Field	Study Information
Title	Applying Distributed Acoustic Sensing Technology to Monitor Large Whales at Atlantic Offshore Wind Areas (AT-25-05)
Administered by	Office of Renewable Energy Programs
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Procurement Type(s)	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	May 9, 2024
Problem	Offshore wind development may affect the distribution and migration of baleen whales in the region.
Intervention	This study would be a partnership with offshore wind developers and use existing fiber-optic cable for baleen whale monitoring, by applying distributed acoustic sensing (DAS) technology.
Comparison	Study results would be compared and validated with acoustic and visual data collected using traditional passive acoustic monitoring and ship and/or aerial surveys of baleen whale distribution and movement.
Outcome	Information from the study on whale distribution and movement in the study area may be used to assess potential environmental impacts on the species.
Context	Atlantic OCS, but knowledge from this study can be used in other OCS regions.

BOEM Information Need(s): One of the most critical questions BOEM faces when regulating offshore wind development are the potential environmental impacts to baleen whales (Bailey et al., 2014; NAP, 2023), especially the critically endangered North Atlantic right whales (NARWs), which have a current estimated population under 370 animals (Hayes et al., 2023; Quintana-Rizzo et al., 2021). To monitor and assess the potential effects on baleen whale distribution, movement, and behavioral status from the large scale long-term offshore wind development in the Atlantic seaboard, BOEM is working with its partners to establish a regional passive acoustic monitoring (PAM) network. The network would consist of numerous hydrophones, hydrophone arrays, and vector acoustic sensors to detect the presence, abundance, movement, and possibly behavior of whales in and around the offshore wind areas. Though this effort will be funded by using a onetime earmark of approximately $5.5 M from the Inflation Reduction Act of 2022 for acoustic sensor acquisition, deployment, and maintenance, it could be a challenge to meet the long-term commitment for this large-scale PAM in future years. Therefore, an innovative lower-cost long-term ocean observation approach using distributed acoustic sensing (DAS) technology could be a viable solution.

Background: DAS is a relatively new sensing technology that can be used to monitor undersea vibroacoustic disturbances, either in the water column or within the seabed, over a large (~ 100 km) distance (Wilcock et al., 2023). The approach is to attach the shore terminal of the fiber-optical cable to an interrogator, which sends a series of short laser pulses through one of the spare fibers (a.k.a., dark fiber) to measure the phase shift from the backscattering of the pulse along the cable. The backscattering of the laser pulse, caused by the nanometer-scale deformation of the fiber, is used inversely to get information on the vibroacoustic waves, such as acoustic pressure and particle motion in the water column or substrate-borne vibration, in the marine environment (Hartog, 2017; Lindsey and Martin, 2021).

Based on experimental settings, such as the distance of phase shift being measured (called gauge length), the spacing segments of scattered pulse (called channel), DAS can be used to monitor undersea vibroacoustic waves from under 0.001 Hz to above 1 kHz with a spatial resolution of a few meters (Guo et al., 2023; Wilcock et al., 2023). Over the past several years, DAS has been successfully demonstrated to monitor a variety of ocean environments, ranging from seismic activities, ocean dynamics, shipping noises, and marine life (e.g., Lindsey et al., 2019; Sladen et al., 2019; Landrø et al., 2020; Williams et al., 2019; Rivet et al., 2021; Bouffaut et al., 2022; Douglass et al., 2023; Wilcock et al., 2023) and to conduct shallow water passive geotechnical imaging (Williams et al., 2021).

Using an existing fiber optical submarine telecommunication cable that was buried in soft sediments at 0–2 m below the seafloor from Longyearbyen to Ny-Ålesund in Svalbard, Norway, Landrø et al. (2020) were able to continuously collect DAS data over 44 days with a sampling rate at 645.16 Hz. Their study detected whale calls along the 120 km of the cable with a 3D position localization of vocalizing whales for density estimation (Bouffaut et al., 2022). In another study, Wilcocks et al. (2023) used the two submarine cables operated by the Ocean Observatories Initiative Regional Cable Array off Pacific City to detect and localize blue (*Balaenoptera musculus*) and fin whale (*B. physalus*) calls as well as vessel traffic over four days in November 2021. The ship track results from DAS showed close agreement with that from the ship's automatic information system.

Because large whale detection and localization can be achieved using existing fiber optical cables on and below the seafloor, DAS technology provides a great opportunity to monitor these animals' distribution, movement, and potential behavior at a lower cost than current PAM systems.

Objective(s): The objectives of this study are: (1) Validate DAS-based baleen whale acoustic detection with those using traditional PAM in the Atlantic offshore wind energy areas (WEAs); (2) Supplement the Atlantic Regional PAM Network with DAS technology to enhance baleen whale detection and localization in the offshore WEAs; and (3) Establish an operational protocol for long-term baleen whale monitoring using DAS technologies for environmental assessments of offshore wind development.

Methods: The proposed research will first conduct a feasibility study to identify the offshore wind developers that own fiber optical cables that can be used for DAS monitoring and investigate the logistics on accessing necessary hardware and sites for the study. Interrogator(s) will then be installed to the shore terminal of the dark fiber(s) to measure backscattering of laser pulses that are emitted into the cable. DAS data collected will then be analyzed to derive information on baleen whale (in particular, NARWs) distribution, movement, and possibly behavioral status.

Specific Research Question(s):

1. Can DAS technology be a reasonable alternative to traditional PAM to conduct baleen whale monitoring at the offshore WEAs? If so, what are the pros and cons of using DAS technology rather than traditional PAM?

2. If DAS technology proves to be a low-cost way to study baleen whale distribution, movement, and behavior in the offshore WEAs, how can it be widely applied for environmental impact assessments?
3. Do baleen whales avoid windfarms construction and/or operations during the study period? Alternatively, are they attracted to these areas during the study period? Or is there no behavior
4. If there is a measurable change in baleen whale distributions across the Atlantic OCS, can we discern whether this change was due to offshore wind development or a different ongoing stressor?
5. What are the general sources, either natural (e.g., microseism, fishes) or anthropogenic (e.g., vessels, pile driving, turbine rotation), in the offshore WEA during the construction and operations of offshore wind farms?
6. Are there observable changes in acoustic behavior and/or behavioral ecology of baleen whales?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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