Environmental Studies Program: Studies Development Plan | FY 2024–2025

Field	Study Information
Title	Ocean Environmental Monitoring and Sound Propagation Study at Mid-Atlantic Shelfbreak Offshore Wind Area
Administered by	Office of Renewable Energy Programs
BOEM Contact(s)	Shane Guan (shane.guan@boem.gov), Mary Boatman (mary.boatman@boem.gov), Tom Kilpatrick (Thomas.kilpatrick@boem.gov)
Procurement Type(s)	Cooperative Agreement (Competitive)
Performance Period	FY 2024–2028
Final Report Due	TBD
Date Revised	February 8, 2023
Problem	Environmental assessments on offshore renewable energy development require accurate modeling and effective monitoring. Neither traditional sound propagation modeling nor existing acoustic monitoring address broader issues such as ecological dynamics and oceanographic processes related to offshore wind development.
Intervention	Undertake comprehensive analyses incorporating real-time physical oceanographic variables into active and passive acoustic datasets collected *in situ*, in addition to on site propagation measurements.
Comparison	The proposed study will deploy active and passive acoustic sensors in the vicinity of the National Science Foundation's Pioneer Array ocean observation platform to collect active and passive acoustic datasets and to conduct sound propagation measurements.
Outcome	Improve understanding of the sub-mesoscale and mesoscale oceanographic processes and changes in relation to offshore wind planning and development at the mid-Atlantic shelfbreak region. Validate regional sound propagation models.
Context	Atlantic seaboard offshore wind development area.

BOEM Information Need(s): To manage development of the U.S. Outer Continental Shelf (OCS) energy and mineral resources in an environmentally responsible way requires the Bureau of Ocean Energy Management (BOEM) to have the best scientific information to conduct accurate modeling and effective monitoring for environmental impact assessment. However, due to the large spatial and temporal scales of the affected area and the ever-changing environment, comprehensive impact assessments that address long-term ecosystem level effects can be extremely challenging. Traditional sound propagation modeling for noise effect analysis often uses historical environmental variables that may not reflect oceanographic regime shifts due to climate change, which could result in less accurate predictions of impact zones. Additionally, most existing acoustic monitoring only evaluates species calls and signal/noise characteristics collected at the recording sites without incorporating oceanographic variables. This makes it challenging to address broader issues such as ecological dynamics and

oceanographic processes related to offshore wind planning and development (e.g., Bergström et al. 2014).

Background: The National Science Foundation (NSF) funds and maintains a coastal ocean observation system called Pioneer Array through its Ocean Observatories Initiative (OOI; Gawarkiewicz et al. 2018; Gawarkiewicz and Plueddemann 2020). Currently deployed at the edge of the continental shelf south of New England, the Pioneer Array is designed to study shelfbreak processes and shelf-deep ocean exchange. As the primary scientific objectives of the Pioneer Array are to study shelfbreak exchange processes, instruments currently equipped to the Array are designed to measure physical and chemical oceanographic and meteorological parameters.

In 2024, NSF plans to relocate the Pioneer Array to the mid-Atlantic shelfbreak between Virginia and North Carolina. The proposed new location is in proximity (~20 km) of the planned Kitty Hawk Wind Farm and CVOW, and also an important migratory corridor for the North Atlantic right whales (NARW; Salisbury et al. 2015). The timing of the Pioneer Array relocation will likely allow for 6-12 months of baseline monitoring in 2024 before wind farm construction begins. NSF has indicated that it would provide a good opportunity to deploy acoustic sensors along with the Pioneer Array to address potential environmental effects from offshore wind development in the area.

Specifically, this study will deploy and collect time series data from bottom-mounted and/or moored active and passive acoustic recorders at the Pioneer Array location for long-term environmental monitoring. Limited acoustic datasets will be transmitted via Pioneer Array's satellite telemetry system real-time and made available for the public. In addition, low-intensity (<160 dB re 1 µPa) low-frequency (<2 kHz) source (e.g., Lubell) will be deployed on the Array and be used intermittently to study propagation conditions at the mid-Atlantic shelfbreak region.

In addition, real-time passive acoustic data will be used to alert on the potential occurrence of unusual oceanographic events so that appropriate actions can be taken to investigate them (e.g., changes in soundscape characteristics due to increased mixing). These detections can also be used to inform regulators on the presence of endangered species (e.g., NARW) for mitigation measures. Detailed long-term acoustic time series in combination with propagation measurements have been successfully used to study ocean climate changes (Munk et al. 1995; Worcester et al. 2005) and to investigate sub-mesoscale and mesoscale oceanographic processes such as stratification and circulation in the Arctic (e.g., Sagen et al. 2017; review by Worcester et al. 2020; Worcester and Ballard 2021). Similar approaches can be applied to gain understanding on the dynamics of the Gulf Stream as it is undergoing some remarkable changes in the past decade or so (Seidov et al. 2019; Boers 2021). Some of the oceanographic changes are suspected to cause adverse consequences in the ontogeny, migration, and distribution of several ecologically and commercially important species (e.g., Fuchs et al. 2020). The results of the proposed study will shed light on the linkage between the oceanographic processes and ecosystem dynamics in relation to offshore wind development at the mid-Atlantic shelfbreak.

Additionally, dedicated sound propagation study using low-intensity low-frequency active source(s) and built-in transponders on the Pioneer Array will provide validations to existing propagation models such as those established by RODEO (Lin et al. 2017). Results from the propagation study along with newly collected oceanographic parameters will also serve as references for future models by BOEM's Center for Marine Acoustics for impact prediction.

Finally, active and passive datasets from this study will be fed into BOEM's broader Atlantic regional PAM network to investigate diurnal, seasonal, and annual occurrence and abundance of planktons, fishes, and marine mammals near offshore wind farm areas. The results will be used to provide critical information to BOEM regarding the potential long-term environmental effects from offshore wind development.

Objectives: The proposed study will achieve the following objectives.

- Gain knowledge on the ecosystem dynamics and sub-mesoscale and mesoscale oceanographic processes from acoustic observations by incorporating physical and chemical variabilities collected at the study site for offshore wind development impact modeling and assessment.
- Gain knowledge on general sound propagation conditions in the study area; and provide validation and references to existing propagation models and future modeling efforts, respectively.
- Gain knowledge on the presence, distribution, and potential changes in habitat use of planktons, fishes, and marine mammals, as well as the dynamics of marine soundscape (geophony, biophony, and anthrophony) in relation to offshore wind development at the Kitty Hawk and CVOW sites for impact assessment.

Methods: The proposed study would deploy active and passive acoustic arrays in the vicinity of the NSF's OOI Pioneer Array ocean observing system to conduct long-term environmental monitoring. Acoustic time series data collected will be used to investigate the presence and distribution of marine organism over the monitoring period. The temporal species occurrence will be studied along with oceanographic variables to understand the ecosystem variations at the study area. The proposed study would also deploy low-intensity active acoustic sensor(s) in the area to conduct acoustic propagation study. Acoustic datasets will be analyzed in conjunction with physical oceanographic variables collect in situ to gain understanding of sub-mesoscale and mesoscale oceanographic processes at the mid-Atlantic shelfbreak offshore wind development area.

Specific Research Question(s): The specific research questions are listed below.

1. What are the variations of the oceanographic processes such as stratification, mixing, circulation, and temperature variation in the study area derived from acoustic datasets and sound propagation measurements conducted over the study period?
2. What are the soundscape characteristics and dynamics at the study area, and how do the changes in soundscape and marine life presence, abundance, distribution, and/or habitat use relate to oceanographic parameters over the monitoring period?
3. What are the general sound propagation conditions in the study area and how do the measurements differ from existing model?
4. Are sounds produced during the construction or operations phase of the two nearby windfarms detectable on the Pioneer array? If so, what are the SNR in terms of ambient noise level and oceanographic conditions?
5. Are there any changes in plankton, fish, and marine mammal presence, distribution, and/or habitat use associated with offshore wind development in the shelfbreak region of the mid-Atlantic area as derived from active and passive acoustic datasets?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: OOI Pioneer Array: https://oceanobservatories.org/array/coastal-pioneer-array/

References:

Bergström L, Kautsky L, Malm T, Rosenberg R, Wahlberg M, Capetillo NÅ, Wilhelmsson D. 2014. Effects of offshore wind farms on marine wildlife – A generalized impact assessment. Environ. Res. 9, 034012.

Fuchs HL, Chant RJ, Hunter EJ, Curchitser EN, Gerbi GP, Chen EY. 2020. Wrong-way migrations of benthic species driven by ocean warming and larval transport, Nature Climate Change. 10:1052–1056.

Gawarkiewicz G, Plueddemann AJ. 2020. Scientific rationale and conceptual design of a process-oriented shelfbreak observatory: The OOI Pioneer Array. Journal of Operational Oceanography. 13:19–36. doi:10.1080/1755876X.2019.1679609.

Gawarkiewicz G, Todd RE, Zhang W, Partida J, Gangopadhyay A, Monim M-U-H, Fratantoni P, Mercer AM, Dent M. 2018. The changing nature of shelf-break exchange revealed by the OOI Pioneer Array. Oceanography. 31(1):60–70.

Lin Y-T, Newhall AE, Miller JH, Potty GR, Vigness-Raposa KJ. 2019. A three-dimensional underwater sound propagation model for offshore wind farm noise prediction. JASA Express Letters. 145:EL335–EL340. doi:10.1121/1.5099560.

Munk WH, Worcester PF, Wunsch C. 1995. Ocean Acoustic Tomography. Cambridge University Press, Cambridge, UK.

Sagen H, Worcester PF, Dzieciuch MA, Geyer F, Sandven S, Babiker M, Beszczynska-Möller A, Dushaw BD, Cornuelle B. 2017. Resolution, identification, and stability of broadband acoustic arrivals in Fram Strait. The Journal of the Acoustical Society of America. 141, 2055–2068. doi:10.1121/1.4978780.

Salisbury DP, Clark CW, Rice AN. 2016. Right whale occurrence in the coastal waters of Virginia, U.S.A.: Endangered species presence in a rapidly developing energy market. Marine Mammal Science. 32:508–519. doi:10.1111/mms.12276.

Seidov D, Mishonov A, Reagan J, Parsons R. 2019. Resilience of the Gulf Stream path on decadal and longer timescales. Scientific Reports. 9:11549. doi:10.1038/s41598-019-48011-9

Worcester PF, Dzieciuch MA, Sagen H. 2020. Ocean acoustics in the rapidly changing Arctic. Acoustics Today. 16(1), 55–64.

Worcester PF, Munk WH, Spindel RC. 2005. Acoustic remote sensing of ocean gyres. Acoustics Today. 1(1), 11–17.