Response to RFI on Topic 2: Offshore Renewable Energy and Aquaculture Synergies
(RFI Questions in Black, and Responses in Blue)

This response was prepared by members of the MOCEAN Initiative. https://m-ocean.org
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Introductory Note about Response

Thank you for preparing such thoughtful questions on this important topic. The holistic view that you are advancing for the design and operation of marine energy installations co-located with aquaculture (and other ecosystem services) would lead to deployments that better serve existing ocean users and create new blue economy opportunities. This would also increase the acceptability of offshore wind farms and other marine energy projects to the ocean community and the public writ large.

This response was prepared by members of the MOCEAN Initiative who recently submitted a large proposal to the U.S. National Science Foundation's Regional Innovation Engines program. The title of the proposed project was "*Accelerating a Just Energy Transition While Nurturing Healthy Oceans and New Blue Economies Through Innovative Nature-Inclusive Offshore Wind Farms*". If successful, this would provide up to $160M of funding for a 10-year center on this topic. It was noteworthy to us how the questions in this RFI aligned with many of the ambitions of the proposed NSF center. The NSF proposal, workshop slides and recordings, and other information about the proposed center are available at https://m-ocean.org

The co-design and co-location of marine energy systems with aquaculture is a very timely consideration for energy system deployments in the U.S. given that a $100B investment is expected over the next 10 years to construct offshore wind farms, which will nearly all be located off of the east coast and will use fixed-bottom foundations. Fortunately, we can start with a knowledge base because much has been learned about this in Europe where more than €100M of R&D support from the European Union has been invested in creating co-located marine energy and aquaculture. MOCEAN has extensively engaged with European communities who are working in this space, so we bring some of what has been learned through their experience in our response to this RFI.

The 2022 Report by the Pacific Northwest National Laboratory on "Offshore Aquaculture a Market for Ocean Renewable Energy" (PNNL 2022) provides a summary of what was learned from some of these European projects, and it identifies challenges/opportunities for co-located Offshore Renewable Energy (ORE) and Aquaculture. Since the development of this report was funded by the DOE Water Power Technologies Office (WPTO), we will not repeat what the WPTO has learned through that initiative or in their 2019 publication "Powering the Blue Economy: Exploring Opportunities for Marine Renewable Energy in Maritime Markets" (WPTO, 2019). Instead, our responses will focus on sharing perspectives that we have heard via our engagement with the offshore wind energy industry, other ocean users, and research communities.

Category 1: Offshore Energy and Aquaculture Responses within this category can refer to both offshore wind and marine energy as relevant technologies.

1. For aquaculturists, how much energy is consumed during aquaculture operations? Please specify the type and size of aquaculture/aquaculture processes in your response.

Our response has nothing to add beyond what was nicely summarized in PNNL (2022), WPTO (2019), and their references.

2. For offshore energy developers, what factors and considerations play the largest role in developing technologies with a specific industry end-user (e.g., aquaculturist) in mind?

Even for offshore wind developers interested in co-located aquaculture, it is not possible to do this as part of the initial project design because it would not be properly and formally valued in the current state-run project selection processes for energy procurement. Currently, the lowest Levelized Cost of Energy (LCoE) drives the selection of offshore wind projects in the U.S. In addition, offshore wind developers would be reluctant to add permitting risk to an already complex permitting process, without specific incentive. For example, finfish aquaculture would pose a particular risk in this regard, due to potential water quality implications.

An effective way to motivate offshore wind developers to include the co-location of aquaculture is to formally and properly value this in the project bid review process. The Netherlands is taking this type of action by having up to 50% of the available merit points in the bid review of offshore wind proposal to be for the effect of the proposed offshore wind farm on the "Ecology"; see "Criteria ranking" at https://english.rvo.nl/information/offshore-wind-energy/hollandse-kust-west-wind-farm-zone

If not included in the initial project design, then there are two other opportunities for co-location of aquaculture with offshore wind. One is during the design and deployment process; because this will likely delay the operational date for the wind farm, it would require contract modifications that are in the best interests of both developers and states. The other opportunity is after completion of the wind farms.

The options for co-located offshore wind energy and aquaculture installations have been explored in several projects that were funded through the European Framework and Horizon programs. PNNL (2022) summarized some of what was learned from projects MERMAID, TROPOS, MUSES, MARIBE, and UNITED. Several other European projects in this area are still in progress including ULTFARMS, OLAMUR, PREP4BLUE, and The Blue Growth Farm. The MOCEAN team has had dialogue with members from some of these projects, and more detailed discussions are warranted to further assess factors and considerations that have the largest role in joint technology development, as well as identifying and quantifying all of the advantages and challenges to co-location and development.

While much can be learned from the European experience, their co-location challenges are much different than ours because commercial fishing is generally not permitted within offshore wind farms in the North Sea; this makes the co-location of aquaculture community more acceptable to fisheries. By contrast, fishing is likely to be permitted within U.S. wind farms, and it is unclear what level of exclusion for sanctuaries, co-located aquaculture, and areas with mooring lines for floating platforms will be acceptable to the commercial fishing community. MOCEAN has had some discussions with ocean planners in The Netherlands about how communities view the shared use of the ocean. They presented some of their more recent spacial-planning maps; their ocean use policies and maps from 2016-2021 can be found at https://www.government.nl/documents/policy-notes/2015/12/15/policy-document-on-the-north-sea-2016-2021

3. What research, data, or action is needed to ensure inclusivity in planning and implementing co-located aquaculture and energy projects, specifically to promote environmental justice and support underserved communities?

An effective means of making progress on this complicated, yet necessary, front is through community-engaged pilot projects that have partnerships between energy developers who are experienced and committed to such integrated projects, and underserved communities that have the expertise and support mechanisms in place to bring the needed parties to the table to plan and deliver these projects in the most equitable and justice-focused manner. An example of a suitable developer and community is now given to illustrate the commitment and preparedness needed for successful projects. The offshore wind developer Orsted is well experienced and committed to co-located aquaculture, as demonstrated in its pilot-level projects in the North Sea (see https://www.derijkenoordzee.nl/en/location/orsted). The New Bedford community in Massachusetts is well qualified and prepared to work with a developer on such an integrated pilot project because it includes federally qualified and state-selected Economic Development Administration (EDA) Zones (low-income) and it has a strong economic development entity (the New Bedford Ocean Cluster (NBOC)) in which "aquaculture", "commercial fishing and processing", "offshore renewables", and "innovation and technologies" are pillars of the NBOC vision as presented at https://newbedfordoceancluster.org/

Data collection, analysis, and reporting plans will be needed to provide agreed upon evidence for how to assess the value of co-located aquaculture and energy projects, and to generate interest and investment for larger-scale projects. This data will also be critical when coordinating with federal and state authorities in charge of permitting different aspects of these projects. There are many researchers and groups that have started to acquire and share the data and metadata that is needed to support such decision-making. Examples of well-structured and accessible data sources include the U.S. Northeast and Mid-Atlantic Ocean Data Portals https://www.northeastoceandata.org/, https://portal.midatlanticocean.org/ and the UK Marine Data Exchange https://www.marinedataexchange.co.uk/content/info/types-of-data (>200 Terabytes). The data collected in pilot projects should be incorporated within existing data initiatives where possible and shared with key stakeholders of historically marginalized communities. This community engaged/embedded approach will ensure that the processes to scale up the pilot projects are foregrounding the communities' voices, including their needs and concerns.

Achieving a just energy transition will require many multi-faceted initiatives through which best practices can be developed and used to guide and grow opportunities for underserved communities. There are several good examples and ideas for this purpose, and these will be presented and discussed at an online workshop on "*Building Clear Pathways to Opportunity for a Just Energy Transition*" that is being organized by MOCEAN. This workshop is being scheduled for between the last week of April and the first two weeks of May, and it will be announced on https://m-ocean.org

4. What types of resource characterization are necessary for the co-location of ocean energy systems to support aquaculture?

These characterizations include an assessment of historical species, potential invasive species, biomass levels for all types, seasonal and climate-related fish movements and migrations, fishing yields, changing ocean conditions due to global warming, energy installations, and other effects. New methods for chemical and biologic assessments are needed for this including the use of eDNA, acoustic and vision based monitoring, and other measurement technologies that are used by divers, mounted on remote-controlled or autonomous underwater vehicles, or fixed onto structures.

Category 2: Offshore Wind Responses within this category should focus on offshore wind, both fixed bottom and floating.

1. What research is needed to understand how co-located aquaculture and offshore wind can be scalable, sustainable, economically viable, and provide benefits both to offshore wind, aquaculturalists, and other affected communities? What specific research areas or data are still needed to properly assess the feasibility of integrating aquaculture and offshore wind projects, either current or future?

As described in PNNL (2022) and in response to Category 1 Question 2, there are several co-located projects in European waters to learn from, and likely several more to come given the European Union's mission in the ocean and implementation plan. See https://research-and-innovation.ec.europa.eu/system/files/2021-09/ocean_and_waters_implementation_plan_for_publication.pdf . The U.S. should learn from these existing and future projects, and identify areas where partnering can bring benefits to both Europe and the U.S. In order to consider the opportunities for co-located aquaculture, investment is needed to develop a deeper understanding of the beneficial functions of offshore wind structures such as artificial reefs and fisheries exclusion zones.

Thereby, an effective approach would be to research and learn intensely from previously conducted and ongoing projects. As this review work is ongoing, pilot projects such as described in response to Category 1 Question 3, should be planned and implemented.

2. Beyond co-location, how can innovative applications of aquaculture support offshore wind development? Examples of innovative applications include but are not limited to fisheries enhancement, carbon sequestration, nature inclusive designs, carbon negative protein, etc.

At present, there is significant resistance by fishing-related industries to the development of the U.S. offshore wind resource. See https://time.com/6102900/offshore-wind-fishing/ and https://www.newscentermaine.com/article/life/maine-lobstermen-rally-to-stop-offshore-wind-power/97-993b5ca9-4bf5-4e63-8c43-24a7eb9cfb90

Aquaculture co-location could play a major role in the acceptability of offshore wind development to existing users of the ocean and to the community at large, as can other activities that benefit the marine ecosystem and other industries as described in the papers below:

Klain, S., Satterfield, T., Chan, K., and Lindbergc, K., "Octopus's garden under the blade: Boosting biodiversity increases willingness to pay for offshore wind in the United States", Journal of Energy Research and Social Science Vol. 69, 2020, 12 pp. https://doi.org/10.1016/j.erss.2020.101744

Stelzenmuller, V., Letschert, J., Gimpel, A., Kraan, C., Probst, W., Degraer, S., and Coring, R., "From plate to plug: The impact of offshore renewables on European fisheries and the role of marine special planning, Renewable and Sustainable Energy Reviews, Vol. 158, 2022, 11 pp. https://doi.org/10.1016/j.rser.2022.112108

The following documents present innovative applications:

Turbine Reefs: Nature-Based Designs for Augmenting Offshore Wind Structures in the United States
https://www.inspireenvironmental.com/wp-content/uploads/2022/01/Turbine-Reef-Report-Nature-Based-Designs-Offshore-Wind-Structures-FINAL-2022.pdf

Nature-Inclusive Design: a catalogue for offshore wind infrastructure completed by Wageningen University for the Dutch The Ministry of Agriculture, Nature and Food Quality
https://edepot.wur.nl/518699

Eco-friendly design of scour protection:
https://www.researchgate.net/publication/315589657_Eco-friendly_design_of_scour_protection_potential_enhancement_of_ecological_functioning_in_offshore_wind_farms_Towards_an_implementation_guide_and_experimental_set-up
Prepared by Deltares and Wageningen University

There is growing recognition by offshore wind developers that the industry will not develop at scale unless it brings net positive benefits to marine ecology and those who rely on fishing and aquaculture for their livelihood. This is reflected in newly constituted mission statements from developers such as "Ørsted aims to deliver a net-positive biodiversity impact from all new renewable energy projects it commissions from 2030 at the latest". Evidence from deliberate nature inclusive design, and from general observations around installed structures https://www.pilotonline.com/news/environment/vp-nw-offshore-wind-marine-life-20211014-npdjx4qzl5d37eiclokeah7q3q-story.html illustrate the potential for providing such benefits to existing marine industries. Successful co-location of aquaculture with offshore wind would be a huge factor in the acceptability of large-scale development of the enormous U.S. offshore wind resource, and this is greatly needed to support the clean energy transition for coastal regions.

3. For each stage of offshore wind energy development projects (pre-construction, operation, and decommissioning), what specific aspects of aquaculture production and operations should be taken into consideration if planning for co-location with offshore wind? How could aquaculture support offshore wind energy development at each stage?

Only a short response is given to each of these so not to repeat what has already been presented.

Pre-Construction: Aquaculture could greatly support the acceptability of offshore wind by building broader coalitions and including critical voices from other marine users as noted in the response to the previous question, as well as the planned design life of wind farms; see response to decommissioning.

Operation: Aquaculture should be designed to take advantage of the lateral and vertical support provided by offshore wind energy structures and the power generation provided by offshore wind that is supplemented with needed energy storage capacity or other forms of clean energy generation. This will enable opportunities for aquaculture that are further from shore than most current installations. Aquaculture activities should also be incorporated into O&M plans for the wind energy structures to reduce the total number of vessel miles traveled.

Decommissioning: If the underwater infrastructure for offshore wind farms is designed to provide benefits to the aquaculture and other fishery-related industries, then there will be an incentive to design this infrastructure for much longer design lives and to view these as Turbine Reefs (see referenced publication from Inspire Environmental and The Nature Conservancy) that are not decommissioned; this is more responsible thinking and aligned with indigenous values. This would dramatically change infrastructure design objectives and selected technologies. For example, concrete gravity base structures would likely be preferred over steel monopiles or jackets because they can more reliably designed for much longer design lives (a century or more) or to future-proof the farm for larger turbines with only modest increases in cost. See https://dl.tufts.edu/concern/pdfs/pk02cr377

4. What are the biggest challenges or concerns to offshore wind energy developers around the inclusion or integration of aquaculture into a project design? What is needed to overcome these challenges?

There are at least three significant challenges to valuing this inclusion or integration.

(i) To value the environmental effects and co-located economic activity in the project selection process as demonstrated by The Netherlands and described in response to Category 1 Question 2 in which up to 50% of the available merit points for project selection are related to the effect on the Ecology. Further efforts are needed to fully quantify such benefits and engage the aquaculture community so that U.S. states and the public can support moving beyond the simplified lowest "sticker price" when selecting projects. Further efforts are needed to bring offshore wind developers, the fisheries, and the aquaculture communities into discussion. The activities of the Responsible Offshore Science Alliance (see https://www.rosascience.org/) and the Regional Wildlife Science Collaborative (see https://rwsc.org/) both strive to do this, and these initiatives should be more strongly supported and informed by data collection initiatives.

(ii) Inclusion would add to the permitting requirements to projects that are generally on very tight schedules. For permitting especially, this would need a holistic approach including stakeholders at both the federal, state, and local levels. Even though the turbines for offshore wind farms are generally in federal waters there is cable infrastructure that extends into state waters and any additional focus on co-location and environmental effects needs to look at the whole picture.

(iii) Another significant challenge is that advancements are needed in marine science and engineering to understand the impact of design decisions (material, geometries, coatings, etc.) on marine growth and habitat development. This knowledge is needed to establish new best practices in design and operation, and it will be dependent on the specific location of the installations in which bathymetry, temperature profiles, benthic conditions, chemistries, and ecologies all vary. Advancement on these fronts is critical for broader conservation efforts, and not just for the co-location of aquaculture and marine energy.

5. What partnerships would be necessary for a successful research or commercial offshore wind project to include aquaculture? How can these partnerships be structured to maximize the likelihood that aquaculturists, offshore wind energy developers, and other interested parties participate in studies? How can we structure such partnerships to create conditions to maximize trust and willingness to share data related to these studies?

The rich North Sea Initiative https://www.derijkenoordzee.nl/en provides several examples for the types of partnerships needed for offshore wind to serve aquaculture, marine energy, and other blue economy industries. Please also see the response to Category 1 Question 3 as to how the New Bedford Ocean Cluster was established to bridge the gap between developers and the aquaculture and fishing industries. https://newbedfordoceancluster.org/
New Bedford MA is particularly well positioned to develop effective mechanisms because it is the largest U.S. fishing port by value, and it is also an innovation hub for offshore wind energy.

6. What research, collaboration, or coordination is needed to understand environmental, social, and economic impacts for applications of aquaculture supporting offshore wind development?

Previous questions spoke to the importance of an integrated approach, and the role of data. We remarked in early responses on the importance of learning from previously conducted and ongoing projects (most which are in Europe), and to engaging with local communities, offshore wind developers with an interest and commitment to co-location, and to regions like New Bedford that have strong support mechanisms, have engaged the offshore wind, aquaculture, and fishing communities, and who have a vision for effective co-location and shared-use.

Other collaborations and coordination are needed with: the federal Bureau of Ocean and Energy Management; the Bureau of Safety and Environment Enforcement; state and local coastal zone management, permitting, and regulatory bodies; and state energy departments set the review criteria for RFPs, and select projects. It will also be important to engage the engineering and technology supply chain including bluetech innovators, venture capitalists, and others with resources or expertise to contribute to finding solutions. As previously mentioned, there are several existing organizations such as ROSA, RWSC, and others, who have already brought some of the needed entities together, so there is much to build upon.

As for research, we need to continue to work towards a better understanding of the multitude of different marine ecosystems that stretch along and outward from our coastlines, and how they are impacted by: the changing climate; fishing and aquaculture practices; the geometry, materials, textures, and coatings on offshore wind structures (foundations, scour protection, electrical lines); the installation, operational, and decommissioning/reuse processes for these structures; threats by invasive species; and others. Research and product development is needed to create the new types of sensors and engineering technologies required for advancing the breadth of science and engineering issues for this. A full description of what is needed is beyond what has been determined or could be provided in response to this RFI. The research needs would be best assessed through projects that bring key contributors and stakeholders together to define practical needs and opportunities. Projects like the EU's PREP4BLUE are important for the development of work plans and investment strategies.

On the matter of economics, a more holistic approach is needed for how costs and value is determined and considered. As mentioned earlier, the current selection of offshore wind projects is usually awarded to the lowest bidder (Levelized Cost of Energy, LCoE, or sticker price) for a wind farm that is designed to have an operational life of 25-30 years. If this continues to be the approach for project selection and design life, then we will miss many opportunities and not live up to our responsibilities. We believe that the studies and reports funded by the WPTO and the broader DOE, as well as this RFI reflect a similar view. To move beyond LCoE, we need to be able to quantify/consider the value of local employment; contributions to addressing inequities; healthy and resilient oceans; co-located aquaculture; marine biodiversity and biomass; healthy and new fishing practices; the effect on endangered species; the broader and new blue economy; public health; and other effects. The book "*Preparing a Workforce for the New Blue Economy: People, Products and Policies*" by Hotaling and Spinrad addresses many of these matters and provides a vision for healthy oceans and prosperity through a new blue economy.

The social view of the value and impact of offshore wind farms is critical to meeting the nations carbon reduction goals because there are no other sources of such large, affordable, and deliverable energy for many coastal regions. The nation's offshore wind resource is enormous, it is very affordable, and its negative effects are modest and mostly addressable. As noted by Klain et al. (2020), communities are more accepting of offshore wind farm development when it brings ecological benefits, and when they have a role in the decision-making progress. With only 7 turbines in US waters, but more than a hundred expected to be installed in the next few years, projects should be initiated to better understand how society views the value and impact of marine energy systems and offshore wind specifically. There can and should often be done in conjunction with the buildout of a large commercial farm. Without the support of marine community and society writ large, there may be only limited development of the offshore wind resource, and it will be much more difficult for the nation to meet its climate goals.

Category 3: Marine Energy Responses within this category should focus on marine energy technologies.

7. For aquaculturists, what factors and considerations typically play the largest role in making energy decisions for aquaculture operations? What specific factors would convince you to switch to alternate or renewable energy sources, like marine energy? How much energy is consumed during aquaculture operations? Please specify the type and size of aquaculture/aquaculture processes in your response.

Our response has nothing to add beyond what was nicely summarized in PNNL (2022), WPTO (2019), and their references.

8. What are the near-term opportunities to power smaller loads for aquaculture with marine energy? This could include environmental monitoring, data collection, or offsetting small power loads.

Our response has nothing to add beyond what was nicely summarized in PNNL (2022), WPTO (2019), and their references.

9. For each stage of aquaculture project development (e.g., siting, environmental assessment, permitting, installation, operation, monitoring), when should co-location of marine energy be considered? Does this change if the project is nearshore or offshore?

It should be considered as early as possible. See response to Category 1 Question 2.

10. What partnerships would be necessary for a successful research or development marine energy project to include aquaculture? How can these partnerships be structured to maximize the likelihood that aquaculturists, marine energy developers, and other interested parties participate in studies?

See response to Category 3 Question 5.

11. What are the biggest challenges or concerns for the development of the co-location of marine energy with aquaculture? What support or information do aquaculturists need to overcome these challenges and/or make informed decisions? Please specify the type of aquaculture you are referring to in your response.

The needed support include engagement of aquaculturists within the offshore wind communities such as ROSA and RWSC, and through co-located pilot projects as are being conducted in Europe. Similarly, marine energy developers need to become further engaged with aquaculture communities.