turbines in the vicinity may make this type of work difficult.

Q: What is the range of average boat visits per turbine per year?

A: Hartfield: Service vessels may visit individual turbines once every 6 months in a standard rotation for preventative turbine maintenance, though many aspects of operations can be monitored remotely.

Marine Mammals, Part 1

Session Moderator: Francine Kershaw, Natural Resources Defense Council

Marine Mammals and Surveys

Presenter: Debra Palka, NOAA Northeast Fisheries Science Center, Woods Hole, MA

There are thousands of marine mammals of over 20 species in and around the Wind Energy Areas (WEAs) in the northwest Atlantic, some of which are listed as endangered or depleted under the Marine Mammal Protection Act (MMPA)[10]. There are density gradients inshore to offshore and north to south, with a lot of seasonal and inter-annual variability in distribution patterns[11]. The highest concentrations of cetaceans are located offshore of WEAs along the shelf break, but there could be interactions between endangered large whales and OSW development activities at any time of year. We don't have a thorough understanding of the diet of many species, or how prey populations of copepod, zooplankton, and small fishes are changing over time. Due to these different sources of variation, buffer areas around WEAs should be considered to reduce development impacts on marine mammals.

Techniques used to understand cetacean distributions and behaviors include:

1. Aerial surveys, which can be conducted by visual observers or high definitions cameras in manned aircraft, or in some cases, by drones. Aerial surveys can cover large areas quickly, but can have human safety implications and require an availability bias correction factor to calculate the number of diving animals that were underwater at the time of survey.
2. Shipboard surveys, which allow intense coverage of an area, and can serve as a platform for collecting multiple types of data simultaneously.
3. Passive acoustics, which can be conducted several ways and automatically record the presence of whales for long periods of time (assuming they are vocalizing and those vocalizations can be recognized).
4. Tagging individuals, which can provide detailed information on individual animal movements, habitat use, and sound, but may provide limited inference for the broader population.

All methods have both advantages and disadvantages, and there are a range of data gaps and opportunities for collaboration.

Workshop Priorities Identified

Knowledge gaps:

- Cetacean diet (particularly for endangered and depleted species such as north Atlantic right, blue, fin, sei, and sperm whales, and certain bottlenose dolphin stocks) – both what are they eating and how it has changed over time.

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[10] USFWS. 2019. Marine Mammal Protection Act. Available at: www.fws.gov/international/laws-treaties-agreements/us-conservation-laws/marine-mammal-protection-act.html

[11] Kraus et al. 2016. Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles. US Department of the Interior, Bureau of Ocean Energy Management, Sterling, Virginia. OCS 2016-054. Pp 1-117.

- Accurate and unbiased abundance estimates for cetacean species. Those with deeper water offshore distributions, in particular, tend to be less well understood, and there has been much less survey effort in locations farther offshore and in northern North America.
- Availability bias correction to improve abundance estimates for long-diving species.
- Methods to quickly and automatically identify species in digital aerial survey data.
- Further development of a sound library of calls for all species, as well as automatic detectors and long-range automated unmanned vehicles for passive acoustic studies.
- Development of longer-lasting tags.

Opportunities for collaboration:

- Through collaboration, can we explain or better understand differences in distribution patterns among species and times of year?
- It would be useful to compare, and then be able to combine, results for visual aerial surveys and surveys conducted with high-definition cameras.
- Ship-based surveys provide a collaboration opportunity, as multiple people can be collecting different types of data (e.g., visual observations, passive acoustics, behavioral data, and a wide range of physical and biological sampling opportunities).
- Citizen science can provide additional information that can be analyzed in conjunction with designed research data.
- There may be opportunities to collaborate between tagging projects, or between tagging and survey projects, to better understand habitat utilization.

Listening (and looking) at finer scales: Existing knowledge and data gaps for whales and dolphins in the New York Bight

Presenter: Melinda Rekdahl, Wildlife Conservation Society
Co-authors: Howard Rosenbaum, Aaron Rice, Brandon Southall

Marine animals produce and use sound for a variety of purposes critical to their life history. Human activities have raised ocean noise levels substantially[12]. The effects of anthropogenic noise on cetaceans include 1) no observable effect, 2) interference with communication (auditory masking, temporary or permanent hearing damage), 3) behavioral response (increased alertness or vocal changes; effects on feeding, social activity, or predation risk; temporary or permanent habitat abandonment), 4) physiological effects (stress), or 5) stranding, causing injury or death. Conceptual models of individual- or population-level consequences of disturbance, such as PCOD (Population Consequences of Disturbance) models[13], can be used to guide research prioritization and mitigation, but we lack baseline data on regional ocean noise conditions, prey interactions and oceanographic conditions (e.g., habitat conditions), and impacts on cetacean populations at scales that enable the identification of drivers of change. In the Mid-Atlantic and New York Bight, there are conservation concerns for several species due to human interactions (entanglement, ship strikes) and noise (New York and New Jersey are the noisiest areas along the entire east coast), and it is important to move towards understanding

[12] Southall B. 2018. Potential Effects of Sound on Marine Mammals. Webinar available at https://dosits.org/decision-makers/webinar-series/webinars-2018/potential-effects-mammals2018/

[13] Pirotta et al. 2018. Understanding the Population Consequences of Disturbance. Ecology and Evolution 8(19):9934-9946.

cumulative effects from multiple stressors. There are ongoing studies, including aerial and passive acoustic surveys, to try to fill data gaps relating to distribution and abundance of marine mammals and the characterization of ocean noise. For endangered species, such as the North Atlantic Right Whale (NARW), we need to consider how to mitigate risks from multiple stressors, including ship strike, entanglement, and wind energy development and operation. NARW are present in the NY Bight outside the time periods and locations with vessel speed restrictions, so we need to better understand their fine-scale movement patterns. More generally, it is important to focus on sub-lethal behavioral and physiological effects, which are much more common than lethal effects, and to develop and implement species-specific best practices to minimize impacts of ocean noise.

Key advances: There are considerable recent and ongoing efforts underway in the New York Bight to improve our understanding of the distribution and abundance of marine mammals, and to characterize ocean noise.

Knowledge gaps: We need additional information on fine-scale habitat use, drivers of movement patterns and change over time, individual- and population-level impacts from human activities, cumulative stressors both locally and regionally, baseline prey interactions and oceanographic conditions, and sub-lethal behavioral and physiological effects.

Opportunities for collaboration: There are opportunities for multi-disciplinary collaborative efforts between many stakeholders to address these data gaps, including integrating and synthesizing data from different projects (such as physiological, observational monitoring, and behavioral response studies in New York waters). Until data gaps are filled, it will be important to develop and implement best practices that include appropriate mitigation and precautionary measures when needed, including technological approaches to reduce acoustic impacts. These measures to reduce ocean noise and associated impacts should be species- and area-specific.

Lessons Learned from Europe: the Effects of Offshore Wind Energy Development on Marine Mammals

Presenter: Karen Hall, Joint Nature Conservation Committee
Co-author: Sónia Mendes

Over 80% of global offshore wind energy is in Europe. Marine mammals are legally protected in the European Union (EU) in a manner analogous to the U.S. MMPA under Habitats Directive Article 12[14]. A range of offshore wind activities could directly affect marine mammals during pre-installation (geophysical surveys, vessel noise, unexploded ordinance), installation (vessel noise, piling noise), and operation (operational turbine noise). Noise propagation modeling is a key process to determine risk and identify mitigation options. A study by Lepper et al. (2012) modeled cumulative sound exposure, using National Marine Fisheries Service (NMFS) thresholds for the onset of permanent threshold shifts in cetacean hearing and assumptions about animal behavior (e.g., that they will swim away from a sound source at 1.5 m/second once the sound Is

[14] European Union. 2007. Guidance Document on the Strict Protection of Animal Species of Community Interest under the Habitats Directive 92/43/EEC. Pp 1-88. Available at: https://ec.europa.eu/environment/nature/conservation/species/guidance/pdf/guidance_en.pdf

initiated). Findings suggested injury risk to harbor porpoises within one to two kilometers of pile driving[15]. Multiple studies have found that during pile driving, harbor porpoises and seals were displaced up to 23-25 km, but moved back into the area within a few hours to a day once pile driving ceased[16,17]. Brandt et al. (2016) [18] reported decreased densities in harbor porpoises at a German wind farm even before piling, possibly due to vessel activity. A seal tracking study at a wind farm in England predicted that half of the tagged animals were likely exposed to cumulative sound exposure levels from pile driving that could have caused auditory damage[19].

There is large individual variability in response to received sound levels. More data are needed to validate modeled dose response curves and reduce uncertainty. Additionally, recent research looked at probability of response in relation to distance from piling, and showed evidence for habituation to piling noise, which is a further source of variability[20].

Noise mitigation techniques such as bubble curtains have been used in Germany to reduce the propagation of piling noise. While expensive and resource-intensive, with a variable degree of efficacy, a recent study[21] found that the use of bubble curtains led to a 90% reduction in the potential area of disturbance for harbor porpoises.

There are multiple modeling frameworks (iPCoD[22]; DEPONS[23]) to help predict the impacts of disturbance on marine mammal populations, but they are very data-intensive. More information is needed to understand behavioral responses to piling in different species, and the effects of piling noise on health, foraging success, body condition, and energy budgets (several studies on some of these issues are ongoing). Long-term individual-based studies of reproduction and survival are also needed.

Key advances:

- Operational noise is no longer considered to have effects on marine mammals in Europe.
- Pile driving is the main source of effect, but vessel construction noise has an effect as well, beginning before piling even starts.

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[15] Lepper et al. 2012. Assessment of Cumulative Sound Exposure Levels for Marine Piling Events. In: Popper, AN and Hopkins A (eds). The effects of Noise on Aquatic Life: Advances in Experimental Medicine and Biology 730:453-457.

[16] Dähne et al. 2013. Effects of Pile-driving on Harbor Porpoises (*Phocoena phocoena)* at the First Offshore Wind Farm in Germany. Environmental Research Letters 8:025002.

[17] Russell et al. 2016. Avoidance of Wind Farms by Harbour Seals is Limited to Pile Driving Activities. Journal of Applied Ecology 55(6):1642-1652.

[18]Brandt et al. 2016. Response of Harbour Porpoises to Pile Driving at the Horns Rev II Offshore Wind Farm in the Danish North Sea. Marine Ecology Progress Series 421:205-216.

[19] Hastie et al. 2015. Sound Exposure in Harbour Seals during the Installation of an Offshore Wind Farm: Predictions of Auditory Damage. Journal of Applied Ecology 52:631-640.

[20] Graham et al. 2019. Harbour Porpoise Responses to Pile-driving Diminish over Time. Royal Society Open Science 6:190335.

[21] Dähne et al. 2017. Bubble Curtains Attenuate Noise from Offshore Wind Farm Construction and Reduce Temporary Habitat Loss for Harbour Porpoises. Marine Ecology Progress Series 580:221-237.

[22] Booth et al. 2017. Using the 'Interim PCoD' Framework to Assess the Potential Effects of Planned Offshore Wind Developments in Eastern English Waters on Harbor Porpoises in the North Sea. Natural England, United Kingdom. Pp 1-39. Available at: http://publications.naturalengland.org.uk/publication/4813967957950464

[23] Nabe-Nielsen et al. 2018. Predicting the Impacts of Anthropogenic Disturbances on Marine Populations. Conservation Letters 2018:e12563.

- Injury risk for species in Europe is usually within 1-2km and can be mitigated using variety of techniques.
- Harbor porpoises and seals are displaced in a gradient fashion away from the noise source ~ 7- 20km- but usually return to the area relatively quickly when piling ceases.

Knowledge gaps:

- As piling size increases, how will pile driving noise affect marine mammals?
- What are the behavioral and physiological effects of displacement of marine mammals?
- What are the population consequences of displacement? Most assessment approaches use expert opinion – we need monitoring data to validate models and decrease uncertainty.

Opportunities for collaboration: Using data from multiple projects and species in disturbance models can provide greater predictive power in understanding effects.

Overview of Pile Driving Sounds and How to Estimate Impacts within the U.S. Regulatory Framework

Presenter: Dave Zeddies, JASCO Applied Sciences

Most research on marine mammals and noise from pile driving in Europe is focused on harbor porpoises. In the U.S., we have different species in different functional hearing groups, and different regulations relating to sound exposure levels (SEL). Sound from a pile, when hit with a hammer, travels through the steel and through the sediment and is released into the environment, with lower frequencies for larger piles[24]. In general, this sound is relatively low frequency (mostly <1000 Hz). Different marine mammals have different hearing sensitivities, so by using auditory weighting functions[25], we can discount impacts for frequencies that a given animal cannot hear well. For low frequency species such as the North Atlantic Right Whale, their hearing overlaps quite a bit with piling noise. When measuring 'loudness' of sound, we should look beyond the signal peak to the cumulative sound energy over the entire signal. By cumulatively summing noise exposure based on animal location within the sound field and received noise levels in that area, you can gain a better understanding of expected effects.

Key advances: We have a much better understanding of the frequencies that different species can detect.

Knowledge gaps: What are the impacts of cumulative sound?

Developments to Minimize Marine Mammal Exposure to Wind Farm Construction Noise

Presenter: Ursula Verfuss, SMRU Consulting

Mitigation strategies for reducing the impacts of pile driving noise on marine mammals include:

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[24] Reinhall, PG and Dahl PH. 2011. Underwater Mach Wave Radiation from Impact Pile Driving: Theory and Observation. Journal of the Acoustic Society of America 130:1209-1216.

[25] National Marine Fisheries Service. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Department of Commerce, NOAA, Silver Spring, Maryland. NOAA Technical Memorandum NMFS-ORP-59. Pp 1-167.

1) Exclusion zones, which are safety zones around piling sites where visual observers and/or passive acoustic monitoring are used to try to ensure that no animals are in the area upon the start of piling. The main limitations to this approach are that animals present in the impact area may not be detected[26], and that it could result in delays to piling.
2) Acoustic deterrent devices (ADDs), which emit deterrent sounds at least 15 minutes prior to the start of piling to deter animals from the site. There are a variety of models with different sound characteristics, and animal responses to these deterrent sounds are individual- and species-specific[27,28].
3) Soft starts, in which piling starts with low hammer energy and low blow rates and slowly builds up to 100% after 30 minutes so that animals have the opportunity to move out of the area. This approach reduces the cumulative sound exposure of animals fleeing the area, but assumes that animals do in fact react (in a timely manner) to piling.
4) Seasonal or spatial restrictions on activity during periods with high animal density (e.g., mating or breeding periods). This approach may affect the feasibility of offshore wind projects, and implicitly assumes that time periods and locations with high animal densities will remain consistent across years.
5) Use of noise abatement systems such as big bubble curtains, isolation casings, and resonators to reduce noise transmitted through the water column, currently by 8-15 dB (more when combined). The approaches increase development costs, and have some limitations relating to efficiency under various environmental conditions or at certain frequencies.
6) Low-noise installation methods and foundations, such as vibratory and BLUE piling approaches and gravity based and suction bucket foundations that do not require piling. These methods may have different environmental limitations and logistical requirements.

Most of these methods are intended to minimize risk of auditory injury, though some also reduce the risk of behavioral impacts. Noise mitigation strategies may increase costs and have the potential to influence construction schedules. Thus, mitigation strategies should be tailored to specific projects, habitats, and species of interest, and we should continue to work to better understand the impacts of noise.

Knowledge gaps:

- As new reduction and mitigation technologies are developed, we need to continue to work to understand how impacts might change.
- We need a better understanding of detection efficiency, and need to improve that efficiency.

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[26] Verfuss et al. 2018. Comparing Methods Suitable for Monitoring Marine Mammals in Low Visibility Conditions during Seismic Surveys. Marine Pollution Bulletin 126:1-18.
[27] Sparling et al. 2015. The Use of Acoustic Deterrents for the Mitigation of Injury to Marine Mammals during Pile Driving for Offshore Wind Farm Construction. ORJIP Project 4. Stage One of Phase Two. Carbon Trust, United Kingdom. Pp 1-152.
[28] McGarry et al. 2018. Guide for the Selection and Deployment of Acoustic Deterrent Devices. JNCC Report No. 615, Peterborough, United Kingdom.

- We also need a better understanding of displacement efficiency of deterrent devices (e.g., ADD), and the implications of trade-offs between spatial reduction and temporal expansion of disturbance.

Marine Mammals Part 1 Q & A Panel Discussion

Q: What types of passive acoustic devices have the best data quality?

A: Palka: There are archival systems that are cheap and collect data easily and without loss, but you need to make sure they have some kind of detector for calls, and all could use more improvements. You can also deploy acoustic detectors on gliders, though those have some limitations. Bottom-mounted hydrophones seem to provide the best data quality for the widest range of species, but the best approach depends on species call frequency.

Q: Relative to the pile, where is monitoring equipment located?

A: Verfuss: This depends. In Germany, stationary buoys are used throughout the OSW farm area, and noise loggers are also deployed within 1.5 km of the pile. In the U.K., sound recordings are usually done during the first four piles of a project, but there is no standard design for deployment of these devices.

Q: How do you determine actual auditory injury from pile driving?

A: Zeddies: Injury isn't actually measured, but rather predicted from models. Thresholds are from theoretical and, to some extent, measured data. But probabilistic modeling approaches give threshold locations which can be used to infer impacts to animals in those areas. We have not yet observed injury to animals.

Q: Is there evidence for recovery from auditory injury?

A: Zeddies/Verfuss: Yes, there have been studies on captive animals in the lab (largely terrestrial animals). You cannot obtain permission to cause permanent threshold shift (PTS) to marine mammals in the wild, and you don't want to do it in captivity either, so most information on hearing impacts in marine mammals is in relation to temporary threshold shifts (TTS), where hearing is temporarily affected but recovers after a short time).

Palka: There was a case of a harbor porpoise caught in a gill net, and we found out that the animal was totally deaf, which is why it didn't hear the pingers on the net. But it was totally healthy and had clearly been surviving well for a while, so there is also potential for animals to adapt.

Q: How do lessons learned translate into U.S. ecosystems? What do we still need to know?

A: Hall: European work, out of necessity, has focused on smaller marine mammals. There are some baleen whales and other deeper-diving species in the North Sea near oil and gas development, which may provide insight. We are seeing consistent initial displacement of animals from pile driving, but we still need to know what the motivation is. Animals could stay near the noise, but what physiological or stress response would result? It is not just about watching animals move, but also what it means and understanding the larger picture.

Q: What do you identify as the greatest data gaps?

A: Rekdahl: 1) the drivers of fine scale movement patterns, including oceanographic conditions and animal behaviors (foraging, socializing etc.), and 2) the physiological impacts of acute chronic stress response.

Q: Is there evidence that marine mammals are attracted to offshore wind projects?

A: Hall: As Sophie mentioned earlier, there is evidence that seals are using platforms to haul out and foraging along cable installations and around hard substrates as they attract fish and other marine life. To be clear, I am not saying there is a reef effect, but there are changes that may be affecting marine mammals or fishing.

Q: What evidence is there to support the use of BLUE piling in the U.S.?

A: Verfuss: BLUE piling is a new method that has just been tested over the last few months, so there are no results yet. Sound exposure levels are reduced from a single pile strike pulse but the pulse lasts longer, so the effects need to be looked at in further detail. The number of strikes does not increase with BLUE piling.

Zeddies: In general, if the peak sound level is reduced by half, but the necessary number of hammer strikes is doubled, there is the same cumulative energy accumulation – so this needs to be carefully considered.

Q: With different foundation options, what are the differences in construction noise?

A: Verfuss: With BLUE piling, it changes the quality of the sound, so it reduces its impulsive character. In terms of auditory injury, it probably reduces risk of auditory injury and may change behavioral impacts. Installing suction bucket foundations does not really make noise – think of it as an upside-down bucket on the sea floor, where you suck the bucket into the ground, then add cement on top. Floating turbines have some noise when putting in the anchoring system, but not as loud as from piling. There is operational noise resonating from the anchor system that is different than with monopiles, however. Thus there may be different impacts that need to be evaluated based on the type of foundation.

Q: How can you effectively test mitigation measures such as soft starts for rare or imperiled species?

A: Verfuss: You need to see the animal to see the reaction.

Hall: Mitigation will never be 100% effective. We need to determine the likelihood of risk and make mitigation proportional to estimated risk. We also need to balance health and safety risk with environmental risk.

Verfuss: The best approach is to use modeling if there are not high densities or species are difficult to monitor sufficiently – use as much behavioral data as you can to model possible impacts.

Sea Turtles, and Marine Mammals Part 2

Session Moderator: Lisa Bonacci, New York State Dept. of Environmental Conservation

Turtle Populations in the Northwest Atlantic

Presenter: Heather Haas, NOAA Northeast Fisheries Science Center

The North Atlantic Distinct Population Segment (DPS) of green sea turtles is listed as threatened under the ESA, have a moderate body size and number of nests, eat grasses and algae, and have relatively few strandings. There are relatively few expected interactions between this species and offshore wind energy development along the east coast (as predicted in the Greater Atlantic Region (GAR) Incidental Take Statements (ITS) in existence as of March of 2018). Leatherback turtles are endangered throughout their range. They have a large body size and high annual number of nests, and feed on gelatinous species in the water column. They are expected to have a relatively small number of interactions with offshore wind according to current ITS in the GAR. Kemp's Ridley turtles are globally endangered, with a small body size and small number of nests, mostly in Mexico; they feed benthically. They occur both on the continental shelf and in inshore waters, but there are few sightings (based on AMAPPS data from 2010-2017), possibly due to their small size and coloration, which make detection difficult. There are a quite substantial number of strandings in Massachusetts due to cold-stunning, however. Finally, the Northwest Atlantic DPS of loggerhead turtles is listed as threatened; they have a moderate body size and feed on gelatinous and benthic prey. They have a moderate number of nests, with several important nesting areas in Florida. There are a large number of expected interactions with offshore wind on the OCS; of all ESA-listed species, loggerheads may have the most interactions with OSW on the east coast. There are many studies on loggerhead turtles to understand their migratory movements, foraging areas and behaviors, seasonal distributions and relative densities, interactions with fisheries, and use of different parts of the water column.

Key advances: Understanding the movement and distribution of loggerhead turtles.
Knowledge gaps: Are Kemp's Ridley turtles as rare as the ITS suggests?

In Water Threats to Sea Turtles
Presenter: Sue Barco, Virginia Aquarium and Marine Science Center

Hard-shelled sea turtles exhibit seasonal movements between foraging habitats and nesting beaches. Hatchlings also have an oceanic stage. Sea turtles are found in the neritic zone (oceanic and coastal) seasonally when feeding, and presence on the continental shelf offshore of Virginia and Maryland is greatest in spring, with loggerheads as the dominant species in sightings data. Sea turtles will come to the surface to rest; surface time varies among species, but also among individuals and by geographic location and season[29]. During the spring and summer, individuals spend a majority of their time at the surface, which increases susceptibility to threats such as vessel strikes.

Threats are reported through stranding response and rehab networks, which mostly provide information on mortalities and injuries occurring coastally. Additional information is gained from fisheries observer programs. Natural mortality occurs from predation (particularly for hatchlings), disease, malnutrition, biotoxins, and cold stunning, many of which may be exacerbated by climate change. Additional threats from human activities include vessel strikes, dredge takes, entanglement in and digestion of gear and debris, along with more subtle threats such as disturbance, noise, contaminants, and resource competition with fisheries[30]. Trauma is most frequently observed, but this may be because it is the easiest to see; for two thirds of sea turtle strandings in Virginia between 2009 and 2013, the cause of death was attributed to some

[29] Mansfield, K. 2006. Sources of mortality, movements and behavior of sea turtles in Virginia. Ph.D. Dissertation, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia. Pp 1-343.
[30] Barco et al. 2016. Loggerhead turtles killed by vessel and fishery interactions in Virginia, USA, are healthy prior to death. Marine Ecology Progress Series 555:221-234.

kind of interaction with boats. Entanglement is another visible issue, with loggerheads, in particular, becoming entangled in crab pot buoy lines and fisheries debris. The threats posed by OSW are difficult to predict, and there are potential indirect effects with increased vessel traffic and possible reef effects.

Knowledge gaps: Baseline sea turtle (and human) distributions and behaviors in and around WEAs; it is important to look outside the WEA as well as within the footprint. A combination of methods should be used, including aerial surveys, tagging, and possibly health assessments. Monitoring of sea turtle distributions and behaviors during construction and operations will likewise be important.

Turtles and Turbines: What We Know

Presenter: Kyle Baker, Bureau of Ocean Energy Management

Based on what we know about other species and types of offshore development, the potential impacts of offshore wind to sea turtles are expected to fall into five categories:

1) Underwater sound. Sea turtles have a primitive ear that can hear low frequency sound (50 Hz to 2 kHz[31]), but we know little about what they use hearing for. Their hearing range overlaps with a lot of OSW noise (e.g., pile driving, cargo vessels, operating wind turbines), but little is known about direct effects. Potential injury criteria are currently based on criteria for fish that do not use a swim bladder for hearing[32], but due to their anatomy, it is possible that sea turtles may be less susceptible than fish to the effects of impulsive sounds. What we know is largely based on studies of behavioral responses to air gun noise, which have included avoidance[33], increased surfacing behaviors[34], changes to diving behaviors, temporary threshold shifts (TTS), habituation[35], and increased erratic behavior[36]. Some invertebrates are also sensitive to low frequency noise[37], and it is possible that this could affect food availability for turtles.
2) Vessel interactions. Vessels are a significant source of injury and mortality for sea turtles, as turtles don't seem to avoid boats moving at faster speeds. At planing speeds, blunt force trauma is 100% lethal[38]. Between 1 and 25% of strandings show vessel strike injury, with risk factors relating to time of year (density and abundance), dive profiles, proximity

[31] Dow Piniak. 2012. Acoustic Ecology of Sea Turtles: Implications for Conservation. Ph.D. Thesis. Duke University.
[32] Popper et al. 2010. Fish: Hearing, Lateral Lines (Mechanisms, Role in Behavior, Adaptations to Life Underwater). Encyclopedia of Ocean Sciences 476-482.
[33] O'Hara and Wilcox. 1990. Avoidance Response of Loggerhead Turtles, *Caretta caretta*, to Low Frequency Sound. Copeia 1990(2): 564-567.
[34] Lenhardt et al. 1994. Evaluation of the Response of Loggerhead Sea Turtles (*Caretta caretta*) to a Fixed Sound Source. U.S. Army Corps of Engineers, Waterways Experiment Station. Pp. 1-13.
[35] Moein et al. 1994. Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges. US Army Corps of Engineers, Waterways Experiment Station. Pp. 1-31.
[36] McCauley et al. 2000. Marine Seismic Surveys – A Study of Environmental Implications. The APPEA Journal 40:692-708.
[37] Guerra et al. 2004. A Review of the Records of Giant Squid in the North-eastern Atlantic and Severe Injuries in *Architeuthis dux* Stranded After Acoustic Exploration. ICES CM 200(2004):29.
[38] Work et al. 2010. Influence of Small Vessel Operation and Propulsion System on Loggerhead Sea Turtle Injuries. Journal of Experimental Marine Biology and Ecology 393:168-175.

to foraging and nesting locations and other areas of high habitat use, and vessel characteristics (type, speed, number of trips, trip distances).

3) Foundation effects. Turbine foundations, as new hard structures placed in the environment, provide potential foraging and sheltering opportunities and can lead to reef effects. Turtles have commonly been found near oil and gas platforms during structure removal in the Gulf of Mexico[39]. Hard structures can accumulate fisheries debris that can cause entanglements, but the degree to which this will occur is unclear.
4) Fisheries interactions. Displacement of fishing activity from OSW development areas could affect sea turtles, but effects are likely to be highly situational (e.g., depending on the type of fishing and degree of displacement, abundance and species of sea turtles present, etc.), and thus must be examined on an individual project basis.
5) Electromagnetic fields (EMF). Sea turtles use EMF for calibration, navigation, and natal beach homing, and turtles in the vicinity of shielded subsea power cables may be able to detect small changes in EMF. However, there are no definitive studies on resulting effects.

Knowledge gaps:

- What are the primary uses of sea turtle hearing (beach finding, warning of threats)?
- How susceptible are sea turtles to the effects of impulsive sound effects (pile driving), and how will they respond?
- What are the effects of EMF on sea turtles?

The Future State of the Science: Developing a Common Regional Monitoring Strategy

Presenter: Kyle Baker, Bureau of Ocean Energy Management

It is important to think about what should be monitored in relation to OSW, and focus on the things that are most important. BOEM is developing strategic goals and a research framework for monitoring protected species. A common monitoring strategy can be advantageous for protected species in order to examine cumulative and population-level effects, habitat impacts, and biodiversity changes, and to develop adaptive management strategies to meet our statutory responsibilities and ensure that offshore development moves forward in a responsible way. There are a range of oceanographic, physiological, behavioral, and demographic endpoints that could be used as indicators of impacts. A workshop was held in New Bedford, Massachusetts in May 2018 to develop a scientific research framework to guide the long-term study of impacts to protected species from wind development. The final report is expected by the end of the year[40]. As part of this effort, several hypotheses were developed regarding short-term effects from pile driving and long-term effects of operations, and possible study designs were identified to test these hypotheses.

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[39] Gitschlag and Renaud. 1989. Sea Turtles and the Explosive Removal of Offshore Oil and Gas Structures. In: Eckert, Eckert, and Richardson (eds). Proc. Ninth Annual Workshop on Sea Turtle Conservation and Biology. NMFS-SEFC-232. Pp 67-68.

[40] The workshop report has since been published: Kraus et al. 2019. A Framework for Studying the Effects of Offshore Wind Development on Marine Mammals and Turtles. Massachusetts Clean Energy Center, Bureau of Ocean Energy Management. Pp. 1-48. Available at: https://www.boem.gov/A-Framework-for-Studying-the-Effects-of-Offshore-Wind-Development/

In addition to the framework, we need to develop a broader strategy document, identify costs and funding sources for implementation, and develop a project advisory group like the ORJIP in the U.K. to help identify common projects. Funding could include a common monitoring fund that the industry contributes to, with potential for the National Fish and Wildlife Foundation (NFWF) to help manage funds.

During group discussions today, we should discuss: Who should be on this joint advisory group (some combination of federal and state agencies, developers, eNGOs, academia, and other partners)? What should the goals and expectations be? What are the funding or cost-sharing mechanisms, and how are projects chosen for funding? What are the end products and how are data shared and archived?

Sea Turtles and Marine Mammals, Part 2 Q & A Panel Discussion

Q: Will fishing effort actually change as a result of OSW development, or just move around? Are interactions with sea turtles likely to increase?

A: If fishing pressure and sea turtles both are common around turbines (e.g., in relation to reef effects), it's possible—but it is likely to be project-specific.

Q: Are turtles likely to be attracted to or displaced from offshore structures?

A: Barco: There is a good chance that turtles will be attracted to structures. These may become popular fishing spots as well as places that you can see more animals. Tagging may be a good way to monitor this, though it would require substantial tagging effort.

Haas: It may also depend on the species. Loggerheads are relatively common and have high interannual site fidelity, so it might be easier to detect changes for them than other species.

Q: Is there information from Europe about the effects of pile driving on turtles?

A: Baker: There are not a lot of turtles where there are oceanic turbines, as most turbines are a bit further north than the species we would see in Europe.

Q: Why do loggerheads have such a high ITS?

A: Haas: The ITS process uses past data as proxies to predict the number of interactions, so the ITS is a relative rate of interaction that is usually not realized or exceeded. The high ITS for loggerheads is largely because they are a much more common species than others.

Q: Are there possibilities or parallels for research coordination with birds?

A: Baker: Do you mean including birds in the protected species research framework? The types of issues and interactions are different but they are occurring.

Q: You mentioned that tissue can be taken from a dead turtle to look into trauma – what is the tissue tested for?

A: Barco: There is an ante-mortem histological reaction that you can detect if trauma occurred prior to death. Muscles contract and react to salt water, so it has to do with how the fibers react to being cut in the presence of salt water. This allows you to determine if the trauma could be the cause of death vs. occurring after the turtle has died of another cause.

Q: What is BOEM considering in terms of vessel speed restrictions?

A: Baker: This is on our minds particularly for North Atlantic right whales. For whales, there are seasonal management areas and we plan to follow the same requirements for OSW. For turtles, it is difficult, as often vessels don't see them, which is why they are struck so often. There are some recommendations to add new restrictions; BOEM needs to think more about this, so there hasn't been a decision made yet.

Q: At what depth do cables need to be buried to avoid EMF impacts?

A: Baker: Most studies show that this is not a big issue. Sharks and rays can detect EMF but continue to eat and swim around them. Cable burial is important to mitigate other impacts such as snagging, but achieving a burial depth that eliminates EMF in the water column may have much greater environmental impacts than burying it more shallowly.

Q: Why has the oil and gas industry not paid for more funding to study these issues?

A: Baker: Cost sharing is something we are still looking into.

Group Discussion – Regional Strategies

Following Kyle Baker's presentation on the development of a regional monitoring strategy, there was a group discussion on this topic as well as an opportunity for discussion on workshop priorities. Though the opinions expressed below are not attributed to individuals, they should not be interpreted to represent any type of consensus among attendees.

Regional Strategies

Research

A regional monitoring framework could provide opportunities to examine large-scale questions and to standardize project-specific data collection. Rather than doing the same studies over and over and chasing project-specific questions (as has happened in the context of terrestrial wind energy development), it may be better to aggregate resources at a regional scale in order to ask the right questions and fund them appropriately. This type of broad-scale thinking could also provide opportunities to better understand cumulative impacts by developing better modeling approaches to be able to look at what happens when multiple projects get built out, and to consider all projects coming down the pike. A challenge to consider when thinking about regional-scale monitoring is access and the ability to sample within a WEA, as sampling both within and outside of WEAs will be important.

The standardization of protocols for data collection could also be part of this regional strategy, though there are questions and challenges to consider. For instance, how might the phase of development of the wind farm affect these protocols? There may be examples from Europe that could be useful, as Germany has published guidelines for collecting environmental data as well as standards for monitoring noise.

Organization and Funding

- There is a recognized need for centralized funding for regional monitoring, but how does this get started? This could possibly be a stand-alone entity designed to identify prime research needs and accomplish broad goals. There may be examples available to use as models, such as the U.S. Offshore Wind Research and Development Consortium or the Mid-Atlantic Regional Council on the Ocean.
- It is important to pick the right organization/convener of these initiatives that is acceptable to stakeholder groups. There are substantial concerns from the fisheries

community regarding working with NFWF; while wildlife and fisheries issues could be addressed separately, they should be interconnected.
- A few words of European wisdom: Don't talk, do. Identify a clear plan of action rather than talking endlessly.

Scope

Should regional coordination focus on all taxonomic groups, not just marine mammals and sea turtles? This may depend on who the players are, how unique issues are for different taxonomic groups, and the need. The BOEM effort is focused on marine mammals and sea turtles, but a similar approach could be developed for birds. If this were the U.K., a majority of this meeting would have been focused on birds – and it is unclear why the focus is so different here, but perhaps it partly has to do with the composition of marine communities and U.S. legislation. In addition to taxonomic scope, there is a need to think about the geographic scale at which a regional strategy should be implemented.

Data gaps:

- Improve our understanding of the attenuation of different sound frequencies underwater, particularly lower frequencies. Threshold levels have recently changed, and it would be useful to understand the discrepancy in predicted levels of impact between the old and new thresholds.

Opportunities for collaboration:

- Engagement with the oceanographic community on OSW and wildlife issues, to better match what we know about the ocean and the wildlife in it. There are already some collaborations, such as metocean buoys that are collecting oceanographic data and also have passive acoustic recorders. There may be opportunities for similar collaborations with developers putting these types of buoys out on wind farm projects.
- Data portals. We should leverage existing platforms and build off of them in order to improve understanding in closer to real time.
- Understanding fine-scale movement and behavior of whales using satellite technology represents both a data gap and an opportunity for collaboration.
- The nexus between wildlife and commercial fishermen is important. Fishermen have an encyclopedic knowledge of the natural environment—not just of fish, but also of marine mammals, birds, bats, and others—and are a missing component in these discussions. Regional coordination should include groups like RODA (Responsible Offshore Development Alliance), NMFS (National Marine Fisheries Service), and NEFSC (Northeast Fisheries Science Center).

Lower Trophic Levels, Fishes, and Fish Habitat, Part 1

Session Moderator: Carl LoBue, The Nature Conservancy

Zooplankton in the Northwest Atlantic

Presenter: Ryan Morse, NOAA Northeast Fisheries Science Center

The environment is drastically changing, which is impacting all levels of the food web. Data from EcoMon zooplankton surveys (1977-present) provide an overview of the plankton communities on the northeast Continental Shelf (e.g., from the Mid-Atlantic Bight to the Scotian Shelf), including changes to underlying physical dynamics, shifts in abundance and community composition, and seasonal and long-term changes in spatial distributions. The northeast shelf is warming rapidly—the Gulf of Maine is warming faster than 99% of the world's oceans—and there have been several large regime shifts in recent years, including in 1998-1999 and again in 2010[41]. There are four dominant copepod species in the region, and there has been a particular decrease in the zooplankton species *Calanus typicus* and a higher ratio of small-bodied to large-bodied copepods from 1988 to 2002[42]. These trends can have knock-on effects to body condition and health in higher trophic levels, such as fish.

Temporal trends in the distribution of species can be examined by looking at 1) the center of biomass, 2) kernel density estimates, and 3) pixel-wise trend analysis based on kernel density estimates. From these analyses, it appears that there are shifting biomass distributions, possibly related to inflection points in water temperature. Many fish species appear to be shifting in the northeast direction, and spring copepod populations are increasing on George's Bank but decreasing in the Mid-Atlantic Bight, particularly *Pseudocalanus* spp. These changes to the base of the food web may be influencing higher trophic levels, such as the North Atlantic right whale, whose population has been decreasing since 2010. *Calanus* spp. are decreasing in some areas but have been increasing in the Gulf of St Lawrence since about 2010, and we are now seeing an increase in right whale presence in the Gulf of St Lawrence as well.

Knowledge gaps: How are shifts in zooplankton populations affecting higher trophic levels?

Fisheries Habitats and Offshore Wind Development: What Should We Be Watching For?

Presenter: Vince Guida, NOAA Northeast Fisheries Science Center
Co-authors: Amy Drohan, Donna Johnson, Jennifer McHenry, Heather Welch, Victoria Kentner, Jonathan Brink, DeMond Timmons, and Erick Estela-Gomez

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[41] Morse et al. 2017. Distinct Zooplankton Regime Shift Patterns across Ecoregions of the U.S. Northeast Continental Shelf Large Marine Ecosystem. Journal of Marine Systems 165:77-91.
[42] Peretti et al. 2017. Regime Shifts in Fish Recruitment on the Northeast US Continental Shelf. Marine Ecology Progress Series 574:1-11.

BOEM recently funded a habitat mapping and assessment effort for WEAs in the northeastern U.S.[43]. The proposed WEAs are large enough that there will be effects of some type on marine habitats. Marine habitats can be defined as where a particular species lives (autecology viewpoint) or as a discrete area where physical and biological conditions provide support for various species (landscape ecology viewpoint). If a marine species depends on a habitat, their short-term survival, distribution, behavior, and population size may be impacted by changes in that habitat. Major changes include disturbance of bottom topography, sediments, and biotic communities, and the creation of new hard substrates. However, it is difficult to separate these impacts from seasonal variations in temperature and variations in sediment type (e.g., gravel, sand, mud) and topography, which influence the distribution and abundance of fishes and other marine organisms.

Species could potentially be considered vulnerable to habitat impacts if they are managed, or create habitats for managed species; are habitat-limited; and/or have an immobile life stage that cannot move away from disturbance. Thus, based on the habitats where offshore wind development is currently proposed, affected species may potentially include Atlantic cod, black sea bass, sea scallops, ocean quahog, and longfin squid. Effects on fisheries are hard to predict, and will probably depend substantially on the location and design of OSW installations.

Knowledge gaps:

- Will habitat changes from offshore wind development affect populations of managed species through temporary disruption of spawning activities, disruption of juvenile cod and black sea bass refuge habitats, temporary disruption of fish or squid spawning behavior, or the creation of new black sea bass or cod habitat?
- Will habitat changes from offshore wind development affect fisheries access, particularly for draggers, and lead to displacement or reduction in fishing activities, or will the fishing industry be able to negotiate on design and spacing of turbines and adapt?

Opportunities for collaboration: There is a need to develop a unified monitoring program sensitive enough to detect subtle changes and smart enough to determine their causes.

Fish Hearing and the Effects of Underwater Noise

Presenter: Arthur N. Popper, University of Maryland and Environmental BioAcoustics, LLC

Man-made sounds from wind farms are a growing issue. Sound is important for many species, and fishes use hearing as a way to glean information about their environment. Without sound, fishes may not detect information about things such as the location of potential mates or the presence of predators and prey. The inability to detect biologically relevant sounds can therefore affect fitness and survival. The potential effects of anthropogenic sound on fishes include affecting behavior (e.g., finding of mates, scaring away from feeding sites) and/or affecting the ability to detect biologically important sounds as a result of acoustic masking and/or production of temporary threshold shifts. Such sounds could also result in physiological effects (e.g.,

[43] Guida et al. 2017. Habitat Mapping and Assessment of Northeast Wind Energy Areas. US Department of the Interior, Bureau of Ocean Energy Management, Stirling, Virginia. OCS Study BOEM 2017-088. Pp. 1-312.

increases in stress hormones), and, in some cases, death. All fishes can hear, but species vary considerably in the frequency range of sounds they can hear and the lowest level sound they can detect at each frequency. Indeed, with over 33,000 species, there is substantial variation in the structure and function of auditory systems. As a consequence, one set of criteria for acceptable sound levels will not fit all (or even most) species. Instead, we need a range of criteria for potential effects of anthropogenic sound on fishes in order to encompass the great variation in sound detection and behavioral responses shown by fishes. Thus, it is important to develop different criteria for (1) eggs and larvae, (2) fishes without swim bladders, (3) fishes with swim bladders that are involved in hearing, and (4) fishes whose swim bladders are not involved in hearing. Most fish species of concern in the eastern U.S., such as sturgeon, primarily hear only at very low frequencies, and often below 500-700 Hz.

We know very little about the effects of anthropogenic sound on fish behavior, as there has been relatively little research on the subject, and we do not know the degree to which behavioral responses observed in the lab with a single sound source on a single species can be extrapolated to animals in the wild, to other species, or to other sound sources. Caged fish studies are not appropriate given the types of behavioral information that are needed – fish do not behave the same in captivity as they might when unrestrained in the wild. We do know that the effects of pile driving noise can be both physical and physiological; depending on distance to the source and signal intensity, there is the potential for tissue damage, hearing loss, masking, and a range of behavioral effects. Based on more recent studies, the current U.S. interim criteria for noise[44] are too conservative and are well below levels that actually result in physical effects on multiple species. More recently, new interim criteria[45] were developed based on the best available science and are being adopted in many parts of the world[46,47]. These criteria should be adopted for regulatory use in the U.S. as well. But there are many gaps in the criteria where there is insufficient peer-reviewed science, particularly relating to behavioral effects, which are much more likely than physical effects and can occur at farther distances from sound sources[48].

Key advances:

- The most important issue regarding anthropogenic sound is the potential for behavioral effects.
- Sounds from operating wind farms are not likely to be detectable by fishes at any substantial distance from the source.

[44] Fisheries Hydroacoustic Working Group. 2008. Agreement in Principal for Interim Criteria for Injury to Fish from Pile Driving Activities. Available at: www.dot.ca.gov/hq/env/bio/files/fhwgcriteria_agree.pdf

[45] Popper et al. 2014. ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer, New York.

[46] Popper, Hawkins, and Halvorsen. 2019. Anthropogenic Sound and Fishes. A Report Prepared for the Washington State Department of Transportation, Olympia, WA. Available at: www.wsdot.wa.gov/research/reports/800/anthropogenic-sound-and-fishes

[47] Popper and Hawkins. 2019. An Overview of Fish Bioacoustics and the Impacts of Anthropogenic Sounds on Fishes. Journal of Fish Biology 94:692-713.

[48] Hawkins, Pembroke, and Popper. 2015. Information Gaps in Understanding the Effects of Noise on Fishes and Invertebrates. Reviews in Fish Biology and Fisheries 25:39-64.

- Pile driving sounds have the potential to be detectable at great distances and affect fishes. Very close to the source (e.g., tens of meters) there is the potential for physical and physiological effects. At greater distances, there are potential behavioral effects both from water-borne and substrate-borne sound. Effects are likely to be species-specific.

Knowledge gaps:

- Criteria to address species that hear through particle motion rather than sound pressure. What are the behavioral impacts of noise on fishes? Are impacts species-specific?
- Impacts of noise on invertebrates, and the development of threshold criteria for invertebrate exposure to noise.

Effects of Electromagnetic Fields (EMF) from Offshore Wind Facilities

Presenter: Andrew Gill, PANGALIA Environmental

Magnetic and electric fields in the environment originate from the earth, from space, and from anthropogenic sources. Offshore wind development involves cables buried under the sea bed, and when a wind farm consists of multiple wind turbines, a network of cables (alternating current (AC) or direct current (DC)) carry electricity between turbines, from turbines to the offshore substation(s), and back to land[49]. Often, models are used to understand how EMF is dissipated into the environment[50], but it is important to examine system behavior, sources, and responses of species to EMF in the field to determine whether these models reflect reality. Previous studies suggest that electromagnetic sensitivity has evolved in the early stages of life and can vary by life stage[51]. In some species this sensitivity may be used to respond to predators, and sensory discrimination can be learned[52]. American lobsters and skates both respond behaviorally to buried DC cables (with changes such as total distance traveled, speed, height, path straightness, and spatial distributions), with skates responding to a higher degree[53]. The EMF in the Cross Sound Cable in this study did not prevent lobsters or skates from crossing the cable, however. Field studies from the Baltic Sea have found that migratory eels slowed down when crossing a cable[54]. With enough cables on migratory routes, this could theoretically affect animal energetics. Impacts will depend on the receptors, their movement and distribution, and their life history, all of which vary by species.

Key advances:

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[49] Gill et al. 2014. Marine Renewable Energy, Electromagnetic (EM) Fields and EM-sensitive Animals. Marine Renewable Energy Technology and Environmental Interactions 61-69.

[50] Normandeau, Exponent, Tricas, and Gill. 2011. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Camarillo, California. OCS Study 2011-09. Pp. 1-426.

[51] Ball et al. 2015. Early Life Sensory Ability – Ventilator Responses of Thornback Ray Embryos (*Raja clavata*) to Predator-type Electric Fields. Developmental Neurobiology 76(6):721-729.

[52] Kimber et al. 2014. Elasmobranch Cognitive Ability: Using Electroreceptive Foraging Behavior to Demonstrate Learning, Habituation and Memory in Benthic Sharks. Animal Cognition 17(1):55-65.

[53] Hutchison et al. 2018. Electromagnetic Field (EMF) Impacts on Elasmobranch (Shark, Rays, and Skates) and American Lobster Movement and Migration from Direct Current Cables. Sterling VA: U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study 2018-003. Pp 1-252.

[54] Westerberg and Lagenfelt. 2008. Sub-sea Power Cables and the Migration Behavior of the European Eel. Fisheries Management and Ecology 15(5-6):369-375.

- The main receptors for EMF are fishes (teleosts & elasmobranchs), aquatic invertebrates, aquatic mammals, and turtles.
- There is a difference between response and effect. We see a range of responses to EMF, but it is unclear if there are impacts.

Knowledge gaps:

- How do abilities to receive EMF and responses vary by species?
- Cables do not seem to be a barrier, but some species seem to slow down when crossing a cable. Is there an energetic cost from this?
- What do responses of receptor animals mean in terms of biological, ecological, fisheries, and socioeconomic significance (i.e. do they cause actual impacts)?

Benthic Ecological Impacts of Offshore Wind

Presenter: Paul English, Fugro

Offshore wind foundations introduce hard substrates into predominantly sedimentary environments, resulting in changes to habitat structure, species composition, and benthic ecosystems. Epifouling species (e.g., mussels, anemones) colonize areas where they would not normally be found, resulting in zonation on the turbine from algae in the intertidal zone to mussels and anemones in the water column to sea stars and crabs dominating the sea bed. The result is an increase in local benthic species richness and biomass, which is not necessarily a good thing. A few studies from the U.K. have begun to address the question of whether foundations are becoming biomass hotspots, and suggest an increase in biomass of 1.4-7.4 tons per monopile foundation[55], though these estimates need to be improved.

At the Block Island Wind Farm, the whole structure is covered in mussels, to a greater depth than previously observed, and the predicted pattern of community zonation described above is not present. The seabed below the foundations is influenced by this biomass above it, with increased fine sediments, total organic carbon, and mussel shells. The animals living in the sediment have not changed, but there has been an increase in mobile scavenger and predator species on the surface, such as sea stars, crabs, and predatory gastropods[56].

Beyond changes to local species diversity and abundance, construction can impact the seabed, creating depressions and scars, and there is potential for sediment plumes. However, evidence suggests that many communities can recover over time; at marine aggregate extraction sites, for example, the process of microbenthic community recovery takes 3-7 years, depending on local conditions. Stony and rocky habitats, in contrast, may never fully recover or may take much longer. Affected areas tend to be spatially limited; sediment plumes from construction are local and short-lived, and can be controlled to minimize sediment loss and environmental risk to sensitive habitats (such as seagrass beds and commercial shellfish areas).

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[55] Krone et al. 2013. Epifauna Dynamics at an Offshore Foundation – Implications of Future Wind Power Farming in the North Sea. Marine Environmental Research 85:1-12.

[56] Study concept, oversight, and funding were provided by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC under Contract Number M15PC00002.

Key advances:

- Colonization of foundations increases local biomass substantially, and provides apparent benefits to mobile benthos and fishes.
- Benthic habitats affected during construction activities recover over time, though the speed and degree of recovery depends on the severity of the original impact, the type of substrate and benthic communities present, seabed mobility and hydrodynamic conditions, and the availability of a local pool of larval recruits. At marine aggregate extraction sites, the process of microbenthic community recovery takes 3-7 years.
- In Europe, statutory impact analyses for permit applications typically conclude minor or negligible significance. Impacts are localized and/or temporary, can usually be easily mitigated, and are reversible on decommissioning; post-construction monitoring usually confirms no significant effects.
- Good quality geophysical and benthic ecology data are needed at each project site to assess project risk, inform the construction design and plans, and identify the appropriate mitigation requirements.

Knowledge gaps:

- Do turbines increase benthic biomass?
- Is one habitat/species more important than another, and what criteria should we use to make this judgment?
- Benthic impacts appear to be localized – are local-scale impacts important, and what are the implications for requirement and design of license compliance monitoring?
- How do changes impact food-chain linkages and benefits to higher trophic levels? Would decommissioning represent the removal of benefits?
- What mitigation is necessary and proportionate for EMF emissions from operational cables?
- Are benthic invertebrates affected by underwater noise and vibration? What are the sensitive species and life stages?

Opportunities for collaboration: The development of a hierarchical value structure for thinking about impacts may help us to design more focused monitoring and mitigation.

Lower Trophic Levels, Fishes, and Fish Habitat, Part 1 Q & A Panel Discussion

Q: What is the difference between AC and DC currents in regards to EMF?

A: Gill: Magnetic fields emanate more from DC cables. Animal movement over a cable will induce a magnetic field. Salt water is conductive, so water over both cables will also induce an electric field. Thus, similar questions can be asked about both of them.

Q: You mentioned impacts of seismic air guns on zooplankton, can you expand on that in relation to offshore wind?

A: Morse: I am not sure how comparable it is to pile driving, but a seismic air gun study of plankton impacts was conducted off the coast of Tasmania, the first of its kind, and it showed clear effects on plankton. If we saw a similar effect from pile driving in sensitive areas, for example where there are larval scallops, this could be a point of concern and something to look into further.

Popper: It's a relatively similar sound to pile driving (the shape of the signal is different, but it's a similar type of impact). There is real controversy about that study relating to concerns about controls, however.

Q: Are there concerns about sandlance in relation to offshore wind as it is an important forage fish?

A: Guida: There is potential for direct disturbance from construction – fishes like to sit in sand troughs, and if we smooth or level these, it is unclear how that might affect fish distribution.

Q: How do we understand baselines in a changing and dynamic system?

A: Guida: Some of the fishes that we expect to be affected by OSW development gravitate a great deal to structures, like black sea bass. But these populations are also being affected by temperature shifts, and it will be difficult to distinguish the effects of temperature changes and wind farms. It is tough to know which species would be good indicators that would allow us to better distinguish impacts from these two sources – perhaps little skate, which are common and are an important part of the system? Regardless, teasing apart temperature change from other effects is difficult.

Q: What type of fish might be considered a hearing specialist versus a fish that just hears?

A: Popper: I don't like the word specialist, but a majority of fish are generalists that don't hear very well – only up to about 700-800 Hz. Sturgeon, tuna, cod, and haddock just don't hear a wide range of frequencies – there aren't many fish in this area that hear well.

Q: What needs to be done to understand fish impacts of pile driving?

A: Popper: Particle motion/displacement in water is actually the critical thing that most fishes detect, rather than sound pressure, but we need a better understanding of how animals respond to particle motion. Perhaps the biggest gap is in understanding behavior – how do animals in the wild respond behaviorally to pile driving?

Q: What do we know about American lobster impacts from EMF?

A: Gill: There have been studies looking at response in spiny lobsters, but the fishing community believes that American lobsters do more local migrations than spiny lobsters. At Block Island there was the first evidence that American lobsters respond to EMF, but we're not sure what it means. This is another species that is retreating northward, so teasing apart the impacts of offshore wind versus things like temperature will be difficult.

Q: How do you differentiate between benthic effects and impacts?

A: English: An effect is a measurable outcome, like an amount of space on the seabed, representing a quantifiable measure of the action. An impact is the behavior or response of the receptor.

Q: How might decreasing copepods impact fish?

A: Morse: With a spring bloom for copepods, fish are going to eat what's there, and there are a host of copepod species present. North Atlantic right whales are more specialists on high fat and high oil copepods such as *Calanus* species, especially in fall, so decreases in *Calanus* abundance in the Gulf of Maine are impacting right whales. There is some evidence that we are seeing skinnier fish as well. Things are definitely changing.

Q: Is there a depth you can bury cables where there is no EMF?

A: Gill: Yes, but it would cost a lot of money and increase benthic disturbance, so it may not be worth it for EMF. Also, when you bury a cable you are taking away the peak, to try to avoid deterrence, but that could potentially lead to more attraction instead – this discussion needs to be species- and impact-specific.

Lower Trophic Levels, Fishes, and Fish Habitat, Part 2

Session Moderator: Sue Tuxbury, NOAA Fisheries

Review of European Studies: Impacts of Offshore Wind Development on Fishes
Presenter: Andrew Gill, PANGALIA Environmental
Co-author: Dan Wilhelmsson

Turbines are continuously getting bigger, and there are a variety of foundation types and turbine designs. There are also different life history stages of fish species, as well as behaviors and sensory abilities, and it is important to consider all of these source of variability when assessing impacts. Some species and life history stages may have frequent interactions with OSW farms, while for others such interactions may only occur occasionally. Likewise, the type and duration of impacts will vary by OSW development phase. To understand environmental impacts, we need to understand the source of impacts, pathway for impacts, and receptors that could be affected. For example, to examine the impacts of pile driving noise, we need to understand underwater acoustic transmission and how both sedentary and mobile species receive that sound.

Possible consequences of construction-related disturbance include displacement from spawning grounds and reduced reproduction and survival, which in turn may reduce catch and cause associated changes to predators like seabirds, such as lowering reproductive success. During wind farm operation, fish distributions may be influenced by habitats and physical factors such as artificial reefs on turbine foundations. An acoustic study of Atlantic cod found hotspots of activity around turbines, though it is unclear what the consequences of this association are. Offshore wind turbines have been shown to have increased local biomass, and offshore oil and gas structures (which have been in the water longer) have local increases in not just foundation colonizers, but also secondary productivity (e.g., fishes) [57]. One could hypothesize that reef effects lead to differences in organic input and potentially to the increased presence of demersal species around structures, but it is unclear whether this leads to biomass increases on a larger scale, or how this might impact trophic interactions and energy flow in the system. As we think about these impacts of turbine foundations to fish, we must also think about what happens if turbine foundations are removed during decommissioning, and what the tradeoffs of foundation removal might be in terms of impacts to biodiversity, fisheries, and other considerations[58]. Overall, targeted, collaborative research and monitoring is essential to address unknowns and

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[57] Claisse et al. 2014. Oil Platforms off California are Among the Most Productive Marine Fish Habitats Globally. Proceedings of the National Academy of Science U.S.A 111(43):15462-15467.
[58] Fowler et al. 2018. Environmental Benefits of Leaving Offshore Infrastructure in the Ocean. Frontiers in Ecology and the Environment 16(10):1-8.

reduce uncertainty in our understanding of the consequences of offshore wind development on fishes.

Key advances:

- Offshore wind farms *will* affect fish communities. There is evidence of local fish increases, which may lead to changes in community structure and trophic interactions.
- Temporal and spatial use, and thus the impacts of offshore development, likely differ among species and life stages.

Knowledge gaps:

- What are the larger scale effects of biomass increases around turbines?
- What are the ecological consequences of fish associations with foundations?
- What are the costs and benefits of removing turbines during decommissioning?

Meta-analysis of Finfish Abundance at Windfarms

Presenter: Elizabeth Methratta, Integrative Sciences Group
Co-author: William R. Dardick

Offshore wind is developing rapidly in Europe and fisheries monitoring has occurred at many wind farms. Potential factors affecting fish distributions around wind farms include habitat change, structure attraction, noise and vibration, electromagnetic fields, and changes in prey fields. Several narrative reviews have been published that describe existing studies, but quantitative synthesis has been lacking in the peer-reviewed literature. A meta-analysis of European studies, with the aim of moving beyond descriptive summaries to a quantitative synthesis of effects of windfarms on fish, could be informative[59].

Synthesis of studies with both treatment (i.e., wind farm) and control (i.e., outside the wind farm) areas can be achieved using standard meta-analytic techniques that calculate a weighted effect size within and among studies. With this approach, we can examine many factors that could influence the abundance of fish at wind farms, such as water depth, distance from shore, age of the windfarm, season, distance from turbine, presence of commercial fishing activity, and the dietary habits of different fish species. A total of 96 species-specific data records from 12 European studies were included for analysis. Fish species were divided into groups (soft-bottom species, such as sand eel, dab, and European plaice; complex-bottom species, such as wrasse, sea scorpion, and eelpout; and pelagic species like herring and pilchard) to examine differences in response. Overall, fish abundance was greater inside wind farms compared to reference sites for soft-bottom and complex-bottom species, but the magnitude of effects varied, and were influenced by a wide range of other characteristics.

Impacts to fish, in relation to these covariates, should be considered in all phases of OSW development. For example, siting of OSW projects should include consideration of water depth

[59] Since the workshop this research has been published: Methratta and Dardick. 2019. Meta-analysis of Finfish Abundance at Offshore Wind Farms. Reviews in Fisheries Science & Aquaculture 27(2):242-260.

and distance to shore, and associated expectations for impacts to fishes. A regional monitoring framework should take into consideration spatial scale (e.g., reference site selection), temporal scale (development state, season), gear (use of multiple sampling types), stratification variables, and statistical power. Such a framework would provide a greater ability to assess effects over time, determine the effectiveness of mitigation, and help disentangle the effects of wind farms from other environmental changes.

Key advances:

- Analysis of data from European studies shows that fish abundance is greater inside of wind farms than in reference sites. The magnitude of this effect depends on species bottom-type affinity and other covariates.
- A regional monitoring framework would provide a greater ability to assess effects over time, determine the effectiveness of mitigation, and help disentangle the effects of wind farms from other environmental changes.

Knowledge gaps: Lack of studies of pelagic fish species.

Opportunities for collaboration: Development of a regional monitoring framework to assess effects of wind farms would allow for comparisons among wind farms and regions, and assessment of the effectiveness of mitigations.

Examining Potential Impacts of America's First Offshore Wind Farm on Fish and Invertebrates

Presenter: Drew Carey, Inspire Environmental
Co-authors: Dara Wilber, Matt Griffin, Andy Lipsky

It was clear early on that there was a need to document conditions at America's first offshore wind project, the Block Island Wind Farm. We knew very little before, thus the goal was to establish an approach that met the expectations of scientists, regulators, and fishermen, while utilizing existing regional knowledge. A variety of environmental studies were undertaken for two years prior to construction, two years during construction, and 2-3 years after operations began at the Block Island Wind Farm[60]. Demersal trawl surveys and lobster trap surveys were conducted within the project footprint as well as in reference areas.

Nine species accounted for 90% of all individuals collected in trawl surveys (conducted using the Northeast Area Monitoring and Assessment Program (NEAMAP)[61] sampling protocol), including butterfish, Atlantic herring, scup, little skate, and longfin squid. Species composition and abundance was consistently different at one of the reference sites compared to the other two survey locations (the wind farm and a second reference site). Longfin squid increased in this reference area during pile driving in early summer, and decreased in the other two sampling locations, but returned to baseline levels at all sites during cable laying and operational periods. In other seasons there was little spatial variation in taxonomic composition associated with

[60] The data presented does not represent a complete dataset, as analysis is ongoing.
[61] NOAA. 2019. Northeast Area Monitoring and Assessment Program Near Shore Trawl Survey (NEAMAP). Available at https://data.noaa.gov/dataset/dataset/northeast-area-monitoring-and-assessment-program-near-shore-trawl-survey-neamap

construction activities. During the operational time period, there was a substantial increase in black sea bass abundance at the project site, consistent with known habitat preferences in this species. Demersal trawl surveys are still ongoing and additional results, such as evaluations of body condition and stomach contents, will be released once these studies are completed. The lobster trap surveys suggest no negative impacts on densities from wind farm construction. The catch was highest at all sites in 2016, during wind farm construction, and was down at all sites in 2017-18, suggesting larger regional changes. Overall there were greater differences among sites than during different phases of wind farm development. This project exemplified the importance of balancing community and scientific interests and using power analysis to ensure study design has the power to detect changes.

Key advances:

- Lower abundances during pile driving occurred for some species, but not lobster.
- Attraction to the wind farm structure was evident for black sea bass.
- Study design should balance fishing community interests and science interests.
- When possible, power analysis should be conducted to determine ecologically meaningful differences. Small changes may not be meaningful, or may not be attributable to OSW development.
- There is a need to develop site-specific designs and results, but be flexible about timing and duration, as projects can change.

Opportunities for collaboration:

- We need to engage as broadly as possible to ensure the study design meets information needs.
- Regional data are necessary to interpret site-specific data. Regional funding and cooperation would leverage efforts.

Fishes, Fish Habitats, and Lower Trophic Levels, Part 2 Q & A Panel Discussion

Q: Are there any telemetry studies that incorporate the pre-construction phase?

A: Gill: There is not a lot of pre-construction telemetry data at sites – it's difficult to do.

Q: With fish aggregating around wind farms, is there evidence that they are using these areas around wind farms to feed instead of estuaries and other habitats?

A: Gill: We don't really know yet, and much of the data we have are focused on adult fish. Things like the impacts on larval fish are much less known. From a behavioral impact perspective, we are not seeing increased initial mortality rates, but there are potentially longer-term behavioral effects on larvae exposed to pile driving that we need more information about.

Q: Is there any way to determine whether wind farms are actually increasing fish abundance, or just attracting and congregating fish (e.g., a redistribution of populations)?

A: Methratta: It's very difficult to demonstrate in the marine environment whether artificial reef effects are actually positive – e.g., whether they are increasing production. You would have to show that habitat is limiting, and that when you add habitat you increase production, which is difficult to demonstrate. So this remains to be resolved.

Q: Should we be concerned about invasive species on new hard substrates?

A: Carey: It varies enormously from region to region, so we first need to ask the question of where? Anecdotally, from Block Island, we haven't seen invasive species on structures, but that doesn't mean it isn't possible. The massive mussel accumulation we see there may have been related to timing, and this assemblage may continue to change through time. This exemplifies the importance of monitoring changes over time. But for that project specifically, we don't have evidence for increased invasions.

Q: Have recreational/commercial fisheries landings changed since OSW farms were built?

A: Gill: I am not sure. It is very difficult to disentangle the effects of OSW development from other things that have changed. Baselines are variable, and trajectories of different species may vary regardless of OSW. Some fishermen have adopted new methodologies, or have diversified their earning potential by running trips to wind farms for recreational fishing or tourism, which could also change landings data. We would need to ask those specific questions to really try to understand OSW farm effects.

Q: Can you explain particle motion versus pressure?

A: Gill: You need an air bladder/swim bladder to hear pressure, so a majority of fish cannot detect pressure changes associated with sound. A majority of fishes detect particle motion instead, which is the back and forth motion of particles. Their auditory apparatus detects this physical particle movement.

Q: Are the effects on herring populations observed at the Scroby Sands OSW farm as a result of pile driving due to adult mortality, or displacement/abandonment of spawning areas?

A: Gill: Both are plausible. If fish don't like something, they are going to leave unless they are constrained in some way to prevent them from leaving. The suggestion is that they will move away, with the possible exception of a few mortalities right near piling activity. Herring stocks in the North Sea have varied enormously, and numbers are declining anyway, but we don't know that wind farms are causing this decline. OSW could be influential, but given the baseline levels of variability, we can't really tell. This is why long-term monitoring is important.

Q: Did the meta-analysis look only at adult life stages? What was the time scale? Could results change over time?

A: Methratta: Most studies looked at adults, but some also included juveniles. The time scale really depended on the age of the wind farm, particularly for complex bottoms. Effects were more noticeable early on, with increases in abundance tailing off after several years of operation. The longest analysis was 7 years of operations, so we still don't know whether the increased abundance in some types of fish is a pulse effect, or represents a long-term pattern. Again, this exemplifies the importance of long term monitoring to better understand these patterns.

Q: What covariates were used to select reference areas for trawl surveys? Could you have selected areas that were more representative?

A: Carey: The southern reference area was difficult to distinguish from the wind energy area. The eastern reference area was selected primarily because the state and commercial fishermen were interested in understanding what species were using that area, as it is a commercially fished site. That site was also closer to cable laying activity than the other two sites. In this case, these reference areas are very close to turbines, and all three sites are close to shore, so we are looking at a complex area. The high resolution of study data has allowed us to start pulling apart some of those complexities.

Q: How did pile driving influence squid – why would catch be higher during pile driving?

A: Carey: We're still teasing apart these data, so causality is difficult to pull out at the moment. The period of pile driving was just a few months. It doesn't surprise me that squid would avoid pile driving, but we saw very high abundance at the reference site closely adjacent to the project site during that period. After the pile driving stopped, squid numbers increased at the other sites.

Q: What are the data gaps relating to fish and benthic systems and offshore wind?

A: Carey: We have relatively little baseline data. So we end up with a control-impact study. We are experiencing changing temperatures and conditions that are creating massive changes, with a wind farm then laid on top of that. Thus teasing factors apart is difficult. What does that site look like *before* the activity?

Gill: We know there are changes, but how do local changes play out? Are these fish populations sources or sinks? At what scale are we going to see what we deem as an impact? Are these changes significant ecologically? We need to be thinking about these questions. How does that then play out on effects to fisheries, biodiversity and species?

Methratta: There are very few studies addressing pelagic species, so this is something we need to work to better understand. Another gap is time scale, as the longest study was 7 years during the operational phase. We need to look at the longer-term in order to look at cyclical patterns in fish. We can look at individual species or groups but they are all interacting, so we need to look at ecosystem-level effects. We need a monitoring framework so we can leverage resources and knowledge within and among regions to do larger-scale comparisons.

Birds and Bats

Session Moderator: Caleb Spiegel, U.S. Fish and Wildlife Service

Bats and Offshore Wind Energy

Presenter: Trevor Peterson, Stantec

Bats are susceptible to turbine-related impacts in the terrestrial environment, and we have learned a lot about these in the last 15 years. Long distance migratory bats such as silver-haired, hoary, and eastern red bats are particularly susceptible to risks related to wind energy development, with the potential for population-level impacts. But are the same concerns transferrable to the offshore environment? Historical observations and regional acoustic surveys suggest that bats can be found dozens or even hundreds of miles offshore, most commonly migratory tree bats, though presence is highly sporadic ("they're everywhere, but not often"). Acoustic detectors deployed on ships and stationary platforms, including buoys, detected bats up to 81 miles offshore, primarily during fall migration (with a peak in August), and the most common species was eastern red bat.

Additional research has looked at bat presence in relation to environmental variables like temperature and wind speed, to better understand collision risk in relation to wind farm operation. Acoustic bat activity detected at an offshore island in Maine tended to occur during time periods with higher temperatures and lower wind speeds[62]. Recent tagging of individuals with nanotags (radio telemetry tags) in the northeast has provided data on individual movements and migratory behavior, including extensive coastal movements along the east coast.

Overall, what we know so far is that risks are largely driven by conditions, including insect abundance and migratory patterns, but there is still much we don't know relating to risk, impacts, and management. It is possible that the exposure of bats to turbines offshore poses minimal risk, but we need data to be able to say for sure.

Key advances:

- Bats are offshore "everywhere, but not often". Bats occur offshore on a seasonally predictable basis, and more isolated locations (e.g., farther from the mainland or islands, smaller landmasses) have lower levels of activity, on average. Bat activity offshore also may to be partially driven by environmental conditions, including insect abundance, wind speed, and temperature.
- The magnitude of collision risk offshore is difficult to predict. Acoustics can be used to help characterize high-risk conditions.

Knowledge gaps:

- We are still lacking information on the magnitude of offshore bat activity, as acoustics cannot provide this information.
- What are baseline mortality rates?
- What is the true level of impact and what level of action does it warrant?
- How do newer and larger turbines operate at low wind speeds?
- What is an acceptable rate of mortality of bats in the offshore environment?

Opportunities for collaboration:

- There are undoubtedly logistical constraints to estimating bat fatality rates offshore, such that a coordinated pilot study using pooled resources may be necessary.
- Acoustics and other technologies, deployed at multiple projects, could allow us to test a variety of assumptions based on pre-construction data. We can figure out which species are active at nacelle height, what the weather is like when bats are active at rotor height, and what the turbines are doing during these conditions.

Impacts of Offshore Wind Energy Development on Marine Birds in Europe

Presenter: Sue O'Brien, Joint Nature Conservation Committee

The main mechanisms of impact from offshore wind development on marine birds are 1) direct mortality through collision, 2) displacement from the wind farm and surrounding area, causing effective habitat loss, and 3) barrier effects, in which the presence of the OSW farm alters migratory flyways and/or local flight paths[63]. Marine bird species that are thought to be most

[62] Stantec Consulting Services Inc. 2016. Long-term Bat Monitoring on Islands, Offshore Structures, and Coastal Sites in the Gulf of Maine, Mid-Atlantic, and Great Lakes – Final Report. US Department of Energy. Pp. 1-68.
[63] Drewitt and Langston. 2006. Assessing the Impacts of Wind Farms on Birds. Ibis 148:29-42.

vulnerable to collision based on their typical flight heights include gannets, gulls, and terns[64]. Many others, such as auks and fulmars, are assumed to fly too low to collide with turbines with any frequency. By using information on wind farm characteristics and species characteristics (e.g., flight speed, flight height, size, density, avoidance rate), we can use models[65] to estimate collision risk. Avoidance rate is a key variable for estimating collision risk, and the ORJIP Bird Collision Avoidance study focused on obtaining empirical measures of avoidance rates through the use of radar, thermal imaging cameras, and laser range finders to track bird movements in an operational wind farm[66]. They tracked 1,555 individuals from five species, and observed 6 collisions. Other research has also focused on informing collision risk modeling by tracking flight heights for key species. Collision risk varies with behavior (commuting, foraging, migrating etc.) and environmental variables (weather, season, etc.)[67].

Species vulnerable to displacement and barrier effects include loons, sea ducks, and auks (e.g., murres, puffins)[68]. While the first step is to quantify the extent of displacement or barrier effects, it is also important to understand the demographic consequences of these effects (e.g., impacts on energetics) and whether habituation occurs over time. A before-after gradient (BAG) study on red-throated loons suggested that birds were displaced up to 16 km from the OSW farm[69]. Individual-based models are being used to try to understand the impacts of this type of displacement on survival and reproduction[70]. To date, there is little evidence for habituation, but detecting habituation requires long-term monitoring efforts. Studies have reported evidence of habituation in some species (common eider[71], black scoter[72]) but not others (long-tailed duck[73], red-throated loon). Once there is more certainty around mortality to marine birds from offshore wind projects, we can utilize population models to understand the potential impacts and assess whether populations can withstand the additional mortality from offshore wind development. While research is ongoing, key evidence gaps remain.

Key advances:

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64 Furness et al. 2013. Assessing Vulnerability of Marine Bird Populations to Offshore Wind Farms. Journal of Environmental Management 119:56-66.

65 McGregor et al. 2018. A Stochastic Collision Risk Model for Seabirds in Flight. Prepared for Marine Scotland. United Kingdom. Pp. 1-59. Available at: https://www2.gov.scot/Topics/marine/marineenergy/mre/current/StochasticCRM

66 Skov et al. 2018. ORJIP Bird Collision and Avoidance Study. Final Report – April 2018. The Carbon Trust, United Kingdom. Pp. 1-247.

67 Cleasby et al. 2015. Three-dimensional Tracking of a Wide-ranging Marine Predator: Flight Heights and Vulnerability to Offshore Wind Farms. Journal of Applied Ecology 52(6):1474-1482.

68 Wade et al. 2016. Incorporating Data Uncertainty when Estimating Potential Vulnerability of Scottish Seabirds to Marine Renewable Energy Developments. Marine Policy 70:108-113.

69 Mendel et al. 2019. Operational Offshore Wind Farms and Associated Ship Traffic Cause Profound Changes in Distribution Patterns of Loons (*Gavia* spp.). Journal of Environmental Management 231:429-438.

70 Searle et al. 2018. Finding Out the Fate of Displaced Birds. Scottish Marine and Freshwater Science 9(8):1-149.

71 Drewitt and Langston. 2006. Assessing the Impacts of Wind Farms on Birds. Ibis 148:29-42.

72 Leonhard et al. 2013. Wind Farms Affect Common Scoter and Red-throated Diver Behaviour. In Danish Offshore Wind: Key Environmental Issues – A Follow-up. The Environment Group: The Danish Energy Agency, DONG Energy and Vattenfall. Pp. 70–93.

73 Petersen et al. 2006. Final Results of Bird Studies at the Offshore Wind Farms at Nysted and Horns Rev, Denmark. Dong Energy and Vattenfall A/S, National Environmental Research Institute, Rønde, Denmark. Pp. 1-161.

- Collision is uncommon, but some marine bird species are at higher risk of collision than others, due to their behaviors. A range of field studies have been undertaken to help understand collision risk.
- Some marine bird species are displaced by offshore wind farms, and evidence for habituation varies with species.

Knowledge gaps:

- What are the energetic and demographic consequences of displacement?
- Does habituation occur?
- How can we better estimate collision mortality?
- How do we directly measure mortality, e.g., via turbine-mounted cameras?
- We need improved baseline population information (such as demographic rates, non-breeding season movements, etc.)
- How can we assess the magnitude of cumulative effects across multiple developments and pressures?

Opportunities for Collaboration: The Offshore Renewables Joint Industry Programme (ORJIP), funded by developers and government in the U.K., provides an excellent example of regional collaboration. An ongoing ORJIP study is examining bird movements to understand collision risk and avoidance behavior of marine birds.

Modeling Avian Distributions and Relative Abundance in the Northwest Atlantic Using Compiled Data

Presenter: Arliss Winship, NOAA NCCOS & CSS
Co-authors: Brian Kinlan, Timothy White, Jeffery Leirness, and John Christensen

As part of an effort at BOEM to understand at-sea distributions of marine birds to inform renewable energy planning, at-sea survey data from the Northwest Atlantic Seabird Catalog[74] and Eastern Canada Seabirds and Sea database[75] were employed in spatial predictive modeling[76]. These data from 1978-2016 included boat-based and aerial surveys (including both visual and digital video counts). Models related static (e.g., bathymetry) and dynamic (e.g., sea surface temperature) variables to species counts, and used results to predict seabird densities across the east coast via boosted generalized additive models. The results included seasonal predicted relative density maps for 47 marine bird species with companion maps representing uncertainty in estimates (as some areas had less survey data than others to work from, and thus more uncertainty in resulting distribution estimates). These maps were reviewed by experts in the field prior to publication. The main objective of this modeling was to inform the locations of BOEM call areas for wind energy development, as well as NEPA analyses, EISs and ESA consultations for OSW development projects. The data have been incorporated into the online Northeast Ocean

[74] O'Connell et al. 2009. Compendium of Avian Occurrence Information for the Continental Shelf Waters along the Atlantic Coast of the United States. U.S. Department of the Interior, Bureau of Ocean Energy Management, Herndon, Virginia. OCS Study 2012-076. Pp. 1-334.
[75] Environment and Climate Change Canada. 2016. Atlas of Seabirds at Sea in Eastern Canada 2006-2016. Available at: http://data.ec.gc.ca/data/species/assess/atlas-of-seabirds-at-sea-in-eastern-canada-2006-2016/
[76] Winship et al. 2018. Modeling At-sea Density of Marine Birds to Support Atlantic Marine Renewable Energy Planning: Final Report. U.S. Department of the Interior, Bureau of Ocean Energy Management, Stirling, Virginia. OCS Study 2018-010. Pp. 1-67.

Data Portal[77], which is accessible to the public, and are also being used by the Marine-life Data Analysis Team (MDAT) to develop synthesis maps to support management and conservation prioritization.

Knowledge gaps: Areas further offshore have lower survey coverage, resulting in lower certainty in species distributions.

Using Individual Tracking of Protected Species to Inform Offshore Wind Development

Presenter: Pam Loring, U.S. Fish and Wildlife Service Division of Migratory Birds

Individual-based tracking studies can provide information on movement and behavior to understand population-level dynamics and inform offshore wind development. VHF (Very High Frequency) transmitters and satellite transmitters have been used by U.S. Fish and Wildlife Service (USFWS) and BOEM to track terns, plovers, and diving birds to understand demographic variation in movement patterns. Small nanotags (VHF tags that are detected using automated telemetry stations) were attached to the backs of adult roseate terns (n=150), common terns (n=266), and piping plovers (n=150) (2014-2017) to better understand movement patterns offshore and the atmospheric conditions under which offshore flights occur, assess potential exposure to federal waters and WEAs, and inform assessments of collision risk. Resulting data on breeding and post-breeding movement suggested that offshore movements of common and roseate terns peaked during mid-July and August, primarily during daylight hours and fair weather conditions (high atmospheric pressure). Piping plovers departing from their breeding grounds in Massachusetts and Rhode Island used offshore migratory routes to sites in the mid-Atlantic. Migratory departures of piping plovers peaked in early August, during evenings with favorable atmospheric conditions for crossing the mid-Atlantic Bight (i.e. tailwinds blowing to the southwest, high visibility, little to no precipitation, and high atmospheric pressure).

Satellite tags were also used to understand the habitat use and movement patterns of diving birds (northern gannets, red-throated loons, and surf scoters), to better understand movement patterns offshore and the habitat characteristics of winter core-use areas, assess potential exposure to federal waters and WEAs, and inform assessments of risk from displacement. Overlap with WEAs varied by species; gannets exhibited much higher overlap than loons and scoters, which both had a more inshore distribution in winter, though overlap increased for red-throated loons during the spring migration period.

Overall, individual-based tracking can provide unique information about spatial, temporal, and demographic variation in movement that can help inform our understanding of collision risk and habitat displacement. Different tracking technologies may be appropriate depending on study objectives and spatial/temporal scale and the size and behavior of the focal species.

Key advances:

[77] Northeast Ocean Data Portal. 2019. Available at: https://www.northeastoceandata.org/

- Peak offshore movements for common and roseate terns (in the summer and fall) occurred from mid-July to mid-September, during daylight hours and periods of high atmospheric pressure and visibility.
- Peak offshore movements for piping plovers (in the summer and fall) occurred in late July to early August, around sunset (18:00 to 21:00 hrs), in periods of high visibility with tail winds (to southwest).
- Non-breeding northern gannets spent more time on the outer continental shelf than either red-throated loons or surf scoters, and as a result appear to have a higher risk of displacement from offshore wind projects. Red-throated loons are most likely to be exposed to WEAs during spring migration.

Opportunities for collaboration: Integration of tracking and survey data and future collaborative analyses using satellite-based or VHF tracking data collected across multiple studies, taxa, and geographic areas to provide greater understanding of marine bird movement and distribution.

Avian and Bat Monitoring at the Block Island Wind Farm

Presenter: Stephanie Wilson, Deepwater Wind

The Block Island Wind Farm, the first wind farm in the U.S., started operations in 2016. Extensive studies of avian and bat resources were performed as part of permit applications, and construction and post-construction monitoring plans were developed during the permitting process. Pre-construction surveys, conducted from 2009-2011, were used to establish baseline data to examine potential impacts. These included onshore visual surveys for birds, beached bird surveys, bat and avian acoustic monitoring, boat-based surveys for birds, and aerial high definition videographic surveys. Post-construction surveys are still underway (the first year of monitoring occurred in 2017, and the second year will be in 2019) and include similar methods, along with turbine-mounted collision monitoring technology and telemetry studies with turbine-mounted VHF receivers. Preliminary results suggest bird abundance is lower in the offshore than coastal environment and that abundance is typically higher in the winter months. While most seabirds and ducks exhibited low flight heights, gulls were observed at greater heights, which may be of concern due to collision risk and requires further investigation. Lessons learned involve challenges relating to deployment and health and safety due to weather, and that while turbine platforms provide an opportunity for data collection, it is better if technology can be incorporated into turbine design planning ahead of time.

Knowledge gaps: Are gulls impacted by turbines?
Opportunities for collaboration: A VHF antenna has been placed on the platform of a Block Island turbines to detect nanotagged animals moving near the project area. Due to the highly collaborative nature of the Motus nanotag network, this antenna array provides data on offshore movements for species tagged in a broad range of ongoing research studies.

State of the Science: Technologies and Approaches for Monitoring Bird and Bat Collisions Offshore

Presenter: Jocelyn Brown-Saracino, Department of Energy, Office of Energy Efficiency and Renewable Energy

To mitigate environmental market barriers for wind energy development, the Wind Energy Technologies Office (WETO) at the Department of Energy (DOE): (1) invests in wind energy-related research to help understand the drivers of risk, (2) invests in mitigation technologies, and (3) aids in the synthesis and sharing of research. As land-based techniques to measure collision risk are not transferable offshore, there is a variety of research and technological innovation focused on either measuring collision directly, or measuring avoidance rates to inform collision risk modeling. Collision risk modeling to help predict risks posed by proposed development[78] has a variety of approaches, with most taking into account variables including species-specific factors, the number of birds passing through, avoidance rates, and turbine-specific data. Models are sensitive to estimates of avoidance rates, thus a lot of research is working on better understanding this aspect, with technologies in various stages of development (technology readiness levels). A study from ORJIP, for example, used range finders, weather radar, naval surveillance radar, and thermal cameras to quantify avoidance behavior of seabirds[79]. Other technologies to detect avoidance behaviors and/or collisions that are in development include some combination of accelerometers, thermal and visual cameras (either fixed or motion-controlled), radar, and microphones[80]. There are a range of challenges relating to the sheer scale of coverage, rarity of collision events, state of technological readiness relative to questions driving regulation, data quantity, and operations, maintenance, and cost considerations. Impact minimization technologies are also in development for birds and bats, though largely in land-based contexts. Offshore deployment would require additional research and development, and DOE is currently reviewing applications for a Funding Opportunity Announcement relating to this topic[81]. However, it is important to remember that collision data alone does not provide much predictive value of how risky the next wind farm might be unless we understand something about the birds that aren't colliding, and what variables are driving risk.

Key advances:

- Seabirds of interest in ORJIP study exhibited avoidance of offshore wind turbines.
- Seabird behaviors reduced risk of collisions.
- Our ability to assess avoidance behaviors and collision risk at offshore wind farms is increasing as new technologies and combinations of technologies are being developed.

Knowledge gaps:

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[78] Smales et al. 2013. A Description of the Biosis Model to Assess Risk of Bird Collisions with Wind Turbines. Wildlife Society Bulletin 37(1):59-65.

[79] Skov et al. 2018. ORJIP Bird Collision and Avoidance Study. Final Report – April 2018. The Carbon Trust, United Kingdom. Pp. 1-247.

[80] Dirksen. 2017. Review of Methods and Techniques for Field Validation of Collision Rates and Avoidance Amongst Birds and Bats at Offshore Wind Turbines. Rijkswaterstaat WVL. SjDE 17-01. Pp. 1-47.

[81] Department of Energy. 2018. Advanced Wind R&D to Reduce Costs and Environmental Impacts. Available at: www.energy.gov/eere/wind/articles/doe-releases-funding-announcement-support-advanced-wind-rd-reduce-costs-and

- How do we get a representative sample of collision/avoidance data to understand whether assessed risk is accurate for current and future projects?
- We need to better understand bat risk offshore and determine cost/benefit relationship prior to application of impact minimization technologies.

Opportunities for collaboration:

- Much of what is known about collision risk at offshore wind farms comes from large-scale, intensive research programs in Europe aimed at measuring avoidance rates, and in some cases collision events as well.
- Continued development and offshore testing is required to bring collision risk technologies to readiness for commercial deployment.
- All collision/avoidance detection systems have limitations and issues relating to sampling rare events. We need to think about how to use these systems to get a representative sample to understand risk predictions and inform decisions for future projects, rather than just monitoring endlessly without consideration of design.

Birds and Bats Q & A Panel Discussion

Q: What do we know about flight heights for bats and birds offshore?

A: Peterson: We don't know much about bats. Most information comes from acoustics, so flight height data is limited. Offshore digital aerial surveys have showed some bats flying several hundred meters above sea level in the daytime. Anecdotal information from European OSW farms suggests that bats fly relatively close to the water's surface but move upward when in the area of a wind turbine, though behavior appears to be highly variable.

Loring: For birds, it is highly species- and behavior-specific. Plovers fly low during the breeding season, but when migrating, they may fly at a few hundred meters above sea level. There is a relationship between detection range and tag height for nanotags, so we can get some information about flight heights from the nanotags if they are simultaneously detected at multiple towers. There are less data for smaller species like plovers than for larger-bodied birds like gannets, as studies from Europe have provided high-accuracy altitude data from GPS transmitters.

Q: How far offshore is the estimated range of a bat?

A: Peterson: Bats can fly tremendous distances and are capable of moving large distances quickly. They can cross the Great Lakes, for example, and they seem to exhibit comparable flight speeds to songbirds. As they can forage while they are flying, they can cross large distances. They are found regularly on islands including Nantucket, and have showed up on Southeast Farallon Island, 25 miles off the coast of California. There are anecdotal records of bats observed from ships up to 130-150 km offshore. Generally, we are sampling small sizes of air, so detecting bats with this small effort relative to overall offshore space suggests they are out there.

Q: Does noise from turbines interfere with acoustic survey work?

A: Peterson: Turbines don't make a lot of ultrasonic noise, so acoustic surveys for bats work very well. The acoustic systems are placed on the tops of turbines. Every turbine is different, but generally speaking you can get really good data.

Q: With displacement of diving birds, is there evidence of increased foraging?

A: O'Brien: Actually, displacement essentially creates a buffer of non-used habitat around the wind farm. With displacement, birds are moving away based on how they perceive turbines, but we don't really understand what it is about turbines that drives this behavior. There is ongoing research on the size and arrangements of wind turbines to see if it is possible to adjust project design to ameliorate the displacement effect.

Q: Thinking about regional changes in ecosystems, what is the lifespan of the seabird distribution models? Are they going to be relevant in the future?

A: Winship: The models, by design, are static – they integrate data from the last few decades and represent an average relative distribution over that time frame. Hopefully they are relevant to recent long-term distributions. For the future, though, we have been considering how to reframe the models in a dynamic way to be able to forecast changes in distributions.

Q: Did tag data on roseate terns look like common tern data?

A: Loring: Both species were quite similar. The key difference was that there were fewer roseate movements south of Long Island – roseate terns did not make as much movement down towards the Mid-Atlantic. We also observed divergent use of foraging habitat during breeding season. We are currently working on a manuscript to summarize these data.

Q: In the monitoring plan for Block Island, why did you choose one, three, and five years for surveys? Are you planning to modify operations based on these results?

A: Wilson: In order to have an opportunity to review, reevaluate, and adjust to work into the next data collection, surveys every two years gives us a bit more time between surveys instead of trying to do them every year. The first year results have just been submitted and we are already getting ready for the next round. There are not any immediate adjustments, but we are committed to collecting the data and figuring out what is going on.

Q: Are there regulatory requirements for post-construction monitoring on birds and bats in Europe?

A: O'Brien: Yes, but the specifics vary on a case-by-case basis, with monitoring undertaken based on post-licensing conditions for each project.

Q: Are marine bird populations declining in Europe?

A: O'Brien: Kittiwakes are a species that is declining quite rapidly, and more broadly, yes.

Q: Can modeling with tag data take into account weather conditions and if so how?

A: Loring: Modeling for nanotag studies has had a large focus on atmospheric conditions. There was also detailed analysis done using satellite data such as wind speed, precipitation, and atmospheric pressure, to get a sense of what factors might be influencing bird movement.
Winship: Some of the datasets we analyzed had data indicative of weather in the form of survey conditions (such as observers' assessment of visibility). However, standardized sighting condition data were not available across all datasets, so we did not directly incorporate weather in our models. We need enough data at the right resolution to look at the effects of local short-term weather on distributions.

Q: Will results and information from the Block Island Wind Farm be disclosed?

A: Wilson: Our pre-construction results are publicly available. As part of permit conditions, we are required to make post-construction results available as well. For post-construction monitoring, we submit reports to agencies, and once they are reviewed and evaluated, they should become available. We want to make sure the data are available and that we find the best venues to do that.

Q: Did you see similar movement patterns for spring and fall migration?
A: Loring: We tagged piping plovers in the Bahamas in winter, to look at spring migration. It's a small sample size, but those data will be available in the final report submitted to BOEM and released to public, which should be available in early 2019[82]. For terns, we did a satellite tagging study on the Maine Coastal Islands National Wildlife Refuge, and from this we got both northbound and southbound satellite tags from common terns. So we are starting to collect data for the full annual cycle to try to get at that question.
Q: Were there targeted surveys at the Block Island Wind Farm to account for fall and spring migration?
A: Wilson: Boat-based surveys were conducted monthly, and there were nesting species like roseate terns and piping plover. We have some data from tagged individuals, so we are still working through that data.
Q: What bird species do you think are at the greatest risk for offshore wind?
A: Wilson: The most abundant species were shorebirds and seabirds, but flight heights were generally much lower for these species. Where gulls are the most abundant, there is potential that they would be at greater risk. This is site- and species-specific and will also depend on the time of year.
O'Brien: To answer this, we need to look at cumulative impacts, particularly species that are vulnerable to other stressors, such as climate change, so it is difficult to know.

Ecosystem Perspectives

Session Moderator: Catherine Bowes, National Wildlife Federation

From Observing Structural Effects to Understanding Functional Effects of Offshore Wind Energy Development

Presenter: Steven Degraer, Royal Belgian Institute of Natural Sciences
Coauthors: Colleagues from the Belgian offshore wind farm monitoring program, FaCE-It and PERSUADE projects, ICES Working Group on Marine Benthos and Renewable Energy Developments, and ICES Benthos Ecology Working Group

Offshore wind farms do impact the environment, but we need to move beyond basic monitoring and observations to understanding ecosystem functioning, and from the scale of a single wind turbine or wind farm to a regional scale of understanding impacts. We want to be able to ask how much wind farms are altering the wider marine ecosystem, but with the local-scale data that we have, we are unable to come up with an answer. Changes can be regarded as positive or negative, and different stakeholders might view these changes differently, but there is no right or wrong, there is just the question of, so what? We must be more selective in the questions we are asking and make sure that monitoring programs are well designed to answer those questions.

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[82] Since the workshop, the report has become available: Loring et al. 2019. Tracking Offshore Occurrence of Common Terns, Endangered Roseate Terns, and Threatened Piping Plovers with VHF Arrays. U.S. Department of the Interior, Bureau of Ocean Energy Management, Stirling, Virginia. OCS Study BOEM 2019-017. Pp. 1-140.

One way forward is to do both basic and targeted monitoring, with basic monitoring focusing on observation and posterior resultant effect quantification, and targeted monitoring to examine cause-and-effect relationships of *a priori* defined impacts. As soon as we understand mechanisms, we can think about mitigation and extrapolate to other sites. Challenges include 1) flexibility in research designs to combine field gradient designs with experimental data, 2) selecting the most pertinent operational questions, and 3) smart and well-considered data collection. Addressing these challenges requires collaboration among stakeholders and an interface between scientists, the public, and policymakers. Operational research questions should be carefully considered, and only tackled if a reliable research scheme can be developed and executed. We need to design studies so that we can get rid of the data-rich information-poor (DRIP) conundrum[83].

Key advances:

- Offshore wind farms do impact the environment, but the spatial scale of interest and effects on actual ecosystem functioning matter. For example, in a 2013 study[84], benthic species richness in Belgian wind farms increased substantially post-construction (by 190%, at the wind farm scale)—but the overall species richness of the Belgian part of the North Sea was completely unaffected. Likewise, macrofauna biomass was 4000x greater at a single turbine location post-construction, but this translated to minimal increases at the wind farm or broader scales.
- It is important to select the most pertinent operational questions, design smart and well-considered data collection approaches, and maintain flexibility in research designs (including combining Before After Control Impact (BACI) and field gradient designs, experimental data collection, and modeling) to answer key questions. We need both well-designed basic monitoring programs and targeted research.

Knowledge gaps: We have learned a lot about local and structural impacts from ecological monitoring of offshore wind projects in Europe, but what are the broader impacts of offshore wind to ecosystem function? Are these changes acceptable?

Opportunities for Collaboration:

- Combining field and lab-based studies to better understand overall impacts to marine ecosystems.
- Selecting pertinent operational questions is a challenge for both science and public policy. The informed public (including environmental advocates and developers), regulators, and the scientific research community should all be involved in identifying major issues and public concerns, identifying overarching questions, and then identifying more specific operational questions.

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[83] Wildling et al. 2017. Turning Off the DRIP ('Data-rich, Information Poor') – Rationalizing Monitoring with a Focus on Marine Renewable Energy Development and the Benthos. Renewable and Sustainable Energy Reviews 74:848-859.

[84] Rumes et al. 2013. Does It Really Matter? Changes in Species Richness and Biomass at Different Spatial Scales. In Degraer, Brabant & Rumes (eds), Environmental Impacts of Offshore Windfarms in the Belgian Part of the North Sea: Learning from the Past to Optimise Future Monitoring Programmes. Royal Belgian Institute of Natural Sciences: Management Unit of the North Sea Mathematical Models. Marine Ecosystem Management Unit. Pp. 183-189.

Designing Research and Monitoring Studies to Detect Impacts

Presenter: David Secor, University of Maryland

The Middle Atlantic shelf region slated for OSW development is a very dynamic ecosystem with high seasonal variation, which will confound detection of impacts from OSW development. Past experience in Europe and current understanding of the key roles of temperature, depth, and soundscapes in shelf environments direct us to move away from BACI designs for impact studies to a Before After Gradient (BAG) design, which allows for a more regional perspective, the assessment of effect size, and incorporation of temporal variability[85,86]. BACI designs only allows for discrete predictions (there is or is not an effect), whereas gradient designs allow for non-linear relationships and a better understanding of effect size[87]. BAG designs can also incorporate some types of environmental covariates and aid in understanding the potential causes of observed patterns. This type of design provides a greater regional perspective to examine cumulative effects over time.

As an example, some recent research is looking at wind energy impacts on migratory and sedentary fishes in the Maryland Wind Energy Area. These are baseline pre-construction studies, but even without development in place, there is substantial variation in detection of tagged fish in relation to temperature, depth, and other environmental gradients. Atlantic sturgeon showed an extended presence in the spring and an inshore bias, whereas striped bass preferentially used water temperatures in a specific range, and shifted their habitat use accordingly. Another example is a study looking at the behavior of black sea bass, which showed the impact of seasonal storms that de-stratified the water column and impacted movement rates of fish[88]. Understanding the strong disturbance effect of storms will inform the interpretation of sea bass movement data during construction and operations of OSW turbines. Overall, gradient designs support predictive models and the potential to incorporate confounding variables in order to look at regional-scale impacts, so experimental design is of the utmost importance.

Key advances:

- Gradient designs support predictive models of key variables (noise, reef attraction) that can translate to regional-scale impacts.
- The Mid-Atlantic Bight has strong gradients and disturbance regimes; wind energy impacts will be confounded by these.

Opportunities for Collaboration: Common guidance on gradient-based designs could help facilitate regional-scale predictions and comparisons between species and communities.

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[85] Stanley and Wilson. 1997. Seasonal and Spatial Variation in the Abundance and Size Distribution of Fishes Associated with a Petroleum Platform in the Northern Gulf of Mexico. Canadian Journal of Fisheries and Aquatic Science 54:1166-1176.

[86] Dähne et al. 2013. Effects of Pile-driving on Harbor Porpoises (*Phocoena phocoena*) at the First Offshore Wind Farm in Germany. Environmental Research Letters 025002.

[87] Dahl et al. 2012. Reduced Breeding Success in White-tailed Eagles at Smøla Windfarm, Western Norway, is Caused by Mortality and Displacement. Biological Conservation 145(1):79-85.

[88] Secor et al. 2018. Ocean Destratification and Fish Evacuation Caused by a Mid-Atlantic Tropical Storm. ICES Journal of Marine Science 75(2): 573-584.

Cumulative Adverse Effects of Offshore Wind Energy Development on Wildlife

Presenter: Wing Goodale, Biodiversity Research Institute

There are potential cumulative positive effects from OSW wind development, but this talk is focusing on adverse effects. Cumulative effects are complex, uncertain, and ambiguous, and definitions and perspectives vary considerably. The NEPA definition of cumulative adverse effects is very broad, and assessments in NEPA documents vary considerably in structure and scope. When thinking about cumulative effects of offshore wind energy development, we must clearly frame the discussion, assess risk, and then evaluate and manage that risk[89].

Cumulative impacts are incremental impacts added to past, present, and future actions. Exposure alone does not equal risk; an adverse effect involves a hazard, vulnerability to that hazard, and finally exposure to that hazard[90]. However, cumulative exposure may be easier to understand than cumulative effects, and provides an avenue to begin identifying species that may be at higher risk. Cumulative exposure models can take into account where development is possible, the number of wind farms, siting, and the exposure and vulnerability of species. The results from these models represent tiers of risk likelihood for different groups of species. In a modeled example with marine birds, sea ducks and loons may be at higher displacement risk from OSW development than some highly pelagic species due to high projected exposure and known vulnerability to displacement[91]. Once we have this information, we can hone in on species we predict to be at highest risk. These cumulative impact assessments can help to inform management decisions such as the avoidance of wildlife hotspots, diffusion of exposure across groups of species, inclusion of movement corridors, and reduction of the effects of each wind farm.

Key advances: Cumulative adverse effects can be managed, in part, by avoiding hotspots (although we need to be careful about how hotspots are defined!); dispersing development across multiple species and subpopulations, separating wind farms to create wildlife corridors, and minimizing and compensating for effects.

Understanding Environmental Impacts of Offshore Wind Development: Recommendations from the European Experience

Presenter: Sue O'Brien, Joint Nature Conservation Committee

With 15 years of offshore wind development at 34 sites, the U.K. has amassed substantial information regarding environmental impacts, but uncertainty and challenges remain. Uncertainty around environmental impacts from OSW increases permitting/consent risk; it has resulted in delays and uncertainty over consent decisions, and even caused projects to be cancelled. Uncertainty also increases costs to developers and consumers.

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[89] Goodale and Milman. 2016. Cumulative Adverse Effects of Offshore Wind Energy Development on Wildlife. Journal of Environmental Planning and Management 59(1):1-21.
[90] Crichton, D. 1999. The Risk Triangle. In Ingleton, (eds), Natural Disaster Management. Tudor Rose, London. Pp. 102-103.
[91] Goodale et al. 2019. Assessing the Cumulative Adverse Effects of Offshore Wind Energy Development on Seabird Foraging Guilds along the East Coast of the United States. Environmental Research Letters 14: 074018.

Several recommendations for how to improve upon this experience in the U.S. context include:

- Information sharing. A centralized database can help ensure consistent monitoring standards and improve access to information. Knowledge exchange is also important.
- Project-specific vs. strategic monitoring and research. It is important to distinguish between project-specific questions (e.g., does this OSW farm have an impact?) and strategic research and development questions (e.g., what will reduce future consent risk?), and ensure sufficient funding for the latter. A strategic monitoring framework would assist with identifying and prioritizing key evidence needs around the impacts of offshore wind on the marine environment.
- Adequate funding. Funding for strategic research and development is a challenge. One approach, used by the Dutch, is to have an obligatory levy that developers must pay. What is the role of government vs. industry in funding research to better understand impacts of offshore wind development on the marine environment? Who would manage such a fund, and who determines how it is used?
- Better science. Research and monitoring at adequate spatial and temporal scales is important to have the power to detect any effect. This includes scientifically robust survey designs like before after gradient studies, and robust statistical analysis. Beyond design, strategic knowledge gaps should be prioritized by consent risk, and work should be done to improve baseline data, including the impacts of climate change. Findings should be published in the peer-reviewed literature.
- Collaborative working. Collaboration is essential for assessing cumulative impacts. Europe is moving in this direction with initiatives such as ORJIP[92] and the European Common Environmental Assessment Framework (CEAF)[93], which can help to inform marine spatial planning.

Key advances:

- Information sharing and information access is important to understanding impacts. Consistent monitoring standards are important for assessing impacts across project sites. Findings should be published in the peer-reviewed literature.
- Strategic research and development questions, to inform permitting and impact assessment for the entire industry, should not be neglected in favor of project-specific monitoring.
- Research and monitoring at adequate spatial and temporal scales is important to have the power to detect an effect. This includes scientifically robust survey designs like before after gradient studies.
- Collaboration is key.

Knowledge gaps: We need to improve understanding of the baseline state to help distinguish OSW impacts from impacts of climate change and other pressures on the marine environment.

Opportunities for Collaboration:

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[92] Offshore Renewables Joint Industry Programme. 2019. Available at: http://www.orjip.org.uk/

[93] Strategic Environmental Assessment North Sea Energy. 2019. Available at: https://northseaportal.eu/project-information/objectives-and-goals/

- Funding for strategic research and development
- Knowledge exchange to better understand who is doing what, where, when, and how.
- A strategic monitoring framework would assist with prioritizing efforts to better understand the impact of offshore wind on the marine environment.

Ecosystem Perspectives Q & A Panel Discussion

Q: How do we take into consideration cumulative stressors, in addition to multiple wind farms?
A: Goodale: This relates to what we know about different species. Is it an endangered species? What are the stressors for this species? We can use population viability analysis and approach the question quantitatively if we have enough information do so. But if we don't know what the population is, or what is regulating it, that may necessitate a more qualitative weight of evidence approach regarding different stressors.
O'Brien: One other consideration is what stressors you have control over. You may want to prioritize understanding those, since you can actually do something about them.
Secor: Fisheries stakeholders can bear the brunt of this type of approach, as we can control fishing mortality, even if we don't fully understand it. So it also becomes a stakeholder engagement issue.
Q: What adverse impacts have you seen from UK wind farms?
A: O'Brien: We know that there is displacement, but does that have a demographic consequence? We don't know. It's still an issue of scale. Offshore wind is ramping up in scale, and we still don't know whether there are population-level effects.
Q: What are the barriers to assessing effects to multi-wind farm scale impacts in the UK?
A: O'Brien: Developers are working together to tackle key questions, through opportunities such as ORJIP.
Degraer: This is not only about collaborating among projects, but also between countries. Not many species feel restricted by national boundaries, so we too need to move beyond these political boundaries. There are groups that are talking about it, but how do you get the money and flexibility to answer questions at the appropriate spatial scale?
Q: Is there evidence that regulators are considering wildlife corridors for offshore wind development?
A: Goodale: WEAs are being spread out along the east coast, but there are conversations about conflicts and potentially providing some movement corridors. But if corridor areas are heavily trafficked by boats, will they really be effective movement corridors for species? Also, a lot of early displacement studies were done with small turbines spaced close together. Moving forward, turbines are going to be larger and spaced farther apart. Will species start to see them individually rather than as a wind farm? Will we start to see more meso-scale avoidance?
O'Brien: There has been some work by the Dutch to look specifically at guillemots (common murres) with different turbine arrays. This study had not yet been published, but there is definitely work looking at array spacing, and over the next few years we will start to see answers to this.
Q: How would you determine hotspot areas? Is there enough volume of data on rare species?

A: Goodale: It is worth thinking about what we mean by hotspots. Are they species-specific? Do they relate to species diversity? Overall abundance? Then how do we map them? You want to look at multiple taxonomic groups to think about areas that have high concentrations of wildlife.
Secor: If you want to detect hotspots, you need a significant investment, including telemetry networks of data sharing so that we have the information to answer these questions.

Q: If we think about not having offshore wind building, it would mean using different energy that has different impacts – how do we factor this into a framework? Are there also benefits to offshore wind?

A: Goodale: Climate change overlays everything when we are trying to understand risk. Our regulatory structure is focused on individual projects. Council of Environmental Quality guidelines mention that you can consider positive effects, but our regulatory structure doesn't provide a good mechanism for this – it's hard to say how a specific OSW farm will directly address climate change. Thus, it becomes a broader policy discussion.
O'Brien: This is difficult. Seabirds are indisputably declining because of climate change. But that doesn't mean that wind energy pressures aren't important too. I don't think you can quantify the benefits from building a wind farm because these things happen at such different scales – you are affecting a relatively small part of a population, whereas climate change is such a wide-scale impact.

Q: What tips can you give for designing studies to determine cumulative impacts?

A: Degraer: We need to have the right questions on the table, as we have limited resources. In Belgium, those questions tend to be selected by the scientific and policy communities, but we need to also involve stakeholders and think about societal concerns. This requires interaction between different stakeholders to come up with a set of operational questions that everyone is happy with so that everyone buys into the process. We need to narrow down to specific operational questions that can actually be answered. Once stakeholders are involved in identifying appropriate questions, it is easier to obtain funding because the whole community is involved and everyone cares about the answer. It really requires a bottom up approach.
Secor: Balancing top down and bottom up approaches is really difficult. If it's bottom up, it's likely piecemeal. How do you enter into a top down approach? Do we start by forming committees? Do we need certain key federal agencies to provide guidance? We need to resolve these issues quickly so different stakeholders don't go separate ways.

Group Discussion with E-TWG Panel – Reflection on Workshop Priorities

Panel: Martin Goff (*Equinor*), Jillian Liner (*Audubon New York*), Joe Martens (*New York Offshore Wind Alliance*)

The final group discussion of the workshop provided an opportunity for a few representatives from the E-TWG to reflect on the workshop and what they will take back to the E-TWG, followed by a discussion around the three key workshop priorities (key advances, data gaps, and opportunities for collaboration). Apart from E-TWG panelists, the input on these three topics below are not attributed to individuals.

Martin Goff, Equinor Wind U.S.

With two great days of information, the next steps are to try to absorb the information, review the references mentioned in presentations, and take the information back to the E-TWG to discuss priorities. Highlights include the importance of pre- and post-development monitoring, the need to improve modeling effects, and the need to further examine behavioral responses. Focusing on behavioral response is important in part because of the challenges posed by oceanographic variability and ongoing changes in oceanographic conditions. I have been surprised at this meeting to learn just how variable oceanographic conditions in this part of the world are. This workshop demonstrated that there is a lot of information we are learning and great work being done, and it would be great for a future workshop to look at what we have taken away and what has been done as a result of this workshop.

Joe Martens, NY Offshore Wind Alliance
It is clear that there is a lot of information available to us, from experience in Europe, work done in support of the NYSERDA Offshore Wind Master Plan, information from the Block Island Wind Farm, and the wealth of research over the years from federal agencies and others. Collectively, there is a huge amount of information, but we have also heard from many panelists that there are knowledge gaps. It is important to establish a baseline, acknowledging that the baseline is a moving target, but it is critical to be able to assess impacts. Many states are looking towards a renewable energy future and with that, they are looking to offshore wind. New York has a 50% goal by 2030, California just passed a goal of 100% renewables, so we are moving towards a fossil fuel free environment in many states. Thus, we must remember that we only have a limited amount of time to figure out gaps, prioritize them, and fill them as quickly as possible. We need to systematically understand impacts and the host of challenges in the marine environment. We want to get it right. We have talked about regional collaboration; the E-TWG is a great mechanism due to its breadth of representation. There is also a technical working group for fisheries, and coordination with them will be essential as well.

Jillian Liner, Audubon NY
The last two days have provided a wealth of information to take back to the E-TWG. The E-TWG has gone through a process of prioritizing research needs, but this should be revisited based on what we have heard at the workshop. We need to compile information, decide where the remaining data gaps are, prioritize them, and design projects to be able to detect impacts. Funding should go towards the highest priority needs. Developing a monitoring framework for all taxa is a key need, which may involve a specialist committee, and cumulative impacts also is a key concern. Collaboration and open lines of communication are important moving forward. Finally, something that hasn't been discussed at this meeting much is best management practices, but if attendees have thoughts, please reach out to E-TWG members.

Group Discussion (*moderated by Jason Gershowitz, Kearns & West*)
This discussion is based around the workshop priorities, which have been discussed by different speakers throughout the workshop and include key advances, data gaps and research needs, and collaboration opportunities. There is a need to assess priorities and recognize when we have enough information on a given topic to shift to a different topic.

Key Advances

- Information on operational noise.

Knowledge Gaps

- Incorporation of food production in our understanding of hotspots.
- We have heard that animals can get auditory damage from pile driving noise and displacement can occur, but what are the behavioral impacts and population-level consequences?
- The social sciences are important too. How does the public perceive offshore wind?
- What are the O&M sound impacts from particle motion?

Opportunities for Collaboration

Regional Collaboration

Strategic and regional monitoring is so important to keep moving forward. Thinking about our discussion yesterday about regional strategies, we should think about how some kind of regional entity would be formulated and how it fits in with the E-TWG. The discussion on regional strategies was really a call for action, as BOEM is not necessarily in the position to appoint a committee, so how do we form something like ORJIP? Perhaps industry could take on this role? Fisheries and environmental issues are currently on separate tracks but perhaps there is a need for a more unified approach. Ørsted is very interested in the idea of this regional coordination and framework, but rather than having multiple groups, it would be beneficial to have just one. The North Pacific Research Board (NPRB) may serve as a good model as it deals with multiple taxa as well as oceanography and fisheries. We need a neutral framework that we are all comfortable with. A first step may be to compare existing frameworks and think about what might work for this situation. Developers are starting to talk together about regional coordination, looking to align pre- and post-construction work to add value and fit our efforts into regional studies.

What is required to get started is a decision-making body, and it may mean starting from scratch, getting some regional funding, and getting a group together to start to develop an approach. BOEM has a framework for research that is in progress now, but what we need is a structure. BOEM wants participation in the process, but it's not necessarily going to lead it. Ørsted would be willing to help fund and support such a group, but it needs to be the right framework. Cooperative research is essential, but it shouldn't just be regional. We need an Atlantic seaboard-wide approach that works with the fishing industry moving forward.

While recognizing that a regional approach to coordinating science is the way to go, there is a diversity of opinions in how it should be set up and so it may take a long time to develop such a framework. However, there is a lot of research that needs to be done now, so is there an interim approach we can take in the meantime so that we don't miss important short-term opportunities?

There are ongoing conversations about regional research for fisheries, but regulatory and permitting decisions are being made now. What permitting conditions do we need to put in place now to buffer impacts? MassCEC has funding on the table to conduct a scoping study to develop research plans for fisheries impacts; how can we incorporate permitting into these efforts and support the process? Congress has not funded the National Marine Fisheries Service to do this work, and we do fund cooperative research and fisheries social science. That being said, we have been asked for a framework to think about what research is needed and what it would cost. A unified approach is not the same as an aligned approach. Baseline studies should have the highest priority. We need monitoring that is research, and that includes adaptive monitoring. Everything should be thought of as a before-after gradient design.

Information Dissemination

Collaboration should not just be among stakeholder groups, we also need to communicate all of this science to the public. A lot of organizations can help communicate science; NYSERDA is doing some of this, but we need to do more. It is important to continue dialogue after this workshop; perhaps a next step could be to use webinars as a tool for speakers to delve into certain topics in greater detail.

Poster Session and Public Open House

Workshop attendees and members of the public attended an evening poster session on November 13th. Over 45 posters from attendees showcased ongoing research and management around offshore wind and wildlife. Abstracts for poster presentations are appended to this report (Appendix C).

In addition to posters on scientific, conservation, and management topics, twelve organizations had exhibit tables with information about their work, and representatives who interacted with members of the public and workshop attendees. Exhibitors included APEM Inc., Applied Biomathematics, the Atlantic Marine Conservation Society, Biodiversity Research Institute (BRI), Bureau of Ocean Energy Management (BOEM), Coonamessett Farm Foundation, Ecology and Environment Inc., New York State Energy Research and Development Authority (NYSERDA), New York State Department of Environmental Conservation, Normandeau Associates, Riverhead Foundation for Marine Research and Preservation, and United States Geological Survey (USGS).

Future Plans

An online survey distributed to attendees after the workshop yielded 78 survey responses. Responses were almost unanimously positive, with all workshop sessions viewed as useful or very useful by a majority (89-96%) of participants. Post-workshop feedback from attendees also indicated overwhelming interest (97% of responses) in continuing to hold similar State of the Science Workshops in the future to support coordination and information dissemination within the offshore wind and wildlife stakeholder community. Respondents indicated that holding such a workshop on a regular basis would help maintain cohesion within the stakeholder community and foster communication about study results and ongoing efforts. Post-workshop survey responses indicated a strong desire from attendees to have another State of the Science workshop within the next 1-2 years. 23% of respondents indicated a preference for more group discussions and 13% would have preferred longer Q&A sessions, suggesting that future workshops could involve greater discussion/interactive components.

In February 2019, the E-TWG convened and discussed the continuation of these workshops. There was overall support, in recognition that the workshop provided a unique platform for conversations around wildlife impacts from offshore wind. NYSERDA has committed to hosting a second workshop in 2020.

Additionally, and in line with several recommendations and points for discussion raised during the workshop, NYSERDA has 1) committed to hosting an ongoing science webinar series on offshore wind topics, and 2) funded an effort to begin outlining potential frameworks for a regional funding entity. In coordination with similar efforts from the Special Initiative on Offshore Wind, conversations are ongoing around the purpose, goals, and possible structures and funding mechanisms for such a regional entity.

Appendix A: The Environmental Technical Working Group (E-TWG)

E-TWG Convener/Chair: Gregory Lampman, NYSERDA (Gregory.Lampman@nyserda.ny.gov)
E-TWG Technical Support: Kate Williams, Biodiversity Research Institute (kate.williams@briloon.org)

As part of New York State's efforts to responsibly develop offshore wind energy, the New York Offshore Wind Master Plan[94] called for the state to convene several Technical Working Groups. These groups, made up of experts and interested stakeholders, are intended to advance common understanding among offshore wind stakeholders and provide input to the state on specific aspects of offshore wind energy development.

In 2018, the New York State Energy Research and Development Authority (NYSERDA) convened the Environmental Technical Working Group (E-TWG). This standing working group consists of a team of offshore wind energy developers, non-governmental organizations (NGOs), and government agencies. In addition to the E-TWG, Specialist Committees (SCs) and public workshops inform the State of New York regarding the environmentally responsible development of offshore wind energy resources (Figure 1). The framework for the E-TWG and related activities was informed by stakeholder input received during development of the Offshore Wind Master Plan, as well as stakeholder interviews conducted by NYSERDA and Biodiversity Research Institute (BRI) in 2017[95].

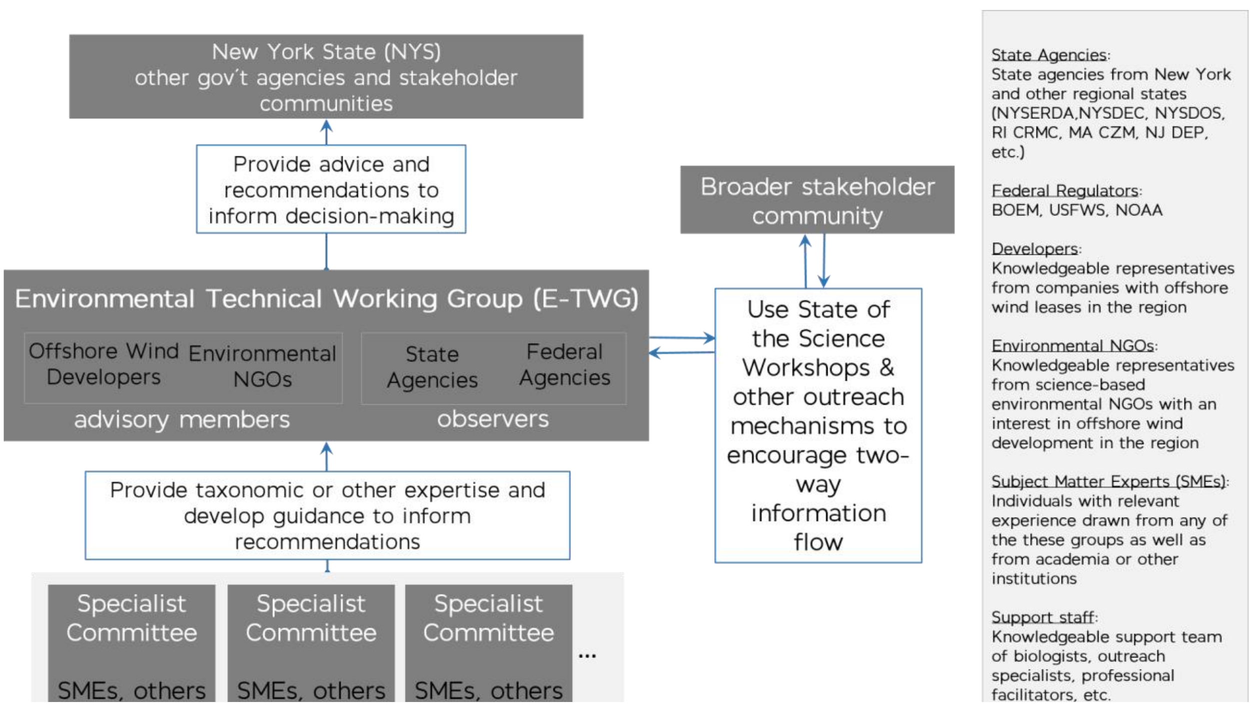

Figure 1. Information flow between stakeholder groups and New York State.

[94] www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Offshore-Wind-in-New-York-State-Overview/NYS-Offshore-Wind-Master-Plan
[95] https://www.nyetwg.com/e-twg-products

E-TWG Objectives

- Improve our understanding of, and ability to manage for, potential effects of offshore wind energy development on wildlife
- Develop transparent, collaborative processes for identifying and addressing priority issues relating to wildlife monitoring and mitigation
- Reduce permitting risk and uncertainty for developers by improving clarity in expectations and processes for wildlife monitoring and mitigation

Current Activities

The first E-TWG meetings were held in 2018. The group is working on a range of initiatives:

- Identifying priority topics for Specialist Committees
- Obtaining stakeholder input through the first State of the Science Workshop
- Informing New York State on how best to incorporate environmental considerations into offshore wind procurement processes
- Recommending topics for inclusion in New York State environmental research solicitations (RFPs)
- Improving communication and coordination of ongoing research, development, and policy

E-TWG Formulation

As of October 2018, the E-TWG had 24 members (Table 1). E-TWG and SC members are volunteers, but NYSERDA supports the groups via funding for technical support staff from BRI.

Table 1. Current E-TWG member organizations (as of October 2018)

Stakeholder	Seats	Specifics
Convener	1	Representative from the New York State Energy Research and Development Authority
Developer	5	Representatives from companies with geographically relevant lease holdings for the State of New York: Deepwater Wind, Equinor, Ørsted, US Wind, and Vineyard Wind
eNGO	5	Representatives from environmental non-profit organizations with a strong scientific grounding and involvement in a range of wildlife and offshore wind issues: Audubon New York, National Wildlife Federation (NWF), Natural Resources Defense Council (NRDC), The Nature Conservancy (TNC), and Wildlife Conservation Society (WCS)
Nonpartisan NGO	1	Representative from an NGO that includes both developers and eNGOs as members (New York Offshore Wind Alliance)
State agency	10	Representatives from New York and other regional states, including Delaware Dept. of Natural Resources & Environmental Control, Maryland Dept. of Natural Resources, Massachusetts Office of Coastal Zone Management, New Jersey Dept. of Environmental Protection, New Jersey Board of Public Utilities, New York Dept. of Environmental Conservation, New York Dept. of State, Rhode Island Coastal Resources Management Council, and Virginia Dept. of Environmental Quality
Federal agency	3	Representatives from the Bureau of Ocean Energy Management (BOEM), U.S. Fish and Wildlife Service (USFWS), and National Oceanic and Atmospheric Administration (NOAA)

Appendix B: Workshop Agenda

DETAILED AGENDA

State of the Science Workshop on Wildlife and Offshore Wind Energy Development

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Hosted by the New York State Energy Research and Development Authority (NYSERDA)
Inn at Fox Hollow, Woodbury, New York

Workshop events are in the Somerley Room unless otherwise noted.

Monday, November 12

7:30 a.m.–8:30 p.m.	**Pre-workshop Social** *(Vintage 25 Bar and Lounge, Inn at Fox Hollow)*

Tuesday, November 13

9:00 a.m.–10:00 a.m.	**Check In** *(Somerley Lobby)*
10:00 a.m.–12:25 p.m.	**Marine Systems and the Offshore Wind Development Process**
	Session Moderator: Gregory Lampman, NYSERDA
	Welcome and workshop overview *Gregory Lampman, NYSERDA*
	Resources in a dynamic ocean *Kevin Friedland, NOAA Northeast Fisheries Science Center*
	Overview of current leases, regulations, and the development process *Mary Boatman, Bureau of Ocean Energy Management*
	Introduction to offshore wind: Development, construction, and operations *Sophie Hartfield, Ørsted*
	Results to date: Real-time Opportunity for Development Environmental Observations (RODEO) project *Mary Boatman, Bureau of Ocean Energy Management*
	Q & A / Panel discussion
12:25 p.m.–1:10 p.m.	**Lunch** *(Springfield Room)*
1:10 p.m.–2:50 p.m.	**Marine Mammals, Part 1**
	Session Moderator: Francine Kershaw, Natural Resources Defense Council
	Marine mammal populations and surveys *Debi Palka, NOAA Northeast Fisheries Science Center*
	Large cetaceans: human impacts, existing knowledge, and data gaps *Melinda Rekdahl, Wildlife Conservation Society*
	Lessons learned from Europe: the effects of offshore wind energy development on marine mammals *Karen Hall, Joint Nature Conservation Commission*
	Overview of pile driving sounds and how to estimate impacts within the U.S. regulatory framework *Dave Zeddies, JASCO Applied Sciences*
	Developments to minimize marine mammal exposure to wind farm construction noise *Ursula Verfuss, SMRU Consulting*
	Q & A / Panel discussion

2:50 p.m.– 3:05 p.m.	**Coffee Break**
3:05 p.m.– 4:30 p.m.	**Sea Turtles, and Marine Mammals Part 2**
	Session Moderator: Lisa Bonacci, New York State Dept. of Environmental Conservation
	Turtle populations in the northwest Atlantic *Heather Haas, NOAA Northeast Fisheries Science Center*
	Impacts from marine development on turtles *Sue Barco, Virginia Aquarium*
	Turtles and offshore wind: what we know (and what we don't) *Kyle Baker, Bureau of Ocean Energy Management*
	Monitoring during the construction and post-construction periods: Developing a regional strategy for data sharing & standardizing protocols *Kyle Baker, Bureau of Ocean Energy Management*
	Q & A / Panel discussion
4:30 p.m.– 5:00 p.m.	**Group Discussion – Regional Strategies**
5:00 p.m.– 6:00 p.m.	**Break** (on your own)
6:00 p.m.– 7:00 p.m.	**Dinner** *(seating in Hearth Room, 1st floor, and Fox Hunt Room, 2nd floor)*
7:00 p.m.– 8:30 p.m.	**Poster Session and Public Open House**

Wednesday, November 14

7:30 a.m.– 8:00 a.m.	**Check In** *(Somerley Lobby)*
8:00 a.m.– 8:05 a.m.	**Welcome and Day One Recap** *Kate Williams, Biodiversity Research Institute*
8:05 a.m.– 9:35 a.m.	**Lower Trophic Levels, Fishes, and Fish Habitat, Part 1**
	Session Moderator: Carl LoBue, The Nature Conservancy
	Zooplankton in the northwest Atlantic: the foundation of the food web *Ryan Morse, NOAA Northeast Fisheries Science Center*
	Fish populations and fish habitats in eastern North America *Vince Guida, NOAA Northeast Fisheries Science Center*
	Review: fish hearing and effects of underwater noise *Arthur Popper, University of Maryland*
	Effects of electromagnetic fields (EMF) from offshore wind facilities *Andrew Gill, PANGALIA Environmental*
	Impacts from offshore wind to benthos and benthic habitats *Paul English, Fugro*
	Q & A / Panel discussion
9:35 a.m.– 9:50 a.m.	**Coffee Break**

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AGENDA (CONTINUED)

9:50 a.m.– 11:00 a.m.	**Lower Trophic Levels, Fishes, and Fish Habitat, Part 2** *Session Moderator: Sue Tuxbury, NOAA Fisheries* **Review of European studies: impacts of offshore wind development on fishes** *Andrew Gill, PANGALIA Environmental* **Meta-analysis of the effects of offshore wind farms on finfish abundance** *Elizabeth Methratta, Integrative Sciences Group* **Examining impacts of America's first offshore wind farm on fishes and invertebrates** *Drew Carey, Inspire Environmental* **Q & A / Panel discussion**
11:00 a.m.– 11:45 a.m.	**Lunch** *(Springfield Room)*
11:45 a.m.– 1:35 p.m.	**Birds and Bats** *Session Moderator: Caleb Spiegel, U.S. Fish and Wildlife Service* **Bats and wind energy** *Trevor Peterson, Stantec* **The current state of knowledge regarding avian impacts from offshore wind energy developments in Europe** *Sue O'Brien, Joint Nature Conservation Commission* **Modeling avian distributions and relative abundance in the northwest Atlantic using compiled data** *Arliss Winship, NOAA NCCOS & CSS* **Using individual tracking of protected species to inform offshore wind development** *Pam Loring, U.S. Fish and Wildlife Service* **Bird and bat monitoring at the Block Island Wind Farm** *Stephanie Wilson, Deepwater Wind* **Recent developments in bird and bat detection and deterrence** *Jocelyn Brown-Saracino, Department of Energy* **Q & A / Panel discussion**
1:35 p.m.– 1:50 p.m.	**Coffee Break**
1:50 p.m.– 3:15 p.m.	**Ecosystem Perspectives** *Session Moderator: Catherine Bowes, National Wildlife Federation* **From observing structural effects to understanding functional effects of offshore wind energy development** *Steven Degraer, Royal Belgian Institute of Natural Sciences* **Designing research and monitoring studies to effectively detect impacts** *David Secor, University of Maryland* **Understanding cumulative impacts** *Wing Goodale, Biodiversity Research Institute* **Lessons learned from the European experience** *Sue O'Brien, Joint Nature Conservation Commission* **Q & A / Panel discussion**
3:15 p.m.– 3:30 p.m.	**Coffee Break**
3:30 p.m.– 4:30 p.m.	**Group Discussion with E-TWG Panel – Reflection on Workshop Priorities** *Martin Goff, Equinor* *Jillian Liner, Audubon New York* *Joe Martens, New York Offshore Wind Alliance*

AGENDA (CONTINUED)

Thursday, November 15

Space for post-workshop meetings is limited; please email contacts below to sign up. (Post-workshop meetings are not being hosted by NYSERDA).

9 a.m.– 12 p.m.	**Environmental impact vs. effect — towards understanding the interaction between benthic environmental receptors and energy emissions (EMF and noise)** *Andrew Gill, PANGALIA Environmental, Devon Room* (kate.williams@briloon.org)
9:30 a.m.– 4:30 p.m.	**Atlantic Marine Bird Cooperative (AMBC) Marine Spatial Planning Working Group** *Caleb Spiegel, U.S. Fish and Wildlife Service, Fox Hunt Room* (caleb_spiegel@fws.gov)

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Appendix C. Poster Presentations

Abstracts are listed in alphabetical order by the last name of the first author.

Table of Contents

CFF Stereo Camera Stands

Ricky Alexander[1] (ralexander@cfarm.org), Liese Siemann[1], Samir Patel[1], and John Ceccolini[1]
[1]Coonamessett Farm Foundation

The CFF custom-built stationary stereo camera stands collect high quality stereo images at programmable intervals from days to weeks at a time, and embed oceanographic data into the images. The cameras are capable of deploying or transplanting bait, live organisms, fish attraction devices, etc., and monitoring interactions for several days.

Measuring Underwater Hearing in Diving Birds using the Auditory Brainstem Response (ABR)

Alicia Berlin[1] (aberlin@usgs.gov), Sara Crowell[2], Jonathan Fiely[3], Glenn Olsen[1], Jennifer James[4], Heather Hopkins[4], Kathleen McGrew[5], and Christopher Williams[5]
[1]USGS PWRC, [2]I.M. Systems Group Inc., [3]Cornell Lab of Ornithology, [4]Naval Underwater Warfare Center [5]University of Delaware

Diving birds may use auditory cues to aid in orientation, communication, and/or foraging, but the ability of individuals to hear underwater has not been experimentally tested. Understanding hearing in diving birds is important to current regulatory and management priorities that would use these data to evaluate the impact of noise pollution, such as offshore energy construction activities, naval sonar activities, and the effectiveness of acoustic deterrents to avoid bycatch of birds in gillnets. This pilot project sought to develop a functional methodology to examine auditory sensitivity in a variety of species of diving birds through electrophysiological methods (the auditory brainstem response). Preliminary testing of four Surf Scoters (*Melanitta perspicillata*) demonstrated maximum underwater ABR sensitivity at 1000 Hz, with an absolute threshold at 107.5 dB re 1 Pa. This pilot test represents an important development of procedures and equipment that can be used to rapidly expand the available data on underwater hearing in diving birds. This data can then be applied to evaluate current and future anthropogenic noise sources that may impact diving birds, including underwater offshore energy construction activities, offshore vessel traffic, bathymetric mapping, and sonar.

Large Whale Sightings in the Apex of the New York Bight, 2011-2017

Danielle M. Brown[1,2] (Danielle.brown1@rutgers.edu), Paul L. Sieswerda[1], Catherine M. Granton[1], David S. Rosenthal,[1] Kristi A. Collom[1], Artie Raslish[1], Celia A. Ackerman[1], and Merryl Kafka[1]
[1]Gotham Whale [2]Rutgers University

The apex of the New York Bight is home to the borough of Manhattan and one of the most highly urbanized ecosystems in the United States. The limited data on large whales in this area come from wide-scale surveys which suggest that they are present in low abundance, with no consistency in sightings or occurrence. Beginning in 2011, Gotham Whale has been opportunistically documenting large whale sightings in the apex through whale-watching and citizen-science. Four species were documented from 2011-2017, and there was a significant increase in humpback whale (*Megaptera novaeangliae*) sightings across years. The identification rate for humpback whales also increased, and juveniles exhibited both seasonal occupancy and annual return. These more fine-scale data are important for management and suggest that the apex may be an increasingly important area for humpback whales.

Fish Tagging and Tracking

Amy Carlson[1] (acarlson@cfarm.org) and Samir Patel[1]
[1]Coonamessett Farm Foundation

Tags can provide valuable insight to movement patterns, behaviors, temperature, and depth thresholds. CFF utilizes passive tags and satellite tags to track sea turtle behavior, movement, and ecology as well as tracking mola location. Acoustic tags will be used to monitor black sea bass location at a high resolution along the eastern seaboard.

Distribution and Occurrence of Large Whales in the New York Bight Prior to 2017: Establishing Baselines and Informing Management

E. Chou[1] (ec3158@columbia.edu), R. Antunes[1], M. Rekdahl[1], C. Spagnoli[1], A.H. Kopelman[2], P.L. Sieswerda[3], R. DiGiovanni[4], C. Good[5], and H.C. Rosenbaum[1]

[1]Wildlife Conservation Society, [2]Coastal Research and Education Society of Long Island, [3]Gotham Whale, [4]Atlantic Marine Conservation Society, [5]Duke University

The New York Bight is one of the busiest waterways in the world, where industries such as shipping, tourism, fishing and renewable energy development coincide with a diversity of marine wildlife. Large whales have been sighted with increasing frequency in recent years, yet detailed information on species distribution, required for effective management and planning, remains scarce. With growing conservation concerns, a synthesis of sightings data over the past 20 years (published and unpublished data) for large whales is presented. Species distribution models, using Maxent, were constructed for two of the most commonly sighted species (humpback and fin whales), which can inform the probable distribution of humpback and fin whales, and potential overlap with anthropogenic activities. Results highlighted areas of overlap between whale occurrence and current anthropogenic use and interest. These results provide valuable baselines to inform future research efforts, monitoring and potentially best management practices that may be most effective.

New York State's Ocean Action Plan

Karen Chytalo[1] (karen.chytalo@dec.ny.gov), Sherryll Jones[1], Krista Stegemann[2], and Greg Capobianco[1]

[1]New York State Department of Environmental Conservation, [2]Cornell University, [3]New York Department of State

The New York State Ocean Action Plan, (OAP) released on January 23, 2017, is the State's first-ever comprehensive 10-year blueprint to guide the protection and conservation of New York's ocean resources. Through interagency cooperation and stakeholder partnerships, the Plan provides a 61-point Action framework for an integrated, adaptive approach to management to address four main goals to ensure the ecological integrity of the ocean ecosystem, to promote sustainable economic growth and responsible human use of the ocean, to increase resilience of ocean resources in the face of climate change, and to empower to public through ocean stewardship.

Habitat Mapping Camera (HabCam) – A System for Optical Benthic Surveys

Jason Clermont[1] (jclermont@cfarm.org), John Ceccolini[1], and Liese Siemann[1]

[1]Coonamessett Farm Foundation

The habitat mapping camera (HabCam) is a towed benthic camera system designed to survey the seafloor. It provides high-resolution imagery of the seafloor including substrate, flora and fauna. On-board sensors collect data such as temperature, salinity and depth during the surveys. Images are taken in an overlapping pattern so mosaics of large areas of the surveyed area can be created. Capabilities include benthic substrate classification and mapping, surveys of benthic flora and fauna, species distributions, and anthropogenic features.

What Europe Has Learned From Recent Wind Wildlife Studies

Stuart Clough[1] (enquiries@apemltd.co.uk), Julia Robinson Willmott[2], Stephanie McGovern[1], Abigail Goulding[1], Bethany Goddard[1]

[1]APEM, [2]Normandeau Associates Inc.

Multiple proposed offshore wind farms in Europe have been challenged during planning over concerns about their impacts on birds and other wildlife, with at least one denied consent on these grounds. Current predictions of potential impacts on wildlife are often little more than expert guesses and may slow industry expansion. Hard evidence is needed. We aim to illuminate recent research methods developed by APEM, Normandeau Inc. and others to understand seabird avoidance rates to inform likelihood of collisions with turbines, analytical approaches to detecting barrier effects, assessments of post-construction displacement of birds, improving aerial survey resolution, the use of GPS telemetry for site usage, simple tools to estimate the scale of diurnal and nocturnal migration, and a new concept for estimating mortality from wind farms.

Seasonal Distribution and Risk Assessment to Bottlenose Dolphins in the Northwestern New York Bight

Kristi A. Collom[1,2] (kristiashleycollom@gmail.com), Eric A. Ramos[3,4], Maria Maust-Mohl[5], Paul Sieswerda[2], David S. Rosenthal[2], Catherine M. Granton[2], Artie Raslish[2], Celia A. Ackerman[2], Merryl Kafka[2], Danielle Monaghan Brown[2] and Diana Reiss[1]
[1]Hunter College, [2]Gotham Whale, [3]City University of New York, [4]Fundación Internacional para la Naturaleza y la Sostenibilidad, Chetumal, [5]Manhattan College
Bottlenose dolphins (*Tursiops truncatus*) are found in transient and resident populations along the North Atlantic however little is known about the factors which contribute to their migratory range. The seasonal occurrence and population structure of dolphins have not been well-studied in the inshore regions of the New York and New Jersey Bight, the most active marine port on the eastern coast of the United States. Information is needed to provide stakeholders with recommendations for improved management. Here, we provide the first assessment of seasonal distribution and assess the potential anthropogenic risks. Photo and sighting data gathered from May to September 2011-2017 aboard a seasonal whale watching vessel were used to determine factors influencing their occurrence, population structure and how their distribution overlaps with commercial shipping lanes and recreational activity. This study provides baseline data to support monitoring efforts for bottlenose dolphins in an area that faces increasing human-wildlife interactions.

Atlantic Marine Conservation Society: A Review of Marine Mammal and Sea Turtle Strandings and Research Efforts

Robert A. DiGiovanni Jr[1] (rdigiovanni@amseas.org), Kimberly F. Durham[1], Allison M. DePerte[1], and Hannah Winslow[1]
[1]Atlantic Marine Conservation Society
Atlantic Marine Conservation Society (AMCS) has responded to 305 marine mammal and sea turtle strandings from January 2017 through September 30, 2018. Twenty six of those were large whale strandings, representing a complex situation requiring coordination among multiple agencies and highly trained response personnel. AMCS is responding to stranded animals, and conducting research on the wild populations of marine mammals and sea turtles to document abundance and distribution of these animals while identifying the threats they face in our waters. We educate the public about our findings to promote marine conservation through action and encourage active environmental stewards.

Addressing Effects of Offshore Wind Development on Bats in the Northeastern United States

Zara Dowling[1] (zdowling@eco.umass.edu), Paul Sievert[1], Dwayne Breger[2], Jonathan Reichard[3], and Elizabeth Dumont[4]
[1]UMass Amherst, [2]Clean Energy Extension, [3]US Fish & Wildlife Service, [4]UC-Merced
We have conducted multiple research studies in order to better characterize bat activity in the offshore environment and inform potential strategies to reduce mortality at offshore wind energy facilities. Our methods include bat movement tracking using Motus automated radio-telemetry network, modelling of the economic costs of curtailment, and design of a mechanical ultrasonic deterrent for wind turbines.

Seasonal Biological Surveys Using Scallop Dredges

Luisa Garcia[1] (lgarcia@cfarm.org) and Liese Siemann[1]
[1]Coonamessett Farm Foundation
This project documents the spatiotemporal distribution of the scallop and groundfish bycatch species, and associated environmental parameters. CFF's ongoing, multiyear survey studies scallop health, groundfish abundance, health, and maturity, and lobster disease and damage on Georges Bank. Surveys are designed to emulate commercial fishing practices to gain relevant fisheries-independent data for industry and government use.

SeaScribe – A Free Mobile Avian Survey Data Collection App

Andrew Gilbert[1] (Andrew.gilbert@briloon.org), and Iain Stenhouse[1]
[1]Biodiversity Research Institute

In 2014, the Bureau of Ocean Energy Management (BOEM) contracted with the Biodiversity Research Institute (BRI) and Tilson Technology Management to create a modern offshore survey data collection application capable of being used on relatively low-cost Apple and Android handheld computing devices (e.g., tablets and phones). In 2016, we rolled out the first version of the app, called SeaScribe, and released an update in 2018. We designed SeaScribe to have better, built in, on-the-fly data checking, improved data standardization across surveys, improved data entry, and reduced time to quality-controlled data. The application was designed to collect core offshore survey data but also gives users the flexibility to add data fields as necessary to satisfy specific survey or research needs. It provides an easy-to-use, intuitive application for the collection of wildlife survey data, including geo-referenced effort and observation data, capturing environmental conditions and behavioral information alongside each geo-referenced observation. SeaScribe is being adopted by researchers across the U.S. and beyond, and BOEM has required its use in projects related to offshore wind development. BOEM has committed to keeping SeaScribe up-to-date and currently a new round of updates is being planned for release within the next year. BOEM has made the app freely available (via the iTunes App Store and Google Play). You can learn more about SeaScribe and download the most recent User's Manual at http://www.briloon.org/seascribe.

Assessment of Block Island Wind Farm Construction Activities on Lobster Resources

Matt Griffin[1], Lorraine Brown Read[1], and Drew Carey[1] (drew@inspireenvironmental.com)
[1] INSPIRE Environmental

The Block Island Wind Farm (BIWF), the first offshore wind farm in the United States, has five wind turbine generators (WTGs) that were sited based on coordination with state and federal management agencies and in cooperation with the local fishing industry. The New England lobster fishery dates to colonial times and continues to support important socioeconomic coastal trades. Lobster resources in Block Island Sound have fluctuated over time and the fishery is currently experiencing a period of low landings. The declining population has spurred increased management measures, careful marine spatial planning, and the need to understand construction impacts on the population. The study is designed to identify changes in local lobster abundance driven by direct physical disturbance effects of construction and uses a Before-After-Control-Impact design. Ventless and vented lobster traps are assessed twice per month (May - October) within two BIWF and two reference areas. Assessments commenced two years prior to construction, during construction and will continue for one year after construction. Results indicate fluctuating relative lobster abundance between survey years and blocks. Fishing pressure within the vicinity of the BIWF appears lower compared to the reference area as indicated by a higher distribution of legal sized lobsters in the BIWF area compared to reference. Preliminary comparisons of relative lobster abundance, reproductive status and disease levels do not indicate increased stress of the lobster resource in the vicinity of the BIWF during construction activities. The inclusion of the fishing industry in the survey allows for the smooth transfer of their local ecological knowledge, a cost-effective survey approach and encourages industry trust.

Assessment of Valuable Hard Bottom Habitats After Base Construction at the Block Island Wind Farm

Marisa Guarinello[1] and Drew Carey[1] (drew@inspireenvironmental.com)
[1]INSPIRE Environmental

The Block Island Wind Farm (BIWF), the first offshore wind farm in the United States, has five wind turbine generators (WTGs) that were sited based on coordination with state and federal management agencies. The potential for anchors to disturb valuable hard bottom habitats adjacent to WTG #5 necessitated additional assessment. Intact hard bottom habitats are critical resources in southeastern New England for juvenile lobster and squid eggs. Surveys were designed to identify the condition of hard bottom habitats before and after foundation installation. Baseline and post-construction surveys were conducted using a multibeam echosounder, a towed video sled, and a high-resolution plan-view (PV) camera. Our baseline assessments showed that the area is diverse and patchy ranging from continuous cobble fields with high biotic cover to rippled gravelly sand. Results demonstrate that WTG #5 was optimally sited in mobile, rippled gravelly sand. Despite extensive data collection efforts, we found no visual evidence of disturbance to high value hard bottom habitats. Cobbles and boulders in mixed sand habitats were dragged into linear arrays visible in acoustic and video data. These linear arrays disturbed small patches of moderate value habitat (cobbles and boulders scoured by sand) raising the boulders above the sand. The linear arrays could serve as higher value habitat after recovery. Further, it is possible that WTG #5 will quickly develop a robust biotic community on its foundation due to proximity to cobble fields, the flora and fauna of which may serve as 'seed' populations for these communities. The integrated survey, quantitative data collection and modified CMECS evaluation methods were a cost-effective, rapid assessment approach that can be applied to offshore wind installations that require seafloor monitoring.

Weighted Environmental Sensitivity Model for Offshore New York

Katie Guttenplan[1] (kguttenplan@ene.com), Jenny Mogavero[1], Marc Koopman[1], and Greg Lampman[2]
[1]Ecology and Environment, Inc.; [2]New York State Energy Research and Development Authority
Ecology and Environment, Inc. with support from New York State Energy Research and Development Authority, developed a weighted sensitivity model to compare the potential impacts to selected marine resources from activities that may occur during pre-construction, construction, and post-construction of offshore wind facilities in New York as part of the state's Offshore Wind Master Plan. The approach was to conduct a literature synthesis and risk assessment, which identified risk and potential impacts to each selected marine resource. Based on the risk assessment, regulatory context, permitting requirements, Bureau Of Ocean Energy Management recommendations, seasonality, and other additional factors, sensitivity weight value were determined for the identified receptor groups for each phase of offshore wind development and applied using a weighted sum geospatial analysis model to produce maps of relative sensitivity throughout the area of analysis. The high-level sensitivity mapping analysis identified seasonal shifts in regions of relatively higher or lower sensitivity.

New York State Fisheries Technical Working Group

Lyndie Hice-Dunton[1] (LHiceDunton@ene.com), Greg Lampman[2], and Morgan Brunbauer[3]
[1]Ecology and Environment, Inc.; [2]New York State Energy Research and Development Authority, [3]New York State Department of Environmental Conservation
Following the release of the New York State Offshore Wind Master Plan in early 2018, the State of New York established four technical working groups (TWGs) focused on environmental, commercial and recreational fishing, maritime, and jobs and supply chain issues related to offshore wind. The goal of the TWGs is to provide advice and guidance to New York State to advance the development of offshore wind in an environmentally responsible manner while also protecting the State and region's valuable marine resources. The Fisheries Technical Working Group (F-TWG) is led by NYS DEC and NYSERDA. It brings together regional fishing industry representatives, offshore wind developers, and regional state and federal agencies to improve communication and coordination between the fishing community and developers. The F-TWG provides a facilitated forum for discussions, and technical support for topics of interest to the group.

Endangered Atlantic Sturgeon in the New York Wind Energy Area

Evan Ingram[1] (evan.ingram@stonybrook.edu), Michael Frisk[1], and Keith Dunton[2]
[1]Stony Brook University; [2]Monmouth University
The New York Wind Energy Area comprises important marine habitat that may be used by endangered Atlantic sturgeon and other commercially important finfish species. Atlantic sturgeon are known to make seasonal migrations along the eastern seaboard of the United States and will often form marine aggregations comprised of individuals of mixed genetic origin—two known aggregation areas are located in close proximity to the NYWEA. In 2016, an array of acoustic receivers was deployed in the NYWEA to monitor seasonal occupancy and movements. Acoustic transmitters were surgically implanted in Atlantic sturgeon during 2016–2018. Downloads identified at least 362 unique Atlantic sturgeon tags and suggest that presence of Atlantic sturgeon in the NY WEA is highly seasonal. This study provides information regarding the presence of Atlantic sturgeon in offshore marine waters that is essential to assess any potential impacts of offshore wind-energy development and will provide data that are critical for ongoing management.

BOEM'S RODEO Program Overview

Anwar Khan[1] (Anwar.Khan@hdrinc.com) and James Elliott[1]
[1]HDR

The objective of BOEM's "Real-time Opportunity for Development Environmental Observations (RODEO) Program" is to acquire real-time observations of the construction and initial operation of offshore wind facilities to aid the evaluation of environmental effects of future facilities. For Outer Continental Shelf (OCS) wind development, there is no previous experience in the U.S., therefore the analyses and subsequent mitigation measures are based on best available information. These analyses will benefit from real-time, independent observations made during actual construction of the nation's first offshore facility located at Block Island, Rhode Island. Lessons learned and data collected from the RODEO Program will guide BOEM in managing future OCS wind energy development. Under the RODEO Program, real time monitoring was conducted in the vicinity of the Block Island wind turbines in 2015 and 2016 during the construction phase to gather data for assessment of turbine scour, seafloor disturbance and recovery, airborne noise, underwater sound, visual impacts, and benthic community abundance and diversity. Monitoring was continued after the facility started initial operations in December 2016. This included visual, benthic, airborne noise and underwater sound monitoring. Data evaluation includes conducting advanced analyses and modeling using acoustic data collected during the pile driving associated with the construction phase. Key findings from the various monitoring events will be presented and discussed in this poster.

Assessment of Ecological Value of Benthic Habitats in Offshore Wind Energy Development and Transmission Line Corridor Areas

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Impacts of human activities on benthic macrofauna in coastal marine ecosystems have been assessed through the application of benthic indices based on species richness; however, the functional diversity of the community is rarely assessed. Functional diversity aspects of the benthic community, including diversity species traits and productivity, are important in connecting benthos to fish and provide a means to assess the relative ecological value of benthic habitats. In this study, ecological value using functional diversity traits was assessed for benthic habitats in proposed offshore wind energy development areas and associated transmission line corridors off Ocean City, Maryland. Species-specific functional traits that reflect or modulate trophic transfer (turnover, productivity) were considered. The resulting management tool is expected to be useful for assessing the relative importance of a community as it relates to benthic ecosystem processes, and to evaluate shifts in functional diversity in areas affected by seabed disturbance.

Migration of Piping Plovers in the U.S. Atlantic: Timing, Routes, and Atmospheric Conditions

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Information on offshore movements of species listed under the Endangered Species Act is needed for assessments of offshore wind energy areas. Our specific objectives were to track federally-threatened Atlantic Coast Piping Plovers (*Charadrius melodus*) to determine: 1) fall migration routes; 2) temporal and demographic variation in offshore movements; and 3) atmospheric conditions during offshore flights. From 2015 to 2017, we attached 1.0 g digitally-coded VHF transmitters to 150 adult Piping Plovers nesting in Rhode Island and Massachusetts, USA and tracked their movements using 35 automated radio telemetry stations along the U.S. Atlantic Coast. Tagged plovers initiated migration from mid-July through early September. Piping Plovers migrated at flight speeds ranging from 50 to 80 km/hr on evenings with predominately southwest winds, above average air temperatures, high visibility and little to no precipitation. Piping Plovers from Cape Cod, Massachusetts departed within six hours prior to local sunset, and primarily used an offshore route across the mid-Atlantic Bight. In contrast, plovers from Rhode Island departed within four hours prior to local sunset, and either followed a coastal route or took an offshore route south of Long Island, New York. Individuals used stopover sites along the U.S. mid-Atlantic coast during migration, with nocturnal migratory flights spanning distances of over 600 km. These results reveal new insights into the migration ecology of Piping Plovers and will be used in assessments of exposure to offshore wind energy areas throughout the U.S. Atlantic Outer Continental Shelf.

Winter Habitat Use of White-winged Scoters in Southern New England: Implications for Offshore Wind Energy Development

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Concern over declining populations of several North American sea duck species has led to increased research addressing how environmental and anthropogenic factors in various stages of the annual cycle affect survival, productivity, habitat use, and site fidelity. As the development of renewable energy sources such as offshore wind power moves closer towards large-scale implementation in the United States, the need for effective pre-construction surveys and site planning is essential. Several sites along the mid-Atlantic Outer Continental Shelf have been proposed for large offshore wind energy facilities. Many of these areas provide important staging and wintering habitat for several sea duck species whose habitat use, migration pathways, and general biology have only recently been studied. This study used satellite telemetry to determine the population linkages between wintering, breeding, and molting areas for White-winged Scoters (*Melanitta fusca*) that winter in southern New England. Location data spanning 1-3 years was used to document connectivity and movement patterns during various life stages and identifies important aspects of near-shore and offshore habitat use and resource selection of sea ducks in southern New England and the potential impacts of proposed offshore development.

Environmental Sensitivity and Associated Risk to Habitats and Species Offshore Central California and Hawaii from Offshore Floating Wind Technologies

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Through funding from the Bureau of Ocean Energy Management's Pacific Outer Continental Shelf (OCS) Region and in collaboration with ICF International, RPS conducted a scoping-level analysis to categorize the effects of offshore floating wind (OFW) development on the marine environment. We compared vulnerability of benthic habitats and species in two study regions offshore California and Hawaii based on a literature review of life history, behavioral traits, and recovery potential. We identified 8 primary impact-causing factors of OFW technology and assessed potential effects on 44 species within 3 broad groups via ranking schemes and summary algorithms. Environmental sensitivity scores for each species, habitat, region, and season represent the combined vulnerability, recovery potential, and impact magnitude of each ICF and receptor. This categorical approach can prioritize potential OFW stressors and sensitive receptors for detailed impact assessment, as well as identify knowledge gaps in the literature to inform further research.

Offshore Wind 101

NYSERDA (gregory.lampman@nyserda.ny.gov)
The U.S. has enormous potential for offshore wind development, with a healthy pipeline of offshore wind projects under development. This provides a background on the growing sector, including the technology that goes into energy production, resource potential, and the different stages of development from siting and pre-construction, to construction, to operations and maintenance.

Offshore Wind in New York State

NYSERDA (gregory.lampman@nyserda.ny.gov)
Offshore wind energy is poised to become a major source of affordable, renewable power for New York State. Meeting state goals will result in supplying 2,400 megawatts of clean power for the State, enough to power 1.2 million homes. Benefits will include clean and locally produced power, investment in coastal infrastructure and

communities, opportunities for job creation, and a diversified electric supply. New York plans to become a hub for the United States' emerging offshore wind energy industry.

Studies and Surveys

NYSERDA (gregory.lampman@nyserda.ny.gov)

In its commitment to developing offshore wind, New York is working to understand the environmental, economic, and social implications of offshore wind development. In this vein, it has completed numerous studies on birds and bats to fish to marine mammals, economic assessments of infrastructure and workforce opportunities to health and safety and recreational use studies, all with the aim of understanding potential impacts of offshore wind development. Work is ongoing to continue research related to key issues of offshore wind turbine siting, construction, performance optimization, and environmental impacts.

Offshore Wind Jobs and Infrastructure

NYSERDA (gregory.lampman@nyserda.ny.gov)

New York's commitment to clean energy includes developing 2,400 megawatts of offshore wind energy by 2030. In order to understand the economic and infrastructure implications of this offshore wind development, NYSERDA completed a Workforce Study. The study found that New York can realize nearly 5,000 new jobs in manufacturing, installation, and operations of offshore wind facilities, with nearly 2,000 of these jobs representing sustained career opportunities in operations and maintenance. The development of port infrastructure in New York is critical for the creation of new in-State jobs. The use of local workforce and infrastructure carries the benefits of economic stimulus and possible reductions of energy costs.

Stakeholder Outreach and Public Engagement

NYSERDA (gregory.lampman@nyserda.ny.gov)

New York is committed to the responsible development of offshore wind energy in the Atlantic Ocean. As New Yorkers also rely on the ocean for food, jobs, and recreation, the State must make certain that offshore wind is developed in a responsible manner. To achieve this, the State will continue to foster outreach and public engagement, conduct additional research, and convene Technical Working Groups. One of New York State's primary goals is to ensure public input is considered at each phase of offshore wind energy planning and development.

Offshore Wind Research and Development Consortium

NYSERDA (gregory.lampman@nyserda.ny.gov)

The New York State Energy Research and Development Authority (NYSERDA) has been selected by the U.S. Department of Energy to administer an offshore wind research and development consortium. The consortium is a cooperative innovation hub that will bring together industry, academia, government, and other stakeholders to advance offshore wind plant technologies, develop innovative methods for wind research and site characterization, and develop advanced technology solutions for installation, operations, maintenance, and supply chain. The overall aim is to reducing the cost of offshore wind in the U.S.

Commercial and Recreational Fishing

NYSERDA (gregory.lampman@nyserda.ny.gov)

New York considers the fishing community to be a key stakeholder group and believes that effective development of offshore wind energy will require coordinated and consistent engagement with commercial and recreational fishers. To foster outreach and dialogue, the State is convening a Commercial and Recreational Fishing Technical Working Group that includes commercial and for-hire recreational fishers. This working group aims to define strategies and activities that could help members engage effectively in offshore wind energy development through improved communications, identifying research needs and coordination, and developing a framework for understanding commercial fishing impacts.

Ecology of Sea Turtles in the Northwest Atlantic Ocean

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Since 2009, CFF has tagged and tracked turtles along the eastern seaboard from Florida to Georges Bank. Long-term research on loggerhead turtles began in an effort to reduce turtle bycatch in the Atlantic sea scallop fishery. This long term research has led to the development of the turtle deflector dredge, the recording of approximately 45 hours of ROC footage, and the direct capture and tagging/sampling of over 200 turtles. In addition to location and environmental data collected by the tags, CFF also collects gut and fecal samples from stranded turtles in Cape Cod waters for stable isotope analyses and to identify parasites within the digestive system.

New York Bight Whale Monitoring Program

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The New York Bight Whale Monitoring Program is a 3-year baseline study using aerial and passive acoustic surveys to understand the seasonal occurrence, distribution, and abundance of six large whale species: North Atlantic right whale, sperm whale, blue whale, fin whale, sei whale, and humpback whale. The first monthly aerial survey was conducted in March 2017 and passive acoustic receivers were deployed adjacent to shipping lanes in October 2017. The results of this baseline study will provide information needed for management and conservation of whale species in the New York Bight at both the state and federal levels and will inform the State's development and implementation of a long-term whale monitoring program.

Understanding the Seasonal Movements of Atlantic Sturgeon and Striped Bass in the Maryland Wind Energy Area

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Although economically important Striped Bass and endangered Atlantic Sturgeon seasonally migrate through the US Mid-Atlantic Bight, the timing and distribution of these movements in near-shelf waters is poorly known. To evaluate seasonal incidence of these species, 20 acoustic-release telemetry receivers were deployed in a gradient design centered on the Maryland Wind Energy Area. From November 2016 to August 2018, the array detected 311 striped bass and 338 Atlantic sturgeon that had been implanted previously with acoustic transmitters. Most sturgeon detections occurred in shallower near-shelf waters (10-20 m) and Striped Bass only occurred in a relatively narrow temperature range: 6-12°C. Despite possible differences in habitat selection between Striped Bass and Atlantic Sturgeon, the infrequency of detections for both species in summer suggests these months could be considered as a potential window for wind tower construction, should these migratory species be a priority.

High-definition Digital Video Aerial Surveys-an Advanced Method to Monitor Marine Mammals and Seabirds

Martin Scott[1], Andy Webb[1], and Georg Nehls[1,2]
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High-definition digital aerial video surveys before, during and after construction produce reliable and reproducible data which can be reviewed by independent experts to support environmental impact assessments and post-consent monitoring. Across hundreds of surveys, it has been shown to be an efficient method to study offshore wildlife and provide insight into the biology and behavior of little known species.

Baited Underwater Video (BUV) Systems to Survey Fish and Other Marine Animals

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The baited underwater video (BUV) system is a CFF custom-built underwater camera system with bait in the field of view to derive fishery-independent indices of abundance. Compared to surveys done with traditional fishing surveys, the BUV causes minimal impact on habitat, a low selectivity for species and sizes, and can also be used to study behavior. The BUV was used to survey blueline and golden tilefish. Video metrics were compared to catch from commercial vessels to create an index of relative fish abundance.

Reducing Cetacean and Sea Turtle Entanglements Using an Inexpensive GPS Radio Buoy – the Budget Smart Buoy

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The budget smart buoy (bsBuoy) can provide an early notification and near-real time location data of entangled whales and sea turtles. CFF developed it because sea turtles and cetaceans, North Atlantic right whales in particular, routinely become entangled in fishing gear, and the majority of recent North Atlantic right whale deaths are attributed to entanglement. CFF's solution is the bsBuoy to provide early notification and near-real time location data of active entanglement, allowing disentanglement teams to reach animal quickly and minimize mortality.

The Atlantic Marine Bird Cooperative: Facilitating over 10 Years of Collaborations to Better Understand and Conserve Marine Birds in the Northwest Atlantic

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Worldwide, seabirds face greater threats from human-related activities than most other bird taxa, with many species experiencing substantial declines during recent decades. In the northwest Atlantic Ocean, primary threats include competition for food resources with fisheries, bycatch in fishing gear, displacement and mortality associated with offshore energy development, pollution, and degradation of nesting habitat. The magnitude of these issues requires collaboration among many stakeholders. Since its formation in 2005, the Atlantic Marine Bird Cooperative (AMBC) has brought together a diverse international partnership of agencies, NGOs, and academic institutions to identify, prioritize, and better understand the most pressing conservation needs for marine birds in the Northwest Atlantic, and develop actions to address them. We review the achievements of the AMBC, and highlight innovative ways the group has developed productive partnerships, shared ideas and information, and utilized working groups to develop action-oriented projects and associated funding.

Comparison of the Efficacy of Boat-based and Digital Aerial Surveys for Monitoring Sea Turtles

Iain Stenhouse[1], Andrew Gilbert[1], Evan Adams[1], Emily Connelly[1], Melissa Duron[1], Sarah Johnson[1], and Kate Williams[1]
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Sea turtles are of high conservation concern worldwide. Accurate counts and distribution data are critical for their appropriate conservation and management, including management of these populations in relation to planned offshore wind energy development. We conducted two years of boat-based surveys and high resolution digital video aerial surveys (2012-2014) on the mid-Atlantic Outer Continental Shelf (OCS), and compared the efficacy of these methods for surveying sea turtle populations. A total of 1,892 sea turtles from five species were observed in digital aerial surveys and 117 (2 species) from boat surveys. After correcting boat-based density estimates to account for detectability bias, both methods captured broad seasonal patterns of abundance in sea turtles on the mid-Atlantic OCS. However, estimates derived from digital aerial surveys had much higher precision and provided a more robust dataset from which to characterize these patterns.

The Ocean Ecosystem Indicators Monitoring Program for New York Bight

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The Ocean Ecosystem Indicators Monitoring Program for New York Bight is an interdisciplinary, multi-trophic level monitoring program in the New York Bight. It is a long-term monitoring program in offshore waters aimed to 1)

document the status and progress of ecosystem status in estuarine, coastal, and open-ocean environments, 2) understand and examine oceanographic drivers of living marine resources, 3) develop a system of indicators of ecosystem health, and 4) support forecasts of ocean ecosystem conditions.

Baseline Soundscape Characterization of Natural and Artificial Reefs to Monitor Ecological Effects of Offshore Wind Energy Development

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To understand the effects of installing offshore wind energy on marine communities, it is critical to document baseline ecological conditions of nearby habitats prior to development. This study documents the spatial and temporal patterns of biological sound production across four temperate reef habitats along the North Carolina OCS. We also evaluate whether natural and artificial reefs broadcast different soundscapes. Analysis of the patterns of sound pressure level (SPL) on hourly and seasonal scales suggest that each reef exhibited similar temporal patterns. However, multivariate analyses using the spectral dissimilarity index indicate that each reef has a distinct spectral composition, possibly due to unique community composition. Results of this study demonstrate the value of soundscape monitoring for comparing natural and artificial reefs and possibly detecting change in soundscapes that may come from installation of wind energy structures.

The Influence of Summer Storm Events on Black Sea Bass Movement and Activity in the Maryland Wind Energy Area

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As sedentary residents to shallow shelf waters, black sea bass are suggested as a model species for investigating offshore wind energy impacts on coastal fisheries. To better understand the responsiveness of black sea bass to impacts, we conducted a before-and-after gradient telemetry-based study in the Maryland Wind Energy Area. During June 2017-2018, 8-15 black sea bass were released with acoustic transponders at each of three reef sites, which were surrounded by data-logging receivers. Data were analyzed for activity levels, reef departures, and fluctuations in ambient noise and temperature. Periods of destratification were observed following storms events, with oscillations in bottom temperatures sometimes >10°C. Movement rates were depressed with each consecutive major storm, and late-season storms were associated with permanent evacuations. Because Mid-Atlantic Bight shelf waters will show storm-induced destratification events each summer and fall, wind energy construction impacts in this region must be considered against this source of natural disturbance.

Assessing Potential Impacts on Demersal Fish of Block Island Wind Farm Construction and Operation

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A demersal trawl survey is being conducted in the vicinity of the Block Island Wind Farm (BIWF) to provide resource agencies and stakeholders with site-specific information about potential impacts of BIWF construction and operation on fish and invertebrates in the area. The BIWF, the first offshore wind farm in the United States, has five wind turbine generators (WTGs) that were sited based on coordination with state and federal resource agencies. The BIWF trawl survey data will be used to examine potential impacts on fish in the area of potential effect (APE) and in two nearby reference areas with similar habitat characteristics, before, during, and after installation and operation of the WTGs. Demersal fisheries resources in the APE and two reference areas have been surveyed monthly for three baseline years and several 'during-construction' months. For select species of concern, such as Atlantic cod, red hake, silver hake, spotted hake, summer flounder, and winter flounder, dietary habits are assessed through stomach content analyses and overall conditions. Numerically dominant species were consistent for all baseline years and included butterfish, Atlantic herring, longfin squid, little skate, winter skate, and scup. Spatial

differences in fish communities reflect higher abundances in the eastern reference area and temporal differences among years are weak compared to spatial differences, indicating that fish habitat use was consistent throughout baseline sampling. Prey availability and consumption patterns were similar in the APE and reference areas for each species examined. These baseline dietary results can be used to examine potential changes to prey consumption among survey areas during and after wind farm construction.

The Offshore Wind Environmental Technical Working Group: A Regional Collaboration to Conduct Wildlife Research and Develop Conservation Guidance

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In 2018, New York State led the formation of a regionally focused, science-based collaboration to develop guidance and fill data gaps around the potential risks and impacts of offshore wind energy development to wildlife along the east coast of the United States (Massachusetts to North Carolina). The resulting standing working group structure takes a novel approach to informing and prioritizing topics for further research and conservation guidance, and New York has made a long-term commitment of technical expertise and administrative support for this effort. This structure includes three major components: (1) The Environmental Technical Working Group (E-TWG) includes representation from offshore wind developers, environmental non-governmental organizations (eNGOs), federal agencies, and state agencies from Massachusetts to Virginia. The group's scope includes development of wildlife best management practices, identification of research needs, and facilitation of regional coordination. (2) Specialist Committees with specific technical expertise are being formed to develop guidelines, recommendations, or other products to address issues that the E-TWG designates as priorities. (3) "State of the Science" workshops engage the broader stakeholder community. The inclusion of a wide range of stakeholders in this effort encourages the development of effective, economically viable approaches towards environmentally responsible development.

Seasonal Variability in Occurrence of Marine Animals in the New York Bight Using High-Resolution Aerial Imagery

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NYSERDA's ultra-high resolution aerial survey of the 12,000 square nautical mile New York State Offshore Planning Area (OPA) has collected images covering at least 7% of the OPA, providing data on birds, turtles, marine mammals, sharks, rays, and fish shoals. Data associated with images include location, size, direction of travel, and flight height (birds only). Surveys began in July 2016, and although >90% of images contained no biota, the first year of data recorded 55 bird, 13 shark, 8 dolphin, 5 whale, 4 sea turtle, 3 ray, and 3 seal species. Some species exhibited distinct spatial relationships associated with bathymetry or the Hudson River outflow while temporal relationships within and among seasons were evident with other species. Flight height data in combination with published bird collision and displacement sensitivity indices provides insight into susceptibility of select species to offshore wind, and this could help prioritize long-term monitoring efforts.

One Fish, Two Fish, Red Fish, Blue Fish: Nearshore Ocean Trawl Survey

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The nearshore ocean trawl survey is a ten-year survey that started in the fall of 2017. The survey collects abundance and biological data from adult and subadult finfish and macro invertebrates to better understand their distribution, relative abundances and life history. The survey samples New York's inshore waters seasonally to supplement data from other surveys. By sampling the entirety of New York's three-mile boundary during all seasons, we will be able to establish a baseline for managers to monitor local fisheries.