Synthesis of the Science

Interactions between Offshore Wind Development & Fisheries

Plenary Notes | DAY 1 | October 15, 2020

Developed by the Consensus Building Institute

Estimated Day 1 Attendance: ~358

I. Day 1 Summary

In the late afternoon of 14 October and for a full day on 15 October, as many as 358 participants engaged on-line in the first of three full days of Synthesis of the Science (SoS) on interactions between offshore wind development and fisheries. The first afternoon included keynote speakers from the SoS sponsors including the National Oceanic and Atmospheric Administration (NOAA), the Bureau of Oceans Energy Management (BOEM), and the Responsible Offshore Development Alliance (RODA). As well, Andrew Gill from the United Kingdom's Centre for Environment, Fisheries and Aquaculture Science provided a kick-off key note address.

For the full day on 15 October, the agenda was broken out into panel or speaker presentations, followed by questions and answers. Such Q&A was conducted verbally, via the Chat function in Zoom, and via an on-line tool called Mentimeter. The results of all such dialogue are captured below for the plenary discussions and additional written comments are captured in an appendix for all comments made in the Chat or Mentimeter. A glossary of acronyms is also included in an Appendix.

The substantive topics covered on this day included:

- Benthic habitat modification
- Physical habitat modification
- Physical process modification
- Finfish, shellfish, and community interactions

The day also included several breakout discussions. The first breakout topics included:

1. Benthic Habitat: Fisheries Approaches and Opportunities
2. Of Hammers and Hammerheads: Effects of EMF and Sound on Marine Life
3. Not to Mix It Up, But Let's Talk about the Cold Pool
4. Living in a New Material World: Assessing Changes with Presence of Structures
5. The Matter of Migration: HMS, Small Pelagics, Anadromous Fish, and Others Who Roam

The second breakout topics included:

1. Interim Report of ROSA's Monitoring Working Group
2. Getting Physical (Oceanography) with Fishermen: Incorporating Traditional Knowledge in Research
3. Case Study in Cumulative Stressors: Squid
4. From the Turbine to the Region: Scaling Up to Population Level Effects

The day is summarized below including appropriate links by major theme or agenda topic.

II. Welcome Keynotes

[Link to Recording]
Chris Oliver, NOAA Fisheries | Walter Cruickshank, BOEM

The Charge

- Interest in off-shore wind (OSW) has grown considerably in recent years in the United States due to technological advancements, falling costs, and aggressive state policies. It is essential to use the best available science and information to ensure OSW development advances in a responsible manner.
- Overall goal is to achieve coexistence of wind energy and fisheries. Collaboration is essential among wind developers, fishery managers, fishermen, fishery scientists, etc. to identify/avoid/mitigate impacts to fishery resources (including the associated fishing communities, protected resources, and marine habitats).

Federal Agency Roles & Responsibilities

- NOAA/NMFS: statutory regulatory oversight (compliant with MMPA, ESA, Magnuson-Stevens Act, CZMA, NEPA, etc.) and science/research support related to stewardship of marine life. NMFS' interests: maintain and maximize fishing opportunities while also supporting responsible resource development.
- DOI BOEM: manage development of energy and mineral resources, and ensure development is done in an environmentally and economically responsible manner.

NOAA/BOEM/RODA 10-year MOU (2019)

- One goal was to identify the most effective ways to bring fishing industry expertise and information into planning and development processes, and to develop a collaborative regional research and monitoring framework.
- Effective regional research and monitoring will improve understanding of the ecological, economic, and social impacts and ensure the best possible science and information are used to inform offshore energy development, planning, siting, permitting, and operations.

Synthesis of the Science (SOS) Workshop

- SOS workshop, a direct product of the MOU partnership, is designed to enhance understanding of existing science and data gaps related to interactions in offshore wind energy and fisheries and is essential for ensuring the successful coexistence of ocean industries on the outer continental shelf.
- SOS workshop and pending synthesis report offer a great opportunity to work together and help ensure that industry perspectives can be more effectively integrated into the planning and development process. This workshop is important to bring together diverse expertise and experience to identify, from a technical and scientific perspective, what we know, what we don't know, and what we need to know going forward.

III. Keynote: Offshore Wind Energy and Ecosystem Effects

[Link to Recording]
Andrew Gill, Centre for Environment, Fisheries and Aquaculture Science

Setting the Context for Analyzing OSW Development and Ecosystem Effects

- **Working together in hopes of seeking net gain**. We have an opportunity to achieve net gain with both industry and ecosystem benefits.
- **Ecosystems are in hierarchy with other systems**. Encouraging participants to adopt a "helicopter" approach – working together to explore the issues from different perspectives at different scales. This supports an iterative approach to learn and understand the ecosystem – for instance, zooming in to the "endosystem" to explore smaller scale components like effects of offshore wind, and zooming out to the "exosystem" to analyze how this ecosystem and its components interconnect with other systems like governance.
- **Definitions**. To apply this ecosystem perspective approach, it is important to categorize and analyze at different levels: phases of wind energy development like pre-construction, operations, and decommissioning; environmental effectors like physical presence of structures, pollution, EMF, etc.; environmental receptors like habitat, species, food chain, etc.; environmental effects defined as short/long-term, acute/chronic, single/multiple, etc.; and how effects may result in meaningful environmental impacts (i.e., cumulative and/or in-combination effects changing populations, communities, and/or biotic processes).
- **"So-what" and applying targeted questions and research**. Offshore wind is advancing rapidly – turbines are larger; there are several different turbine designs and foundations, etc. Need specific information that considers the location, timing, duration, size/area, characteristics, etc. of the wind energy facilities and the organisms that might be affected. Then "helicopter out" to understand the overall context of the system and consider what impacts are substantial enough to warrant management (often a societal discussion).
- **Intelligent monitoring (scale and baseline)**. Current status of assessing cumulative impacts – analytical procedures are fairly robust; temporal and baseline elements are generally still major unknowns; and very little information exists on understanding cumulative impacts. Need to address "DRIP" trend (Data-Rich, Information-Poor) and apply more strategic focus and ensure better scientific rigor for identifying the important variables that matter and gathering information needed to assess impacts (particularly for monitoring).
- **System will change**. Need to acknowledge the system is changing and will continue to change. Need to continue to monitor regional and ecosystem components in addition to other scales of effects, evaluate, and share information.

IV. Benthic Habitat Modification

[Link to Recording]
Panelists: Michelle Bachman, NEFMC | Drew Carey, Inspire Environmental | Steven Degraer, Royal Belgian Institute of Natural Sciences
Moderator: Brian Hooker, BOEM

General considerations

- By introducing various structures into the system, we are essentially creating intertidal habitat offshore and substantially changing the biology immediately surrounding each turbine. Important to understand these changes as they can cascade up through the food web and can change carbon flows in the system, connectivity of different organisms, habitat suitability, etc.
- Need to analyze how the presence of turbines (plus cables and other associated physical structures) and construction/operation of activity modify the environment, and how does the rest of the ecosystem respond.

- Need to prioritize our "known unknowns," which is a societal discussion – importance of the fisheries, energy development, protecting rare/vulnerable species, etc. – and create focused technical questions to guide more meaningful monitoring and research.
- While OSW is relatively new, fisheries have been grappling with several of these ecosystem dynamics for many years – opportunity to leverage that knowledge.

Bottom sediment modification

How OSW affects carbon flow into the system – first "helicopter zoom in" to understand the local scale (and "local" usually refers to an individual turbine and sometimes an individual wind project).

- ***What we know*** – Changes in particle size and flora/fauna – Primarily biofilters/suspension feeders colonizing on the piles that collect carbon from the water = creating a very localized food web (locally enrich the environment, provide food for benthic community, attracting predators, etc.)
- ***What we need to know*** – How that local food web links to the general system productivity (e.g., impacts to fisheries production). What is the fate of the carbon? What is the appropriate spatial scale?
    - Belgium site with 12+ years of monitoring carbon fate – have anecdotal evidence of organic enrichment expanding through the wind project (~250 meters away).
    - Carbon will be exported outside of the wind project via larger predators (many of which have commercial value).
- ***Other considerations:*** In southern New England and the Block Island Wind Farm (BIWF) project – turbines had a lattice jacket structure. In the future, monopiles (= less surface area for suspension feeders to colonize) will likely be more common.

Connectivity/habitat expansion

How placing these "islands" of intertidal habitat in the deeper water offshore environment affects the system. Creates potential habitat expansion for desirable and undesirable species.

- ***What we know*** – Intertidal species colonize offshore structures. Seeing species like mussels expanding their range to new areas via "island hopping."
- ***What we need to know*** – At what scale does this connectivity move from small-scale effects to large-scale effects? Previous research (primarily Europe) often studied turbines in relatively soft sediment; future wind farms along the Atlantic are expected to be in more hard substrate habitats. Therefore, we need to consider the expected soft bottom modification near the turbine as well as impacts to the other neighboring hard substrate habitats (and how organisms may respond to those habitat modifications).

Habitat suitability

- ***Background***: How species, particularly the commercial and recreation fishery species, may use the habitat – potential food source, spawning habitat, refuge, etc. that can be important to various life stages of fish.
- ***What we know*** – Documentation of species presence/absence and spatial/temporal resolution. Relying heavily on European examples (only one case study in US).
- ***What we need to know*** – How is it functioning at an ecosystem scale? Is the effect positive, negative, or functionally equivalent? Challenge to predict timing, scale, and consequence. Scale develops over multiple years (e.g., organic enrichment expanding beyond a single turbine to the entire wind project).

- ***Other Considerations***: Proposed wind project designs are expected to space turbines at least 1 nautical mile from each other; potentially reducing the direct accumulation of habitat observed at European projects that have closer turbine spacing.

Benthic Habitat | Q&A Session

- **Species composition shifts**. What have you seen (either in Europe or BIWF) related to any species composition shifts (particularly commercial or recreational fishery species), at local and broader scales?
    - European sites are often in softer sediment, so species that prefer hard substrates are attracted to the structures. Clam fisheries are prohibited in Belgium, so not much information is available from Europe. However, assume that clam species would likely benefit from the increased organic enrichment. One Belgium study found a large increase in cod species (recreational fishery species) and horse mackerel. (note: recreational fishing is not allowed in Belgium wind sites).
- **"Red flag" thresholds**. What is the threshold of change that we should be concerned about? At what point should we care and manage/mitigate the impacts?
    - Challenge is the thresholds have not been well defined yet.
    - If there are clear signals in the larger ecosystem that can be attributed to OSW, then it's a societal values discussion as to whether there is a concern that warrants intervention.
    - Potential thresholds could include:
        - Carbon enrichment becomes so high that it creates anoxic benthic environment
        - Introduction of nonnative species that have measurable negative effects
        - Negative impacts to species of concern (e.g., a depleted stock)
- **Beneficial materials**. Is there research that is exploring how we might use these structures (e.g., scouring protection) that would result in positive, desired impacts?
    - There is ongoing research exploring how community structure or biodiversity responds to different types of erosion protection layers and addition of alternative substrates (e.g., Denmark's "nature inclusive designs" - reef balls). Generally found lower epifaunal colonization on non-naturally occurring materials. Expect these findings will be ready in about 2-3 years.

V. Physical Habitat Modification

[Link to Recording]
Panelists: Andrew Gill, CEFAS | Zoe Hutchison, URI | Erica Staaterman, BOEM
Moderator: Brian Hooker, BOEM

Sound and vibration

Physical attributes

- ***Background:*** Sound waves involve creating areas of high and low pressure and tiny displacement of particles (despite the wave propagating away from the source, there is overall no net movement of particles.)
- ***What we know*** – particle motion diminishes rapidly from the source, while the pressure wave propagates further. Therefore, impulsive sounds (e.g., pile-driving) become less impulsive with distance. Some acoustic energy re-radiates out of sediment (Jurassic Park reference as T Rex's stomping causes rippling in a water glass). Bubble curtains are effective at reducing acoustic pressure.

- ***What we need to know*** – How rapidly particle motion diminishes from the source? How exactly impulsive sounds become non-impulsive? How much acoustic energy travels through substrate and re-radiates out. How well noise abatement technologies reduce particle motion or substrate vibration?

Biological implications

- ***Background:*** Fish and invertebrates with no air-filled cavity have a "narrow" hearing range and would detect only particle motion (most inverts, sharks/skates, sculpins, etc.). Conversely, those with specialized swim bladders (e.g., shad, anchovy, cod, etc.) have a wider range of hearing, and the "widest" hearing range have a bony connection between their swim bladder and ear and would detect pressure and participle motion (e.g., herring).
- ***What we know*** – Animals that detect particle motion may only be affected close to the source, whereas animals that detect pressure could be affected over greater distances. Operational noise is generally below "hearing thresholds," but need more data for many fish and inverts.
- ***What we need to know*** – Basic hearing thresholds of many species. How benthic and burrowing organisms are affected by substrate vibration from pile-driving or operations. Potential masking effects from vessel noise, operational noise, etc.

Electromagnetic fields

- ***Background***: Cables introduce EMFs (comprised of magnetic fields, electric fields, and induced electric fields) into the environment that interact with the natural EMF environment. Observed changes in behavior (e.g., foraging, exploring, sheltering, etc.) in organisms sensitive to EMFs and/or utilize natural EMFs to direct movement (e.g., skates electro-receptive).
- ***What we know*** – EMFs are generally modelled and less frequently measured (models generally performing well; empirical measurements detected an unexpected AC field that warrants further exploration). EMFs reduce with distance from source. EMFs are influenced by cable type, power transmission, and natural EMF environment. EMFs are spatial-temporally variable. There are no subsea cable EMF thresholds to adhere to.
- ***What we need to know*** – Better understand the influence of cable characteristics (type, materials, operations). Improve ability to predict EMFs (model validation). Better understand the temporal variability with longer data sets (daily and seasonal measurements) and spatial variability (changes along the cable length and distance from cable). Further explore cable EMF interaction with the natural EMF environment.

Thermal radiation

- ***Background:*** Operational cables potentially could be emitting heat, but not much evidence exists.
- ***What we know*** – No heat signature detected at the seabed during EMF sledging (Long Island site).
- ***What we need to know*** – What is the heat signature as cable power increases? Relevance to species. Spatial scale of heat emitted.

Physical Habitat | Q&A Session

- **Electric v. magnetic fields**. Is there a difference between electric fields and magnetic fields?
    - In reality, cables' EMF have both an electric and magnetic component, but it's helpful in aquarium studies to separate the two components when analyzing animals' response (magnetic-receptive vs. electro-receptive).

- **Impact priorities**. Which of these factors (sound, EMF, thermal) is more important, or perhaps which species are more affected by one than the other? What associated research supports those conclusions? Do we have information to help us focus our concerns?
    - For fish that detect pressure: Sound is the bigger concern. However, species that mainly detect particle motion may be more vulnerable to another variable (e.g., sharks more sensitive to magnetic cues). One challenge is that we don't always know which species are magneto-receptive or electro-receptive. There can also be crossover impacts. We also need to determine at what point there are meaningful impacts (e.g., permanent or multi-year changes in their distribution).
    - There are sound thresholds and mitigation measures for pile driving, but does that need to be studied further?
- **Impacts to squid and shellfish**. Where do squid, scallops, and clams fall on the hearing sensitivity spectrum?
    - Sensitive to particle motion only, which could be felt through the substrate.
- **Larval life stage impacts**. Have studies been conducted looking at sound pressure impacts from operational wind farms on larval stages of fish and shellfish.
    - Limited information exists, but generally can assume that the effect would be minimal. Belgium study on sea bass larvae didn't find substantial impacts. Research on seismic air gun impacts on fish eggs and fish larvae found little effect even at close distances. Also keep in mind that larvae mortality is naturally very high so sound impacts are unlikely to have a significant relative to the many other sources of mortality.
- **Burying cables**. Can we simply define a burial depth based on EMF that will not impact species?
    - Distance-from-source is the greater contributing factor for EMF impacts. Burying a cable doesn't necessarily dampen the EMF, and we don't know if reducing the EMF may bring it into an organism's perceivable EMF range. Previous research estimated you would have to bury the cable 11 meters underground to be undetectable by organisms. Additionally, burying cables may create a thermal overheating concern.
- **Block Island Wind Farm (BIWF) EMF studies**. What in situ measurements were done on the Block Island Wind Farm (BIWF) cable regarding EMF? What type of cable was used and burial depth?
    - Post-installation surveys looked at the export cable (had challenges measuring inter-array). The results from the BIWF EMF measurement will be released soon.

VI. Physical Process Modification

[Link to Recording]

Panelists: Hans Burchard, DHI | Josh Kohut, Rutgers | Ruth Perry, Mayflower | Ole Svenstrup Petersen, DHI

Moderator: Brian Hooker, BOEM

Horizontal flow and turbulence

- ***Background:*** Oceanographic processes (e.g., changes in temperature or salinity) can significantly impact ecological processes, as they influence the available nutrients that may directly or indirectly impact important fishery species of interest.

Horizontal flow and turbulence

- ***What we know*** – Average flows are reduced/disrupted immediately downstream of a turbine monopile foundation.

- ***What we need to know*** – How far do these impacts reach before flows return to ambient? How to distinguish from existing processes.

Vertical mixing and stratification

- ***What we know*** – Vertical mixing is increased, and stratification is decreased downstream of a wind turbine.
- ***What we need to know*** – What are the larger scale effects? Dependence on location, season, and wind project designs?

Mid-Atlantic Cold Pool

- ***What we know*** – Cold pool is a dynamic feature that is a critical habitat in the Mid-Atlantic. Modeling studies indicate that turbines can increase turbulent mixing and impact stratification.
- ***What we need to know*** – Turbine impacts specific to conditions seen throughout the annual cold pool cycle.

Scour and sedimentation

- Scouring in the sediment is generally a local impact, but the presence of the devices in the substrate could potentially change sediment transport.
- ***What we know*** – Associated with structure diameter, water depth, and sediment conditions, and meta-ocean conditions. Scouring impacts usually appear soon after installation and are generally stable (currents scour a hold and waves backfill).
- ***What we need to know*** – How scour protection impacts hydrodynamic changes caused by piles.

Ocean-atmospheric interactions (wind wake effects and marine wind)

- ***What we know*** – Highly variable based on ambient wind speed, direction, and degree of atmospheric stability.
- ***What we need to know*** – Regional wind-wake/hydrodynamic effects from the joint effect of multiple off-shore wind projects.

Physical Processes | Q&A Session

[Link: Zoom Chat | Full list of Mentimeter Questions (No applicable Zoom Chat questions/comments)]

- **Modeling validation**. Are there experimental studies in existence to validate the modeling?
    - Schultze et al. (2020) – direct measurements of turbine wake effect. Important to conduct data model-empirical measurement comparisons going forward.
- **Structural design**. The cross-sectional shape of pilings and columns is circular. If we change the cross-sectional shape to a more fusiform shape, would it reduce turbulence and scouring?
    - Plenty of research focused on this major engineering issue. There is a tradeoff between reducing drag and ensuring structure stability (as well as optimizing performance while minimizing cost). Scouring greater with cylindrical structures. Not many jacketed wind turbine arrays in Europe (jacketed more expensive, so seen more often in deeper waters).
- **Biological implications**. How do these processes relate to species biology and habitat? Is there a possibility that if you had enough OWF structures, you might affect the stratification and induce nutrient upwelling?
    - Very important to understand the physical processes of the ocean (e.g., temperature affects introduction of nutrients, affects euphotic zone, primary producers , etc.). Off

the northeast coast, the Atlantic waters have very dramatic seasonal changes, and the species have evolved to take advantage of those dynamics (e.g., refuge in the cold pool).

VII. Finfish, Squid, Shellfish and Community Interactions

[Link to Recording | Presentation Slides]
Panelists: Drew Carey, Inspire Environmental | Zoe Hutchison, URI | Cami McCandless, NOAA Fisheries | Dara Wilber, Inspire Environmental
Moderator: Elizabeth Methratta, NOAA Fisheries

Context and Charge

- Focused on "environmental receptors," which include a broad group – fisheries (fish, squid, and shellfish), associated users/consumers, etc.
- Important to remember there are other human activities besides OSW affecting fisheries. Moving forward using the best available data and information requires working together with the full community of users, local traditional knowledge, fisheries community, etc.
- The high variance in fisheries catch size (varies across months, years, location, etc.) presents a substantial challenge to identifying environmental effects.
- Purpose of this panel is to integrate what was discussed during the previous panels (benthic habitat, physical habitat, and physical processes) with fishery species of concern (finfish, squid, and shellfish) and the species that are important to those fishery species.
- Several variables to potentially explore to analyze species impacts (e.g., abundance, biomass, behavioral and physiological changes) and community interactions (e.g., predator-prey relationships and food web dynamics) that will help us "helicopter out" to understand ecosystem effects.
- Broad engagement and collaboration are crucial to ensure study design meets information needs, particularly to obtain regional data and support/funding.
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Demersal finfish and shellfish/other invertebrates

- ***What we know*** – State of our knowledge primarily stems from Block Island Wind Farm (BIWF) trawl survey and lobster trap survey, and European studies in the North Sea.
    - Preliminary BIWF findings: Community composition and abundance were similar to regional studies' trends. Observed artificial reef effect. Observed trophic changes (mussels appeared in fish diets shortly after BIWF installation). Lobster catches declined across the site and the region and the decline was greater at the site. Lots of Jonah crab and rock crab bycatch = good opportunity for gathering info on growing fisheries.
    - European studies: Observed changes in short-term, local effects to longer-term, regional effects; subtle changes in fishing activity for some species. We have lots of information on baseline movement, residence, and seasonal occurrence of species within wind farm areas; and EMF impacts to organisms based on field (non-offshore wind farms, OWF) and lab studies.
        - Difficult to apply to US because of multiple differences (e.g., variable OWF designs/operations/size; fishermen prohibited from fishing with OWF area; different community structures associated with different habitat).
    - Takeaway similarities b/w BIWF and European studies: Artificial reef effect is widespread (species dominance varies, even within ecoregions). Crustacean abundances increase near turbines. Organisms responded to noise (e.g., mussels - higher clearance rates; squid – alarm response; juvenile seabass – disrupted schooling behavior).

- ***What we need to know*** – EMF impacts (receptive species, particularly commercial species, and at different life stages). Noise impacts (construction-impulsive sound and operations-continuous sound). Invertebrates' responses to OWF construction and operation (that may cause distribution changes) and sound in general (particularly particle motion). Explore different cable protection designs that may provide additional shellfish habitat.

- ***Opportunities to integrate fishing communities' knowledge***: Incorporate self-reported fisheries data. Engage developers on outreach data collected by fisheries' representatives. Communicate with fishers to learn about perceived changes and potential underlying causes. Share and discuss information (e.g., preliminary monitoring results). Apply adaptive monitoring and data analysis based on fishermen's feedback. Work with OWF developers and fishermen to consider temporary closures during construction (observed lobster fisheries improving in UK example).

Pelagic Finfish

- ***Background:*** Limited information on OSW impacts to northeast pelagic species but can utilize related studies to infer potential effects (focused on sound production, EMFs, and artificial structures).

- ***What we know*** – Pile driving (impulsive sound) = high sound pressure levels, and fish with more advanced swim bladders (e.g., striped bass, butterfish, bluefish, and swordfish) may be more vulnerable. Conversely, Atlantic mackerel, tuna, and sharks may be less affected. Operations (continuous sound) will likely have varying effects across species (detection ability, attraction/deterrent response). EMFs induce behavioral responses in species sensitive to EMFs (benthic elasmobranchs, Chinook salmon, and European eel), but the animals adjusted fairly quickly (movement not restricted). Certain pelagic species detect changes in electric fields (e.g., shark species) for prey/predator detection; other species detect changes in magnetic fields for navigation (e.g., salmon, tuna, shark species). Highly migratory species (HMS) and other pelagic finfish species generally appear to be attracted to artificial structures (but may not apply to all species).

- ***What we need to know*** – Address data gaps for effects of OWF sound (construction/operation) and cables' EMFs; and direct/indirect effects of OWF on species (reproduction, distribution, migration, predator/prey dynamics, and abundance). Strongly recommend establishing pre-construction/operation baselines and conduct long-term monitoring during OWF operations.

- ***Opportunities to integrate fishing communities' knowledge***: Communicate throughout the process through various forums (surveys, working groups, etc.). Integrate fisheries' at-sea data collection efforts.

Finfish/Squid/Shellfish | Q&A Session

Question Prompts for Participants

- **What processes are of greatest concern to you and why?**
    - Changes to the thermocline, potential for upwelling to try to predict the impact on the ecosystem... will we get upwelling and BOOM or BUST, BOOM then BUST?
- **What species are of concern to you and why?**
    - The base of the food chain = phytoplankton. Friedland et. al. show that phyto and zooplankton abundance are important for describing abundance of higher trophic levels.

- **Are changes in community interactions at OWFs a concern?**
    - Yes. But it seems that changes to the ecosystem will drive what species occupy the area. Of import is historical species distribution and abundance. It will drive who benefits economically.
- **At what spatial and temporal scales should studies be conducted?** Why?
    - Spatial scales are most important at a regional level. Of course process level research is required at small scale, but the large impact is important as Andrew showed - take the blinders off.
- **How does the fishing community want to be engaged in research and monitoring projects?**
    - There are plenty of fishing boats on this coast with acoustics. Have those boats get involved in survey work.

Panel Q&A

- **Teasing out other variables**. How do you detect and distinguish OSW impacts from other variables such as climate change and natural variation?
    - Speaks to the importance for standardized monitoring – a sampling protocol that's compatible with regional studies to aggregate data from a larger spatial context and over a longer period of time.
    - Address DRIP issue – to detect longer term variability, need to compare longer term data sets with longer term baselines.
    - ROSA and partners are working on the standardized monitoring issue.
- **Monitoring temporal scale needs**. How many years of pre-construction and post-construction data are needed to identify meaningful effects?
    - For benthic organic enrichment – effect may be several years after construction. Therefore, the baseline should cover a longer time scale.
    - Beginning a baseline monitoring program is challenging as different OSW projects are in different phases of design/application/review/approval. Efforts by ROSA and others might conduct systemic surveys in broad areas to help build a baseline that could be applied to a variety of projects.
- **Acoustic lab vs. field studies.** Several comments received related to the acoustic studies conducted within the controlled lab environment. What are the limitations of both lab/aquarium studies and field studies?
    - Aquarium studies can be specially designed to characterize the sound components of interest to better understand certain specifics (sound pressure, particle motion, and vibrational sounds).
    - Challenging to detect organisms' response to sound in the environment. Various techniques could be used to complement each other and compensate for each design's limitations (e.g., telemetry with larger species to detect responses, mesocosm studies, etc.).
- **G&G Studies**. Do geological and geophysical (G&G) surveying efforts contaminate fisheries research? What separation distance is required between G&G and other activities (including active commercial fisheries)?
    - Not many studies exist related to offshore wind (shallower exploration compared to oil and gas G&G). White paper authors plan to review the existing literature to determine if there are applicable studies.
    - There is a desire for future baseline data collection to ensure reference areas are placed well outside of the G&G survey footprint.

- **Fishermen engagement**. Several questions and comments speak to the importance for involving and engaging fishermen in the data gathering process. For example, how might they provide their data while protecting proprietary data (e.g., coordinates)?
    - RODA has been working on the confidential information issue.
    - Example of fishermen engagement – BIWF study design was modified to address / ground-truth fishermen observations and interests.
- **Lessons learned from other industries**. What have we learned from gas and oil (particularly in the Gulf of Mexico) regarding potential offshore development impacts, and how might that information apply to the east coast?
    - Limited comparability - Gulf of Mexico ecosystem dramatically differs from the northeast, Atlantic. Many studies in Gulf and California on the effect of the structures on fish, but the OSW structure designs are different from the oil and gas structures.
- **BIWF Statistical significance**. What is the statistical power of the BIWF data collections and also given the project's relatively small size of 5 turbines? How can the sample size and methodology used at BIWF inform the studies being planned for larger developments?
    - We conducted power analyses when designing the survey methodologies to ensure statistical power. We detected statistically significant changes, not all of which could be attributed to the OWF (data analyses are still underway though).
    - We also invite feedback on what different stakeholders/agencies/industry defines as significant impacts.
- **BIWF: Changes in fish diets**. Were the species that weren't eating mussels prior to construction the same as those caught post-construction (when mussels appeared in fish diets)?
    - Changes occurred primarily with winter flounder – absent in their diet prior to construction, appeared in 1-2 flounder during construction, and substantially increased during operations.
- **BIWF: BSB diets.** Did you find lobsters in black sea bass (BSB) diets?
    - Fishers told us lobsters are a common prey item, but we didn't find any in the BSB diets, a variable added to the survey in Year 7. The sampling design (traps size) were not designed to capture the smaller size class of lobsters that BSB would be eating.
- **BIWF: Lobsters impacts**. What changes (if any) for lobsters were detected in the BIWF study?
    - We're still in QA/QC for final year, but currently have data for comparing two baseline years to two operational years. Observed lower lobster catches during operations in both near and far field locations but larger declines observed in the near field location. We also compared to sites in different states to explore temporal differences and observed comparable temporal variations.
- **BIWF: Other shellfish.** Did BIWF look at clams or scallops?
    - These shellfish are not a substantial fishery in that particular location. Thus, clams and scallops were not targeted by either a dredge or digital photography survey. However, scallops were collected in the trawl.
- **Squid impacts.** Can the effects of spawning failure *Loligo* squid due to noise be quantified? Any data from *Loligo vulgaris* fishery in the North Sea that can inform spawning failure on a short-lived terminal spawn due to noise.
    - Uncertain if the study exists or if it hasn't been analyzed yet.

VIII. Breakout Session 1

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2. Of Hammers and Hammerheads: Effects of EMF and Sound on Marine Life

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See Appendix C for Breakout Session summaries

IX. Breakout Session 2

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4. From the Turbine to the Region: Scaling Up to Population Level Effects

See Appendix C for Breakout Session summaries

Plenary Notes | DAY 1 | October 15, 2020
Appendix A: Full Mentimeter and Zoom Chat Entries

I. Benthic Habitat Modification

Mentimeter and Chat Questions and Responses

- Does the need for scour protection indicate an expected presence of wakes? The scour protection is emplaced to reduce the horseshoe vortex at the "wing-body" junction. If the velocity is great enough
- In one of your slides, it is insinuated that EM transmissions are going to aggregate a number of elasmobranch species, but have we studied displacement of commercially valuable species?
- Several studies that discuss the loss of phytoplankton as a result of biofouling by mussels specifically, affecting the very basis of the food web - most recently in 2018. https://arxiv.org/pdf/1709.
- What is being done in the US or in Europe to model and monitor this issue as it will directly affect food webs?
- Assumption we have made for cables is that if physical habitat (grain size and topography) is restored then infauna will recover – is that a good assumption?
- Thinking in terms of net gain, are there specific materials that are better for colonization than others for scour and the turbines themselves? (Natural material vs concrete.)
- In Europe, is fish abundance in wind farm areas greater than control areas outside of wind farms? Bottom line have wind farms produced more fin fish or less fin fish?
- Is the question: “What are the effects of changes?”, or rather “Do the changes matter?” or "Can they be detected?” If something “changes” is that inherently bad?
- How do we study the potential for the new habitat to drive a species shift compared to what is available for commercial harvest? Recreational + commercial - always with new structure?
- So far, the discussion has centered around species in the water column above the substrate. Is this an indication that adequate science does not exist for buried species like clams? EMF, vibrations, etc.
- Do we know the percentage of the Block Island wind farm footprint that has been colonized by mussel beds?
- Could the panelists speak to any research about augmenting the benthic habitat benefits of scour protection by using particular materials for different life stages and species?
- Are there any studies on structure effects to benthic habitat from GBS foundations? To date, there are no GBS foundations in the U.S. except perhaps for bridges or other structures.
- Though, we look at the changes that occurred at the BIWF, we need to consider the massive difference in scale and the very different species and uses when drawing any meaningful comparisons.
- How does the alkalinity impact these communities? E.g. will ocean acidification reduce the mollusk life cycle, do these species have a carbonate shell that may be threatened with CO2 in the ocean?
- Is there information about seasonality and likelihood of colonization by invasive? For example, should we be installing structure during certain times or taking biosecurity measures of some sort?
- For Steven--any evidence of localized hypoxia due to the enrichment near the turbines in Belgium?

- How do these connectivity studies of wind turbines and surrounding habitats compare to already existing oil and gas structures?
- Does anyone have estimates of how much bottom within the total farm footprint is occupied by scour protection, AND cables?
- We cannot assume that US sited foundations will all be 1 nm apart so all spatial scales should be considered by science.
- What is the effect size we are trying to measure? A change of 5%? 25%? Is there a standard we can agree on?
- Why are impacts of offshore wind given so much more scrutiny than offshore oil and gas?
- Should we let uncertainty about ecosystem level effects prevent the development of the first large offshore wind farm?
- With regards to habitat suitability and scour protection - How do we evaluate the potential for enhancing scour protection to be the most suitable for each respective environment?
- Clearly issues on the West Coast will differ (floating structures v fixed) - have studies been commissioned which study the differential impacts of the fixed v floating structures on habitat?
- If productivity is increased at turbines, does that mean they are trapping carbon? If so, is anyone modeling how much?
- Is there any threshold of change that you are looking at?
- The Windmills below the waterline are untreated? If so, is the reason to promote growth? Does this shorten the life of a windmill? What will happen to the habitats on/adjacent to the windmill in severe weather?
- Floating offshore wind in the Gulf of Maine will have different habitat issues to research. What information has been produced from the few projects in the water such as Hywind Scotland?
- Considering benthos, what is most sensitive to monitor as an indicator of change? Biological, chemical? Can this be automated to study this?
- What is being done to standardize monitoring of individual projects to be able to compare monitoring results?
- Would it be possible for panelists to draft quick responses to these great questions - maybe to be included as a separate document for the next workshop that is later in October?
- What is being done to assess potential ecosystem and halo effects (cumulative effects) that would occur once there is full build out?
- Climate change will happen at a separate time scale as development's impact, so we have to assume both changes. How will climate change impact these areas; species shifts, acidification, T_water, ...
- There are many studies on artificial hard substrates, are those being considered when looking at potential effects and study design?

Zoom Chat Questions/Comments

- No discussion during this section

II. Physical Habitat Modification

Mentimeter and Chat Questions and Responses

- Many sources have stated that there is no electric field from cables but only magnetic fields, is this scientific truth?
- What research is there regarding which of these factors (sound, EMF, thermal) is more important, or perhaps which species are more affected by one than another?
- Will bubble curtains be used for turbine foundation piling offshore the US?

- With a shock wave in air, there is a sharp pressure disturbance but also a change in the local temperature. For the impacts in the ocean, what will the corresponding rise in T be, impact on biota?
- Any reason to think that sound propagation through the substrate in the ocean is any different than through a water table on land (soils fully submerged in groundwater)?
- Very contradictory on what we do know and don't know. What we know diminishes rapidly. Don't know; do not know how rapid sound diminishes. What is it?"
- Erica's spectrum slide was very helpful. Where do squid, scallops, and clams fall on that spectrum of sensitivity?
- Should we redefine EMF to MF in relation to Wind and Fisheries? The term EMF always brings up a lot of heated discussion and confusion on the electric field.
- Have studies been conducted looking at sound pressure impacts from operational wind farms on larval stages of fish and shellfish?
- Dr. Hutchinson mentioned both AC and DC fields. What research is there regarding which is more likely to have an effect on different species?
- What limitations exist to measuring / monitoring the EMF from the export cables as they are mostly modeled?
- What assumptions go into the EMF modeling of the cables and are these valid in the current context? Are the models subject to numerical uncertainties and stability?
- How might EMF from undersea cables differentially impact animals, depending on the mechanism by which they detect magnetic fields (electromagnetic induction, magnetite-based, or radical-pairs)?
- In the diagram, which shows the distance travel of the EMF, what voltage capacity cable was used for this diagram?
- Can we simply define a burial depth based on EMF that will not impact species? Or should take the effort to study the impact on all species or groups of species?
- Do we know what species are most sensitive to EMF?
- Are there any studies you could refer me to that examines how EMF may affect migratory fish, such as salmon? Thank you!
- Don't the developers do detailed engineering studies of the heat emitted from the cables for faults, why not work with the engineers?
- How many cables now cross the Atlantic and what impact have they had and how is this different?
- Dr Kevin Scott from UK has studied EMF impacts on crab and lobsters for several years and states that they are attracted to EMF cable. Behavior changes obvious.
- How is uncertainty assigned to the EMF modeling studies?
- Can a group of experts develop a preliminary threshold at which cable shielding/burial should be increased?
- Most cables crossing the Atlantic are telecoms and fiber optics, is there anything that we can adopt from the work on these to power transmission cables?
- Can BOEM require EMF monitoring of the cables in permit conditions?
- We are learning more every day about how sensitive dispersive invertebrate larvae are to sound, particularly at settlement. Any ideas about impacts of sound or EMF on bivalve larval recruitment?
- What in situ measurements were done on the Block Island cable regarding EMF? What type of cable was used and burial depth?
- Are there non-pile driving methods for turbine installation? Why not just do that?

- Given that EMF varies by location, is it appropriate to apply data from one area (e.g. North Sea) to another area (e.g. Pacific Ocean) with on-site validation? Is this an appropriate way to streamline?
- Surface shear waves can escape bubble curtains. For sound propagation is there any focus on the benthic shear wave propagation, is this even useful to study? Can we list and rank all the issues?
- Have impacts to Marine Mammals and/or Sea Turtles been studied? Impacts to migratory patterns, feeding patterns, behavioral changes for example.
- Does the EMF fluctuate based on salinity levels such as upwelling / downwelling events and does it also fluctuate with temperature events? If so, are they narrow or wide fluctuations?
- Most of the sound info during pile driving is based on hammers of 2500kJ strength. Proposed monopiles (+10m diameter) and the current hammers that exceed 4500kJ is any data available on sound propagate
- Is it possible to completely insulate against EMF?
- How do we separate time scales in these studies? As Andrew said, there is chronic and instant potential impact? The instantaneous needs to have a probability of occurrence with sensitive species not.
- Can they make a Faraday Cage like structure for the cables to remove the EMF impacts?
- Has platform surface lighting emerged as an issue affecting visual specialists, diel behaviors, etc.?
- Do we learn anything from all of the Navy studies on sound impacts on mammals? How do the sound sources from Naval activity compare to Offshore Energy sources?
- Do we assess the natural crustal anomalies typically in rock/boulders and impacts due to EMF?
- Dr Kevin Scott UK study concludes that Crab/Lobster are attracted to EMF cable with behavior changes, dormant, not potting, feeding less and mating less. Juveniles deformed. Should have him present!

Zoom Chat Questions/Comments

- No notes

III. Physical Process Modification

Mentimeter and Chat Questions and Responses

- What experimental studies exist to validate the physical modeling of the flow in and near the wind farms?
- What is the wake of a vertical cylinder in a stratified environment? Where does this evidence come from? Citation? It is hard to find in the literature this basic building block to begin to model found
- Is there any empirical evidence of the wind-wake induced up-, downwelling dipoles predicted from theoretical work of e.g. Broström 2008 for thermally stratified waters?
- Which breakout session will deal with coastal upwelling rather than the cold pool?
- Fluid dynamics around vertical cylinders have been extensively studied in the aerospace engineering community in relation to boundary layer dynamics, have these been extended to density stratification?
- How do thermoclines affect flow?
- What studies have been done on the magnetic field/EMF impacts of cables on salmonid homing abilities (which is at least partially based on magnetic orientation to Earth's magnetic field)?

- Thanks Hans, gives me insight into many of the questions I have been raising for the past year and a half. Much work to be done. Glad to see you working on this.
- What effects of climate change have we seen on the cold pool?
- What experimental studies exist to validate the modeling efforts? What turbulence models are being used for these simulations are you doing LES and how do you parameterize the nearfield stratified wake?
- The cross-sectional shape of pilings and columns is circular. If we change the cross-sectional shape to a more fusiform shape; would it reduce turbulence and scouring?
- Could speakers discuss efforts to model this information to predict changes in primary productivity at the sea-scape level?
- Would be good to see linkages of these processes to actual species biology? Thinking about the excellent work done on Atlantic Mackerel and Butterfish to dynamically model habitat preferences
- Can the foundations collectively on a regional level break down the stratification to a level that there is significant nutrient upwelling? Does a nutrient pool exist at depth as a source if mixing?
- "Does spacing between the wind farms impact the wake effects?
- Have studies looked at how impacts may differ depending on foundation types? Seems like European models focused on pile foundations - what about jacket foundations?
- There are many questions, how do we rank the importance and establish a critical path on what should be funded and where progress is most effective for our tight time scales (development and climate)?
- Re the cold pool, it looks like most turbines will be inshore of the cold pool. How does that relative location effect the hydrodynamics of potential cold pool disruption?
- How far apart are the turbines in the Netherlands spaced to have that 10% loss in energy production?
- While there is a dominant current direction, you cannot make a fixed structure shape that is directional, it may make the scour much worse under specific conditions, so cylinders are best.
- If you use larger grain sizes, can the scour protection pad be smaller?
- Will all turbines have scour protection or is it only applied under certain conditions?

Zoom Chat Questions/Comments

- No relevant comments or questions

IV. Finfish, Squid, Shellfish and Community Interactions

Mentimeter and Chat Questions and Responses

- Does the displacement of effort out of wea offset any benefits "new" habitat may provide for lobster?
- How do we tease out the effects of climate change and effects of WE development? It's a concern that changes will be blamed on climate change only.
- Spatial scales are most important at a regional level. Of course process level research is required at small scale, but the large impact is important as Andrew showed - take the blinders off.
- Can the effects of a spawning failure for Loligo squid due to noise be quantified? Any data from loligo vulgaris fishery in north sea that can inform spawning failure on a short-lived terminal spawn
- If our regional monitoring surveys are at risk of becoming less accurate due to displacement from wind, how will we put site specific surveys in context or understand noise in the system?

- Yes, but it seems that changes to the ecosystem will drive what species occupy the area. Of import is historical species distribution and abundance. It will drive who benefits economically.
- How many years of "before" data are needed to make these studies effective?
- When the report is formulated, in the introduction, can we have an overview of all the pressures on fisheries rather than framing this just as Energy v. Fishing? What are all the relevant processes?
- What questions do wind developers need to answer about the ecosystem?
- If we don't have an adequate baseline, then what – what questions should we be focused on?
- Processes of greatest concern - changes to the thermocline, potential for upwelling to try to predict the impact on the ecosystem... will we get upwelling and BOOM or BUST, BOOM then BUST?
- Species of greatest concern - the base of the food chain = phytoplankton. Friedland et. al. show that abundance is described best by phyto/zooplankton abundance.
- Can the white paper include a description of the various science methods are to determine the changes - BACI, power analysis, and please include examples so we can explain to others
- Socio-economic- BIWF - recreational fishing increased - did this suppress lobstering activity or was fishing pressure equal pre-post construction for lobster?
- Does BOEM or NMFS have any intention to require (or encourage) developers to perform a standard type of monitoring so that a long-term regional dataset can be generated?
- Did I just hear here correctly we may not be permitted to fish in the wind turbine areas in the future?
- What is the duration of post-construction monitoring that is needed to effectively answer these questions?
- Are any of these surveys doable inside the windfarms? It sounds like there are a lot of surveys necessary. Can they actually be done?
- Shellfish was one of the topics in this section. Lobster seems to be the focus of studies completed at BI. Were studies done on clams or scallops?
- Can we definitively answer the question: do G&G surveying efforts contaminate fisheries research, what separation distance is required between G&G and other activities (including active commercial fishing)
- How can data generated by decades of impact analyses on offshore oil and gas infrastructure in the Gulf of Mexico be leveraged to understand similar processes in the US Atlantic wind energy areas?
- Please clarify that Black Sea Bass do not eat lobsters. I have seen numerous pictures from fishermen that gut BSB and there is nothing but lobsters in their bellies. Thank you.
- We need to keep in focus the time scales required to propose/fund/complete/report research contrasted with climate change and development schedules.
- Yesterday we heard that the RODEO study was complete, can we get a link to those results as they cannot be found on the BOEM website?
- As an observation, there are very major issues with the cited Nedwell (2007) study, particularly with respect to the relationship to fish. That work has fundamental errors (see. Hawkins & Popper)
- Are the sound studies conducted on small (2-6 MW) turbines applicable to 15-20 MW turbines?
- The white papers should provide extensive review and citation of literature for each section topic
- Loads of good references, can we please get a list of citations with some meta data to classify them into their relevance to each topic so we can quickly navigate the citation list?

- What are the physical limitations on the application of bubble curtains to reduce sound impacts from pile driving (i.e. depth, currents, etc.)?
- What effect size should we be trying to measure?
- How are variable ocean conditions considered in these studies?
- Are there concerns that we can determine are no longer concerns or are not priorities? For example, we've heard that species may no longer migrate through wind energy areas. Still something to study?
- Is the lack of lobsters in the BSB a result of climatic shift and the lobsters have moved to cooler waters?
- What results were a surprise to you?
- Fishers should also be engaged in sampling - they have the best knowledge and tools to sample. This is particularly so with clams. You will not sample clams adequately unless you use fishing gear
- How can we get trustworthy data from the actual catch records and an accurate location? Can we get buy-in from fishermen to enhance the data pool and give in situ observation of behavior?
- Are BACI studies the best way to monitor this?
- Not sure this is the proper section - where can we get more information on how important bottom relief is to ecosystems? How do we properly classify glacial moraines and APCs with geo-bio importance?
- Zoe mentioned data on behavioral responses to noise. Where are these studies done in the field or in the lab? Are there citations to the work?
- What is the statistical power of the BI data? Is it our understanding that changes due to wind would have to be catastrophic to attribute change due to the project due to sample sizes ?
- Do the antifouling chemicals applied to wind turbine foundations result in bioaccumulation of toxins among the various species that prey on mussels and other epifauna growing on the foundations?
- Dara - at BIWF - were the species caught that did not eat mussels in the baseline the same as the ones seen post construction that were feeding on mussels?
- Have any impacts to finfish and /or shellfish from floating structures been studied?
- the changes we have observed in the spatial distribution and extent of select species as a result of climatic shift is going to be challenging to address baseline and future impacts if any
- Dara, you indicate that there have been extensive studies on fish abundance and distribution changes in Europe. However--Lisa Methratta's work now a couple of years old found only 13 peer review pubs?
- Why has the ventless trap survey at BI in the last 3 years demonstrated an abundance drop-off around the 5 turbines compared to the other control sites?
- For those who worked on Shellfish aspects - there is a session at the upcoming National Shellfisheries Association Annual meeting on shellfish and wind farms. Call for abstracts now open!
- Are programs in place to link CVOW to BIWF for ecosystem research? It seems natural to work together particularly since CVOW is monopoly which is the dominant proposed foundation.
- Assumption we have made for cables is that if physical habitat (grain size and topography) is restored then infauna will recover and impacts to fisheries will be minimal – is that a good assumption?
- We just heard from Zoe Hutchison that we "need" to understand how all receptors are affected by all stressors - which is impossible. What is meant by "need"?

Zoom Chat Comments/Questions

- **CBI**: "Answer to Menti question on studies on noise effects: Stanley et al. 2020. Ontogenetic variation in the auditory sensitivity of black sea bass. (Centropristis striata) and the implications of anthropogenic sound on behavior and communication Jones, Stanley, Mooney, 2019. Marine Pollution Bulletin, Impulse pile driving noise elicits alarm responses in squid (Doryteuthis pealeii)."
- **CBI**: Tethys at https://tethys.pnnl.gov has a database literature that may be helpful. Its website says: "The core of Tethys is a Knowledge Base that draws together metadata, supporting reports, relevant papers, videos, and other material to provide a current state of knowledge of environmental effects."
- **CBI**: To the two studies cited in the chat on sound, a participant noted: "The problem with the fish work you cite on noise effects is that they were done in the lab and using ABR rather than actually testing hearing (ABR is not hearing - Jenni agrees with this statement, by the way). The acoustic environment of the lab tanks is vastly different than in the wild and so extrapolation from the lab tanks (no matter the size) to the field is highly questionable. There are also issues in the speaker used to reproduce the pile driving sounds for the squid since it does not produce the low frequencies in such sounds and probably does not capture the rapid onset of the signal. The studies you cite are good, but the only real solution will be good field studies.
- **CBI**: The dedicated RODEO site is not yet up. But, In the short-term the RODEO studies are here at: https://www.boem.gov/renewable-energy-research-completed-studies. You do have to hunt around a bit to find them.
- **Participant**: Decline due to climatic shift?
- **Participant**: A challenge will be to assess cumulative impacts given anticipated maximum build out of 1000s of OWTs. What is the ecological footprint of OTWs? Vertical structure will aggregate forage species and midwater predators. Scour material on the seafloor will concentrate reef species (like Black Sea bass). BSB will hunt further from actual reefs, and in the water column. Mid-water species will hunt on the seafloor. What are trophic implications for the local and regional food web (reciprocal OTW species and MAB fine-grain sediment species)? Integration of study projects will be required and should be planned a priori.
- **Speaker**: RE: the menti question regarding standardized monitoring- yes, we are working on that collaboratively through ROSA. We have a breakout at 4pm today with more info and are preparing a guidance document that will go out for broad review by the time we meet again on 10/30.
- **Participant**: Based on the effects of sound and vibrations that has been spoken about and the lack of small pelagics in the vicinity of the farms I am very concerned about herring, mackerel, menhaden and squid. Of course those are the fish we target in our fishery bout they are also major prey for others.
- **Participant**: Regarding number 5. There are plenty of fishing boats on this coast with acoustics. Have those boats get involved in survey work.
- **Speaker**: [Directed to previous commenter] Gratitude. Let's do it
- **Speaker**: Regarding the squid question, join us at 4pm for our breakout specifically on squid stressors.
- **NOAA**: There is at least one tank study pertaining to sound impacts on Doryteuthis pealeii. The species is most sensitive to frequencies of 100-300 Hz.
- **Participant**: One of the problems are the boats, is that there is reason to think that the sounds they make might have an impact on how fish (and perhaps squid) respond. Indeed, "quiet" boats seem to have an impact on catch even when the design was intended to stop that impact.
- **Speaker:** For some effects, we know they will happen e.g. organisms will colonise - we don't really need to keep collecting such info. What is important is the 'so what' question. So this

means 'What aspects of the change/effect do we think will have a meaningful effect (i.e. an impact), however we define this. Then we can look at the appropriate methods to collect the data to answer research questions that are targeted at the meaningful change we have defined. (as an example please refer to WIlding et al 2017 Turning of the DRIP publication https://www.researchgate.net/publication/314524540_Turning_off_the_DRIP_%27Data-rich_information-poor%27_-_rationalising_monitoring_with_a_focus_on_marine_renewable_energy_developments_and_the_benthos

Plenary Notes | DAY 1 | October 15, 2020
Appendix B: Acronyms Glossary

Acronym	Definition
BACI	Before After Control Impact study
BIWF	Block Island Wind Farm
BOEM	Bureau of Ocean Energy Management
CEA	Cumulative effects assessment
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CVOW	Coastal Virgina Offshore Wind Project\
CZMA	Coastal Zone Management Act
DOI	Department of Interior
EBM	Ecosystem-based management
EIA	Environmental Impact Analysis
EIS	Environmental Impact Statement
EM	Electronic monitoring
EMF	Electromagnetic fields
ESA	Endangered Species Act
FDD	Fishery dependent data
FID	Fishery independent data
FIR	Fishing industry representatives (UK terminology)
FLO	Fishery liason officer
FMC	Fishery management councils
FR	Fishery representative
G&G surveys	Geological and geophysical surveys
HMS	Highly migratory species
IEA	Integrated Ecosystem Assessment
LiDAR	Light detection and ranging (type of remote sensing)
MAB	Mid Atlantic Bight
MAFMC	Mid Atlantic Fisheries Management Council
MMPA	Marine Mammal Protection Act
MOU	Memorandum of understanding
NEAMAP	Northeast Area Monitoring and Assessment Program

NEFMC	New England Fishery Management Council
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OSW	Offshore wind
OWF	Offshore wind farm
PAM	Passive acoustic monitoring
PSP	Paralytic shellfish poisoning
QA/QC	Quality assurance/quality control
RODA	Responsible Offshore Development Alliance
ROSA	Responsible Offshore Science Alliance
RWSE	Regional Wildlife Science Entity
SLO	Social license to operate
SOE	State of the ecosystem (component of IEA)
SSB	Social Sciences Branch
VMS	Vessel monitoring system
VTR	Vessel trip reports
WEA	Wind energy areas

Plenary Notes | DAY 1 | October 15, 2020
Appendix C: Breakout Session Summaries

All breakout sessions were asked to answer the following three questions:

1. **Question 1:** What are the major gaps in our knowledge? What topics would benefit from additional or expanded research despite the studies that have been conducted, due to conflicting results, limitations of scope, or lack of integration with other topics?
2. **Question 2:** What are the perspectives of commercial and recreational fishing communities on this topic? (e.g., anticipated impacts or consequences, suggested research topics and approaches) How can the knowledge of the commercial and recreational fishing communities be gathered and included to address this topic?
3. **Question 3:** What are the recommendations for future directions/studies on this topic?

Benthic Habitat: Fisheries Approaches and Opportunities

Question 1

- Biggest unknowns: changes at scale; tidal & current changes, and how those physical changes will impact habitat. Need to determine what matters and then prioritize. This means asking specific questions to test hypotheses against. Monitoring plans must be part of this effort. The biggest challenge is simply not knowing what we don't know.
- Participants asked questions on scour protection, foundation type and materials; benthic habitat changes will be dependent on this. These details will be project specific and habitat varies across the region, therefore standardization of surveys may not always be applicable. Time scale also matters. Lessons can be learned from Europe, but adaptive monitoring needs to be implemented.

Question 2

- There will be some positive impacts from turbines; for recreational fishermen, structure increases will increase fish abundance in wind farms. It is yet unknown if the aggregation of species will just lead to more exploitation or if species abundance will also increase. Recommendation to learn from the habitat restoration community, including how larval settlement for some species prefer hard substrate (such as concrete mattresses or scour protection).

Question 3

- Need to look at many scales - project changes and regional changes. Also, prioritization and transparency/data sharing needs to improve to ensure we are conducting research efficiently and effectively. An integrative approach to monitoring could be helpful.

Additional resources

- https://www.wur.nl/en/show/Catalogue-launched-for-designing-nature-inclusive-offshore-wind-farms.htm

Of Hammers and Hammerheads: Effects of EMF and Sound on Marine Life

Question 1

- Biggest concerns: Understanding EMF impacts that will occur at the large scale of implementation in the U.S. - and out of a lab environment; EMF and cable burial on shellfish

beds; how does EMF propagate in the water column (i.e. for floating technology and floating cables) and how will this be modeled in 3D space; how much power will actually be emitted when cables are installed (unknown until after installation); how will EMF impact animals compass (to set a heading) and mapping (to assess position) abilities; how will thermoclines affect the distance sound travels;

Question 2

- There is a need for better understanding of where fish/animals actually are in the field, more acoustic tagging should be considered (perhaps supported by ROSA).
- Testing has not been at a full voltage load, so we need better information to understand what will happen.
- The fishing industry should be a collaborative partner in studies and monitoring efforts, including working with existing efforts through the NEFSC Cooperative Research Branch.

Question 3

- Research to determine how EMF impacts compass and mapping abilities of animals.
- Implications and access to new technology to minimize pile driving efforts should be looked into.
- Impacts for sound propagation and voltage transfer through the substrate, and more measurements on particle motion.

Additional Resources:

- https://espis.boem.gov/final%20reports/BOEM_2019-049.pdf
- https://www.boem.gov/sites/default/files/documents/renewable-energy/mapping-and-data/Electromagnetic-Fields-Marine-Life.pdf
- https://tethys.pnnl.gov/sites/default/files/publications/OES-Environmental-2020-State-of-the-Science-Ch-5_final_hr.pdf
- http://www.crosssoundcable.com/
- Popper, A. N., Hawkins, A. D. amd Thomsen, F. (2020). Trends in Ecology and Evolution. 35:787-794. https://doi.org/10.1016/j.tree.2020.05.002
- https://tethys.pnnl.gov/research-studies/marven-research-study-noise-vibrations-electromagnetic-emissions

Not to Mix It Up, But Let's Talk about the Cold Pool

Question 1

- Understanding of the Cold Pool has increased but there is a need to educate different communities of experts on its impacts on ecology and the physical characteristics of the region.
- Water column stratification exists everywhere and impacts from OSW are poorly understood. Warm water eddies and core rings can cause mixing, intrusions and can even impact fisheries.
- There is a lot of data available - IOOS systems and commercial industry - these baselines could be combined to improve our understanding of how they interact. Model inputs for stratification studies should be looked at.

- Flow studies should be done using the size of foundations to be used and current speeds in the Mid Atlantic Bight. Also need to look at what happens with an array and on a region wide scale, including impacts to the insulating effect of the Cold Pool.

Question 2

- There needs to be more trust in the expertise held by fishermen. This includes anecdotal and observational data.
- More opportunities are needed for collaboration and data collection because ocean models (often used for these studies) are only as good as the data that is put into them.

Question 3

- Developer surveys and monitoring should incorporate ocean conditions to ensure enough data is included.
- There are no required standards for oceanographic monitoring within each energy area, perhaps this could be addressed and improved.

Living in a New Material World: Assessing Changes with Presence of Structures

Question 1

- What will happen with more structure: aggregation or increased abundance of species that prefer structure? If distribution is changing, how will this affect management? What about changes to spawning, migration and larval dispersal behaviors?
- Concern that catches have been off, not just during construction phase.
- Are there optimal designs for scour protection that create preferred habitat? Can artificial structures facilitate migration? How does the pH of the material used change the potential benefits?
- How do impacts change with distance from a foundation?
- What tools are available? - remote operated non-fouling video devices, gliders, fishing echosounders, multibeam, divers, etc.

Question 2

- Understanding the relationship between increased structure, fish distribution, and species abundance is poor. It is important to know this to understand the biological relevance of the attraction that structure will provide.
- Floating structures and cables provide an additional level of unknown.

Question 3

- How can post-construction monitoring identify the best methods to answer these questions?
- What is the relationship between invasive species and structure? If there is biosecurity that can be done, how can that prevent the spread of invasive species?

Additional Resource

- Farmer, N.A., W.D. Heyman, M. Karnauskas, S. Kobara, T.I. Smart, J.C. Ballenger, M.J.M. Reichert, D.M. Wyanski, M.S. Tishler, K.C. Lindeman, S.K. Lowerre-Barbieri, T.S. Switzer, J.J. Solomon, K. McCain, M. Marhefka, and G.R. Sedberry. 2017. Timing and locations of reef fish spawning off the southeastern United States. PLOS ONE 12(3):e0172968. doi: 10.1371/journal.pone.0172968.

The Matter of Migration: HMS, Small Pelagics, Anadromous Fish, and Others Who Roam

Question 1

- The NE/MA regions have extreme seasonal dynamics and thermal environments; a year-round understanding must be pursued (trawl and seasonal surveys are limited in temporal sampling).

- Will wind farms in the Mid-A Bight disrupt flyways, increase residency, etc.? Will end points for migratory species be altered, be displaced from historic foraging grounds, aggregate in wind areas and not travel the full historic extent of their migration?
- How will aggregation of predatory species impact larval survival rates in areas where spawning historically has occurred? Will this change spawning behavior?
- Direct comparisons between areas, habitat and species is not always appropriate.
- What are the other biological and behavioral impacts from wind farms/turbines/cables on species tha migration (noise, predation, EMF, etc.)

Question 2

- What about the use of transducers on turbines to look at aggregations (similar to what is used in ICCAT fishery)?
- How will migration be disrupted by wind farms for species that migrate along island chains (Hawaiian islands in particular)? Fish aggregating devices are already pulling fish away from traditional areas.
- How does structure pull species into new environments, away from historic fisheries?

Question 3

- How can eDNA be a component of the monitoring in wind farms?
- How will wind-driven mixing, important for dynamics such as larval distribution, be impacted by wind farms?
- How will turbines affect predator prey interactions?
- Vessels with acoustic sensors should be used to monitor fish.

Interim Report from ROSA's Monitoring Working Group

Introduction on ROSA - partnership between fishing industry and offshore wind developers

- A Fisheries Monitoring Working Group was determined as a time-sensitive top priority and an interim group got together to draft a monitoring framework.
- Specifically, the guidance would establish proper monitoring objectives, sampling design, ensuring that the data collected is useful, sampling methods, analytical methods, applicability with other existing data/survey efforts. It does not address cumulative impacts, socioeconomic impacts, or data sharing.

Recommendations/comments/questions from participants

- There are no federal requirements to monitor wind farm impacts, and only some requirements from states. Data & research reduces uncertainty which will help the fishing industry and developers. But data collected must be relevant for both industries and have some consistency across projects/developers/etc.
- A series of different monitoring plans is challenging for fisheries experts, such as NMFS, and no guidance is challenging for developers. ROSA can help fill this grey space. Guidance was developed on a quick timeline, centered around defined questions and objectives, and attempted to develop a methodology that looks at project scale and how that may affect population level.
- Problem: there still is no regulatory requirement for monitoring. If guidelines were to become requirements in the future, they may be more generalized.
- The spatial and temporal scales of monitoring should also be considered. Impacts do not seem to be homogenous across a wind farm, or across the region. There also is a challenge in finding suitable control areas.

Additional Resources

- https://www.mass.gov/doc/management-objectives-and-research-priorities-for-offshore-wind-and-fisheries/download

- https://academic.oup.com/icesjms/article/77/3/890/5802590

Getting Physical (Oceanography) with Fishermen: Incorporating Traditional Knowledge in Research

Question 1

- Data is the bridge in the dialogue between traditional knowledge and scientific research. Building upon relationships and trust is also important. There is short term funding but need long term relationships to understand regional changes.
- There are challenges integrating qualitative and quantitative data.

Question 2

- Dialogue is vital, models will be based on the inputs and traditional knowledge must be part of that. Fishing industry knows what's going on out there and this must be valued.
- There are limitations to data sharing - fishing is a competitive industry. Ways to crowdsource data should be pursued. Having control over data and its use may be one way to increase confidence and trust, and must not be a one-way street or result in negative management consequences such as reduced quotas (benefits should accrue from synthesizing confidential data). There may be less sensitivity for purely oceanographic data that is collected.
- Without tapping into all knowledge available, including from the fishing industry, there will be missed opportunities.

Question 3

- Collecting physical data may be a starting point as it is a few steps removed from the regulatory world.
- There may be lessons to be learned from collaborative research with Native peoples.
- Incentive programs and use of vessels should be part of data collection.

Additional Resources

- https://scottishpelagic.co.uk/scientific-research/

Case Study in Cumulative Stressors: Squid

Question 1

- Spawning effects near wind farms, changes to predator-prey dynamics (and affects to spawning), effects of pile driving, and potential water chemistry changes
- Squid practice communal spawning with elaborate behavioral patterns, we do not know how/if that will be affected by wind farms. Embryos attach to hard substrate, avoiding silty low-oxygen areas; concern that mussels will move in and colonize foundation structures. Squid are also sensitive to sound.
- Our understanding of month-to-month and year-to-year drivers of squid productivity is still shaky.

Question 2

- Concern with water temp variations causing more "squid-nadoes", or potential cold pools produced by wind turbines could affect these species
- What about squid that come up from the deeper water to spawn? Data gaps on offshore wind farms also include the impacts on fisheries further offshore
- Areas surrounding wind turbines could form congregation areas preventing squid from migrating closer to shore.

Question 3

- Did not cover.

Additional Resources

- https://www.nature.com/articles/srep4589

- https://psl.noaa.gov/people/michael.alexander/hare.etal.plos-one.02-16.pdf
- https://www.cell.com/current-biology/fulltext/S0960-9822(16)30319-0

From the Turbine to the Region: Scaling Up to Population Level Effects

Question 1 & Question 2

- Research heavily skewed to small and moderate spatial scales. There is a need for some level of coordination of small scale monitoring (pre-, during, post-construction) to detect population level impacts. Right now, monitoring plans are developed at different times by different companies; if coordinated well, we may be able to use interventions and sequence of interventions to monitor regional impacts.
- We may be able to learn some things on regional cumulative impacts from Europe, but scope in northeast US is bigger than anything in Europe. Also oil and gas platforms do not seem to have stopped tuna migrations (which was feared during implementation).
- There is a need for a conceptual framework of population models, overlain with changes to the environment created by wind development.
- We need to think about which species and species groups are going to be more/less impacted than others. (risk assessment for vulnerable species)
- IEA is a good approach and trawl survey data can help support baseline data. Comments also made that the current statistical areas are too coarse to fully understand impacts on the scale of a wind farm footprint.
- Need for a dynamic view, seasonal and considering flow of energy and species across the region (not just a static approach).
- We need a mechanistic understanding of the impacts that are sensitive to OSW development vs climate.
- Data is lacking in the HMS recreational fishery. Reporting areas for recreational fisheries do not provide high enough spatial resolution. EFH model could be a good model for HMS.

Question 3

- Need pre-construction monitoring and baseline data >3 years in advance of construction. Interannual variability is important.
- Need to build frameworks for understanding impacts to population dynamics now. This will help inform what data we need to start collecting across all projects and the region.
- Create a fishermen's working group to review monitoring data as it comes in and include an annual monitoring plan with scientific review.