STATEMENT OF WORK

Ocean Environmental Monitoring and Sound Propagation Study at Mid-Atlantic Shelfbreak Offshore Wind Area (AT-24-03)

PURPOSE

Environmental assessments on offshore renewable energy development require accurate modeling and effective monitoring. Traditional sound propagation modeling for noise effect analysis often uses historical environmental variables that may not reflect oceanographic regime shifts due to climate change. Existing acoustic monitoring only evaluates species calls and signal/noise characteristics collected at the recording sites without incorporating oceanographic variables, and is thus unable to address broader issues such as ecological dynamics and oceanographic processes related to offshore wind development.

The proposed study will deploy acoustic sensors in the vicinity of the National Science Foundation's (NSF's) Pioneer Array ocean observation platform to collect active and passive acoustic datasets and to conduct sound propagation measurements. Acoustic data analyses will incorporate physical oceanographic time series collected *in situ* to understand mesoscale and sub-mesoscale oceanographic dynamics and ecosystem level effects from offshore wind development.

The outcome of the study will assist to understand the sub-mesoscale and mesoscale oceanographic processes and changes in relation to offshore wind planning and development at the mid-Atlantic shelfbreak region. The outcome will also provide validation to regional sound propagation models. Additionally, the outcome will include information on diurnal, seasonal, and annual occurrence and abundance of planktons, fishes, and marine mammals near offshore wind farm areas.

BACKGROUND

Integrated coastal observing systems can provide long-term multidisciplinary environmental monitoring over the continental shelf scale (Liu *et al*. 2015). Because sound waves travel much further than electromagnetic waves in seawater, active and passive acoustic sensors can be effectively used to monitor the marine environment, ranging from the presence, abundance, and distribution of marine life to meteorological phenomena such as wind speed and rainfall rates, to geological processes such as underwater earthquakes and volcanoes, and ice carving, to underwater noise generated from human activities (Howe *et al*. 2021). However, designing, developing, deploying, maintaining, and retrieving such an integrative ecosystem observing system can be very expensive.

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. There are three primary components of the Pioneer Array: moorings, underwater gliders, and autonomous underwater vehicles (AUVs). 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 timing of the Pioneer Array relocation will likely allow for 6-12 months of baseline monitoring in 2024 before construction begins. The proposed new location is in proximity (~20 km) to the planned Kitty Hawk and Coastal Virginia Offshore Wind (CVOW) wind farms, and also an important migratory corridor for North Atlantic right whales (NARW; Salisbury *et al*. 2015). Discussion with NSF 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 bottom-mounted and/or moored stationary ~~stational~~ active and passive acoustic recorders at the Pioneer Array location to collect both active and passive acoustic time series data 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, active acoustic sources will be deployed on the Array and be used intermittently to study propagation conditions at the mid-Atlantic shelfbreak region.

While real-time passive acoustic data can be used to inform regulators on the presence of endangered species (e.g., NARW) for mitigation measures, they will also 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). 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 (Andres 2016; Gangopadhyay 2019; 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 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 these established by the Realtime Opportunity for Development Environmental Observations (RODEO) studies funded by BOEM (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 (CMA) for impact prediction.

Finally, active and passive datasets from this study can 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 provide

critical information to BOEM regarding the potential long-term environmental effects from offshore wind development.

The integrated approach of this study could be applied to other geographic areas to deploy acoustic sensors where existing ocean observing platforms are located to achieve innovative ocean monitoring efforts. Results from acoustic monitoring can be analyzed along with other in situ physical and geophysical observations to investigate mesoscale oceanographic processes, which will allow more comprehensive understanding of ecosystem dynamics than using traditional PAM deployment.

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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.

- Supplement active and passive acoustic datasets to broader Atlantic regional PAM network to 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 Coastal Virginia Offshore Wind (CVOW) sites for impact assessment.

Some of the key questions to be addressed are:

1. What are the variations of the oceanographic processes such as stratification, mixing, circulation, and temperature variation, in particular concerning the dynamics of the Gulf Stream, 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 signal-to-noise ratio 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?

DESCRIPTION OF WORK

Methods: The proposed study would deploy active and passive acoustic sensors (e.g., hydrophones and/or hydrophone arrays) and low-intensity active source(s) in the vicinity of the NSF's OOI Pioneer Array ocean observing system and to conduct long-term environmental monitoring and 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 and ecosystem dynamics at the mid-Atlantic shelfbreak offshore wind development area.

TASKS

Task 1: Conduct a post award project kick-off meeting.

a. Schedule a post award online project kick-off meeting that includes the Contracting Officer (CO), Project Officer (PO), BOEM Environmental Studies Program Representative (ESPR), principal investigator, and other key personnel involved in the study.
b. Discuss with BOEM experts the scope and timeline of the project.

Deliverable 1: Provide a summary of the post award project kick-off meeting to BOEM.

Task 2: Develop a study plan that includes active and passive sensor selection and deployment to collect data to achieve the objectives of the study, as well as identifying analytical method(s) for data processing so the desired quantities listed in Deliverable 1 can be accurately obtained.

a. Work with BOEM experts and coordinate with NSF OOI Pioneer Array managers and researchers who operate and conduct research using the Array to develop a field plan to deploy active and active sensors and conduct data collection, following existing OOI policies and procedures.
b. Work with BOEM experts to develop a data processing plan for data analyses.
c. Work with BOEM experts to develop a plan for data and result dissemination, presentation, and publication

Deliverable 2: Study plans presented to BOEM experts for discussion and approval.

Task 3: Field data collection of passive and active acoustic data

a. Work with BOEM experts, NSF OOI Pioneer Array managers and researchers who operate and conduct research using the Array to coordinate acoustic sensor deployment and retrieval at agreed-upon locations in the vicinity of the Pioneer Array and potential cost sharing on ship time according to OOI policies and procedures.
b. Work with BOEM experts, NSF OOI Pioneer Array managers, and researchers who operate and conduct research using the Array to leverage resources,

including but not limited to cost sharing on data transmission (to the extent permissible on OOI infrastructure) and sharing of oceanographic datasets according to OOI policies and procedures.

c. Work with BOEM experts to conduct active and passive data collection and sound transmission.
d. Work with BOEM experts on initial QA/QC of collected raw data.

Deliverable 3: Passive and active acoustic data collected in the field and associated metadata.

Task 4: Ocean acoustic datasets analyses and interpretation, soundscape characterization, and sound propagation modeling

a. Develop signal processing software to investigate oceanographic processes and ecosystem dynamic using acoustic data collected from sensors and oceanographic data obtained from the Pioneer Array.
b. Develop signal processing software to characterize and interpret soundscape dynamics of the study area.
c. Develop signal processing software to improve sound propagation models that incorporate environmental parameters.
d. Provide marine species detection and, if possible, localization, to support Atlantic regional PAM network efforts.

Deliverable 4: An output of results and signal processing codes used to generate the results to be shared with BOEM experts and be made open-source.

Task 5: Interpret results. The analysis and interpretation of the results would emphasize the following areas:

a. Results and interpretation of mesoscale and sub-mesoscale oceanographic processes, in particular concerning the dynamics of the Gulf Stream, in relation to the offshore wind development.
b. Soundscape characteristics of the mid-Atlantic shelfbreak over the study period, and whether variations are observed that may be influenced by the offshore wind development in the region.
c. Improved sound propagation model that incorporates environmental variables for impact prediction.
d. Marine species passive acoustic detection and localization in the study area.

Deliverable 5: A summary of analysis and interpretation of the results on mid-Atlantic oceanographic processes, ecosystem dynamics, soundscape characteristics, sound propagation characteristics, and marine species detection through the study period.

Task 6: Work with BOEM experts on future directions on studies of oceanographic processes and ecosystem dynamics using passive and active acoustics.

a. Work with BOEM experts on recommendations for future data collection methodologies, including, but not limited to, the need to expanding ocean acoustic research to address environmental effects from offshore wind development using means of acoustics.
b. Work with BOEM experts on recommendations for improved sound propagation modeling that incorporates environmental parameters to predict ranges to impacts.

Deliverable 6: A summary report (or report chapter, see below) of recommendations for future research on using acoustics to study oceanographic processes and ecosystem dynamics in relation to offshore wind development, as well as improved sound propagation modeling that incorporates *in situ* environmental parameters.

Task 7: Reports, presentation(s), and publication(s).

a. Work with BOEM experts on quarterly reports that summarize progresses of this study.
b. Work with BOEM experts on the draft and final reports and technical summaries that details all the tasks and results listed above.
c. Work with BOEM experts on presentation(s) at scientific conferences on the study
d. Work with BOEM experts on at least one peer-reviewed publication on the study of substrate-borne acoustic waves from this study.

Deliverable 7: Quarterly reports, draft report and technical summary, final report and technical summary, presentation(s), and peer-reviewed publication(s).

ESPIS Data Deliverables Requirements

- Final Report and Technical Summary: The copies of the narratives of study results in both the MS Word and Adobe Acrobat (PDF/A) formats, without any password protections, following the ESP Report Specifications.
- Study Footprint: The geographic information that enables the referencing of the study using a GIS, following the study footprint specifications.
- Study Footprint Metadata: The scientific attribution information required to enhance discoverability of the study in the ESPIS system and third-party sites (such as data.gov), following the study footprint metadata specifications.
- Study Map: The study area map embedded in the Final Report and Technical Summary that depicts the study footprint and that is cited in the study footprint metadata.
- Federal Geographic Data Committee (FGDC) compliant metadata for each scientific dataset: The scientific, technical, and administrative information for each coherent unit of

scientific data, including the physical medium, file information, volume, and access URL, when applicable.

- Include boilerplate language in every ESP contract/agreement.
  - Copy of related publications: "The manuscripts of scholarly publications and conference presentations for research funded by this [contract/ agreement] for free and unlimited use by BOEM staff, which may take the form of a full-text, final, pre-publication copy of the related publication in cases that the publisher enforces pay for access or copyright restrictions."
  - Bibliographic information for related publications: "The information on each related publication needed for formatting CSE [Council of Science Editors] bibliographies using the name-date system

Data Management Plan

- All data (including raw acoustic datasets and associated metadata) from this study will be delivered to BOEM and shared at a specific public repository (e.g., National Center for Environmental Information).
- All acoustic modeling codes developed specifically for this study will be shared with BOEM and made open-source.
- Existing modeling software used in this study but are not developed specifically for this study may be proprietary, however, BOEM will prioritize the use of open-source software and modeling tools when considering award.

Scientific Integrity

Scientific integrity is vital to Department of the Interior (DOI) activities under which scientific research, data, summaries, syntheses, interpretations, presentations, and/or publications are developed and used. Failure to uphold the highest degree of scientific integrity will result not only in potentially flawed scientific results, interpretations, and applications but will damage DOI's reputation and ability to uphold the public's trust. All work performed must comply with the DOI Scientific Integrity Policy posted to http://www.doi.gov, or its equivalent as provided by their organization or State law.

AWARD INFORMATION

Total project allocation for this study is $3 million from FY24 to FY27. A preliminary breakout of funding amount is listed below but can be amended as needed per BOEM approval. No study proposal may have a budget exceeding $3 million in funds requested from BOEM. Matching contributions from the applicant are strongly recommended. BOEM anticipates that there would be a single award as part of this project.

FY24: $1,000,000

FY25: $800,000

FY26: $600,000

FY27: $600,000

DELIVERABLES

(1.) Post-award Teleconference: Under the moderation of the BOEM project officer (PO) and the BSEE contract officer for this cooperative agreement (CO), a post-award teleconference will be conducted. The participants will be the PO, CO, BOEM ESP Representative (ESPR), Office or Renewable Energy Programs (OREP) Science Coordinator, and the principal investigator who performs the study. The teleconference will be conducted as soon after the BOEM funding award as is practical under the scheduling constraints of the participants.

A synopsis of the kick-off meeting will be drafted by the PO and distributed to the Chief of the Environmental Sciences Division and to all the participants of the teleconference.

(2.) Study Plan(s): The principal investigator shall produce study plan(s) detailing: sensor deployment, acoustic and geophysical data collection, and data analysis and dissemination.

(3.) Passive and active acoustic data (raw acoustic data), oceanographic data, and associated metadata: The principal investigator shall submit all datasets (including raw acoustic data and associated metadata, other environmental variables, and sensor specifications) to BOEM at the end of the project.

(4.) Results and signal processing codes: The principal investigator shall submit an output of results from the test run and signal processing codes used to generate the results to BOEM at the end of the project.

(5.) Summary of analysis and interpretation: The principal investigator shall include the summary of analysis and interpretation of the results on mid-Atlantic shelfbreak oceanographic processes and ecosystem dynamics, soundscape characteristics, sound propagation characteristics, and marine species acoustic detection in the draft and final reports submitted to BOEM at the end of the project.

(6.) Directions on Future Research: The principal investigator shall include future directions on using acoustics to study oceanographic processes and ecosystem dynamics in relation to offshore wind development in the draft and final reports submitted to BOEM at the end of the project.

(7a.) Quarterly Progress Reports: The principal investigator shall produce quarterly reports briefly stating: progress made in the past quarter; any particular problems needing BOEM intervention to resolve; and anticipated progress to made in the next quarter.

(7b.) Draft Final Report and Technical Summary: The principal investigator shall complete and submit a draft final report and draft technical summary to BOEM for scientific peer and editorial review. The report and technical summary shall be in the format specified at http://www.boem.gov/Environmental-Studies-Program-Report-Specifications/. The report shall contain the following language concerning its availability in ESPIS:

"To download a PDF file of this Environmental Studies Program report, go to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program Information System website and search on OCS Study BOEM xxxx-xxx.", where xxxx-xxx will be replaced with the assigned BOEM study number.

In addition, in the Acknowledgement of Sponsorship Section, the report shall contain the following disclaimer and acknowledgement language:

"Disclaimer: This report has been technically reviewed by BOEM, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use."

and

"Acknowledgement: Study collaboration and funding were provided by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC under Agreement Number _____."

(7c.) Final Report and Final Technical Summary: The principal investigator shall revise the draft final report and draft technical summary according to feedback given by BOEM reviewers and the PO. The PI shall provide three high-quality, bound paper copies of the revised final report suitable for reproduction and five (5) CD-ROMs or DVDs each containing searchable text in the pdf format of the final report with book marks and a pdf copy of the final technical summary.

Deliverables, Due Dates, and Distribution

Deliverable	Distribution	Due Date
A. Post Award Teleconference and Summary Notes	Chief, DES—One (1) electronic copy ESP Rep—One (1) electronic copy CO—One (1) electronic copy OREP Science Coordinator—One (1) electronic copy All other participants in the teleconference—One (1) electronic copy	As soon as practical after BOEM funding award Summary Notes due approximately one (1) week after teleconference

Deliverable	Distribution	Due Date
B. Study Plan(s)	Chief, DES—One (1) electronic copy ESP Rep—One (1) electronic copy PO—One (1) electronic copy OREP Science Coordinator—One (1) electronic copy CO—One (1) electronic copy	Within two weeks after the Principal Investigator and BOEM reaches agreement on study design and data collection, analysis, and dissemination processes.
C. Passive and active acoustic data (raw data), oceanographic data, and associated metadata	PO—One (1) electronic copy OREP Science Coordinator—One (1) electronic copy	Due two (2) months prior to the end of the period of performance, along with Draft Report and Technical Summary
D. Output results and signal processing codes	ESP Rep—One (1) electronic copy PO—One (1) electronic copy CO—One (1) electronic copy OREP Science Coordinator—One (1) electronic copy	Due two (2) months prior to the end of the period of performance, along with Draft Report and Technical Summary
E. Summary of analysis and interpretation	Chief, DES—One (1) electronic copy ESP Rep—One (1) electronic copy PO—One (1) electronic copy CO—One (1) electronic copy OREP Science Coordinator—One (1) electronic copy	Due two (2) months prior to the end of the period of performance, to be included in the Draft Report and Technical Summary and Final Report
F. Directions on Future Research	Chief, DES—One (1) electronic copy	Due two (2) months prior to the end of the period of performance, to be included in the Draft

Deliverable	Distribution	Due Date
	ESP Rep—One (1) electronic copy PO—One (1) electronic copy CO—One (1) electronic copy OREP Science Coordinator—One (1) electronic copy	Report and Technical Summary and Final Report
G(1). Quarterly Reports	Chief, DES—One (1) electronic copy ESP Rep—One (1) electronic copy PO—One (1) electronic copy CO—One (1) electronic copy OREP Science Coordinator—One (1) electronic copy	Within four (4) months from award and Quarterly afterward.
G(2). Draft Report and Technical Summary	Chief, DES—One (1) electronic copy (in MS Word format) ESP Rep—One (1) electronic copy (in MS Word format) PO—One (1) electronic copy (MS Word) for report CO—One (1) electronic copy of transmittal letter only OREP Science Coordinator—One (1) electronic copy	Draft due two (2) months prior to the end of the period of performance
G(3). Final Report and Technical Summary	Chief, DES—One electronic copy (in pdf format) ESP Rep—One (1) electronic copy (in pdf format) PO—One (1) electronic copy (in pdf format), three (3)	Before the end of the period of performance

Deliverable	Distribution	Due Date
	bound paper copies and five (5) CD-ROM copies, containing both the technical report and the technical summary in Adobe Acrobat (.pdf) format and labeled with the study title, BOEM report number, BOEM contract number, contractor name and date CO—One (1) copy transmittal letter only OREP Science Coordinator—One (1) electronic copy	

CONTACT INFORMATION FOR DELIVERABLES

Contracting Officer (CO) for BOEM

TBD
Lead Contract Specialist
U.S. Department of the Interior
Bureau of Safety and Environmental Enforcement
Acquisition Policy and Financial Assistance Branch
45600 Woodland Rd., VAE-AMD
Sterling, Virginia 20170
Email:
Phone:

Project Officer (PO), BOEM

Dr. Shane Guan
Bureau of Ocean Energy Management
Office of Environmental Studies
45600 Woodland Road, MS VAM-OEP
Sterling, VA 20166
Office phone: 703-787-1444
e-mail: shane.guan@boem.gov

Chief, DES, BOEM

Chief, Division of Environmental Sciences
U.S. Department of the Interior
Bureau of Ocean Energy Management (BOEM)
45600 Woodland Road, MS VAM-OEP
Sterling, Virginia 20166
Environmentalstudiesprogram2@boem.gov

ESP Representative (ESP Rep), BOEM

Dr. Thomas Kilpatrick
Bureau of Ocean Energy Management (BOEM)
Division of Environmental Sciences
45600 Woodland Road, MS VAM-OEP
Sterling, VA 20166
Office phone: 703-787-1823
Email: thomas.kilpatrick@boem.gov

OREP Science Coordinator, BOEM
TBD
Lead Contract Specialist
U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs
45600 Woodland Road, MS VAM-OREP
Sterling, VA 20166
Email:
Phone: