Field	Study Information
Title	Developing a Reliable Biosurveillance Monitoring System for Offshore Energy Activities Using Environmental DNA (NT-25-02)
Administered by	Office of Environmental Programs
BOEM Contact(s)	Timothy White (timothy.white@boem.gov)
Procurement Type(s)	Contract, Interagency Agreement
Performance Period	FY 2025–2029
Final Report Due	TBD
Date Revised	February 15, 2024
Problem	At-sea biosurveillance systems are needed to collect direct wildlife observations for monitoring offshore wind energy areas and leases.
Intervention	Establish species-specific and community-level analytical pipelines for advancing environmental DNA (eDNA) as one of the primary biosurveillance monitoring technologies for before-and-after wind industry development.
Comparison	Integrate eDNA samples collected at-sea, near and within wind energy areas and leases, with benchmark samples from long-term monitoring programs (e.g., Atlantic Marine Assessment for Protected Species Program [AMAPPS] observations, EcoMon zooplankton net hauls), and with models of oceanic currents to determine the likelihood of species occurrence, eDNA transport and fate.
Outcome	1) Advance toward developing near-real time species detection systems and scalable at-sea collections. 2) Identification of taxa easily resolved by eDNA and those that are not. 3) Buildout of genetic database and recommendations for improvement. 4) Biostatistical development to inform eDNA monitoring design and decision support.
Context	Applicable to all regions

BOEM Information Need(s): The environmental monitoring efforts of BOEM aim to support informed and effective decision-making. The National Academies of Science Engineering and Medicine encouraged BOEM to explore innovative approaches, technologies, and ideas to continuously improve its environmental studies (National Academies of Sciences, Engineering, and Medicine, 2022). Collecting comprehensive and high-quality ecological data over large spatial and temporal scales presents significant challenges, often within tight time frames. eDNA sampling stands out as a promising tool for ecological sampling and monitoring, as it offers a contemporaneous snapshot of species occurrence within the study area. BOEM intends to evaluate the effectiveness of eDNA sampling in capturing the diversity of known local marine communities and networks, determining its reliability in detecting federally managed species. Additionally, BOEM aims to advance eDNA innovation by assessing the strengths and limitations of genetic libraries and integrating historical data, such as visual observations and trawl data, with eDNA samples to enhance confidence in detection probabilities. The work conducted in lease and wind energy areas will provide case studies and new information that BOEM can use in its assessments.

Background: eDNA sampling is a non-invasive monitoring technique used to detect the presence of organisms in an environment by analyzing their genetic material from environmental samples. It involves collecting water, soil, or sediment samples and analyzing them for traces of DNA left behind by organisms. eDNA sampling is valuable for ecological monitoring, species detection, and biodiversity assessment in ecosystems.

eDNA is released into the environment through sources, such as skin cells, feces, urine, and other bodily fluids. When organisms shed or excrete these materials, their DNA becomes available in the surrounding environment. eDNA can persist from hours to a few days, depending on environmental conditions (Ficetola et al. 2008; Lafferty et al. 2018). This persistence makes it possible to detect the presence of organisms even if they are not directly observed during surveys.

eDNA sampling offers several advantages over traditional monitoring methods such as visual surveys or trawls. It is non-invasive, does not require handling or disturbing organisms, and can detect rare or elusive species. eDNA sampling can also provide information on the relative abundance of species and track changes in species composition and biodiversity over time.

Objective(s): The aim of this project is to test, benchmark, and scale eDNA protocols for measuring marine and continental shelf biodiversity by focused water sampling in areas associated with wind energy development. The seasonal and spatial sampling will coincide with other research programs such as NSF, NOAA, etc., where the expected regional fauna is well understood.

BOEM and the USGS team will use hypothesis-driven science and state-of-the-art miniaturized technology to assess the eDNA "net" for accuracy in resolving community structure in space and through time. This will be done by comparing taxa identified in water samples with benchmarked data associated with quantified hotspots derived from fisheries and observer-based sampling programs, such as AMAPPS. eDNA metabarcoding technology has been used extensively to classify fish community structure; however, this study will widen the eDNA lens to detect many more organisms represented in marine food webs and relevant to BOEM activities, such as clams, zooplankton, cetaceans and seabirds.

The outcomes of this project will produce 1) pipelines for targeted species identification and resolving wildlife community occurrence and 2) ecological relationships through statistical frameworks that consider the transport and fate of eDNA in relation to hydrography and modeled ocean currents. eDNA fate and transport must be considered to alert to false-positive inferences, when eDNA of a species is detected in a water sample even though the target species is not present at a site. This phenomenon can occur when eDNA is carried away from its source by vectors like moving water (e.g., currents) or wildlife (e.g., guano dropped by birds flying overhead). Accounting for eDNA false-positive inferences is critical for effective and efficient decision-making. The project will also reliably resolve the community composition of federally managed taxa to support NEPA evaluations, permitting processes, and population estimates.

Methods: The use of eDNA technology for monitoring different taxa is constantly evolving with the development of new methods. Nonetheless, current applications of eDNA metabarcoding demonstrate its ability to identify more species compared to other standard sampling methods (Pitz et al. 2017, Cordier et al. 2019). This includes identifying cryptic or rare species not previously known to exist in a particular study area (Foote et al., 2012). By conducting a potential study, we can better understand the extent to which eDNA technology can accurately identify managed species and community structure. The study will also guide BOEM and USGS in improving the technology's robustness and unified goals of developing a near real-time biosurveillance system. Additionally, it will help enhance the genetic reference libraries, which are essential for accurate species classification from eDNA samples (Watts and Miksis-Olds, 2018; Liu et al. 2019). Overall, eDNA technology has been shown to be effective and can be deployed at sea for various research and operational interests to improve accuracy in directly detecting marine species (Hansen et al. 2018; Stoeckle et al., 2018).

Temporal and Spatial coverage:

- Temporal: two seasons, one in each year over three years (either spring/fall, spring/spring, or fall/fall comparisons)
- Diel: Sub-daily, high frequency sampling across day and night periods
- Spatial: at foci on the Atlantic, Gulf of Mexico and Pacific EEZ
- Vertical: Replicates at multiple vertical stations (surface, Chlmax, thermocline, bottom, etc.)

eDNA:

- Multi-marker approach to sample vertebrates and invertebrates
- DNA extraction and preliminary QA/QC
- Community metabarcoding approach using next generation sequencing
- Bioinformatics and related quantitative analyses and reporting
- Reference collections that are actively being improved in collaboration with the Smithsonian Institution.
- Build reference collections in publicly accessible databases such as GenBank, consistent with the goals of a multi-genomic-marker approach

Specific Research Question(s):

1. Can eDNA reliably detect managed taxa and community structure (e.g., from clams to seabirds) to support NEPA evaluations and BOEM's permitting processes?
2. How can we use eDNA results and long-term fisheries and observer-based data to evaluate the likelihood of contemporaneous species occurrence in an area of interest?
3. Can we scale up eDNA collections rapidly, advance best practices, and curate reference libraries to support near-realtime observations in the future?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites:

https://www.fisheries.noaa.gov/feature-story/tracking-marine-life-invisible-clues-edna-enhances-ecosystem-monitoring https://www.usgs.gov/centers/norock/science/readi-net-providing-tools-early-detection-and-management-aquatic-invasive

References:

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Hansen BK, Bekkevold D, Clausen LW, Nielsen EE. 2018. The sceptical optimist: challenges and perspectives for the application of environmental DNA in marine fisheries. Fish Fish. 19:751–768.

Lafferty KD, Benesh KC, Mahon AR, Jerde CL, Lowe CG. 2018. Detecting southern California's white sharks with environmental DNA. Front Mar Sci. 5:355.

Liu Y, Wikfors GH, Rose JM, McBride RS, Milke LM, Mercaldo-Allen R. 2019. Application of environmental DNA metabarcoding to spatiotemporal finfish community assessment in a temperate embayment. Front Mar Sci. 6:674.

National Academies of Sciences, Engineering, and Medicine. 2022. Attributes of a first-in-class environmental program: a letter report prepared for the Bureau of Ocean Energy Management. 70 p. Washington(DC): The National Academies Press. https://doi.org/10.17226/26368 .

Stoeckle MY, Adolf J, Charlop-Powers Z, Dunton KJ, Hinks G, VanMorter SM. 2020. Trawl and eDNA assessment of marine fish diversity, seasonality, and relative abundance in coastal New Jersey, USA. J Mar Sci. 78(1):293–304. https://doi.org/10.1002/edn3.472.

Watts AW, Miksis-Olds JL. 2018. The ocean as a living sensor: environmental DNA and acoustics for detecting marine life. In: The National Conference on Marine Environmental DNA; 2018 November 29–30; New York, NY. 18 p.