## Environmental Studies Program: Studies Development Plan | FY 2023–2024

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| Title | Feel the Vibrations: Behavioral Response by Fish and Invertebrates to Particle Motion/Substrate Vibration from Pile-Driving (NT-23-10) |
| Administered by | Office of Environmental Programs |
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| Procurement Type(s) | Contract, Cooperative Agreement |
| Conducting Organization(s) | TBD |
| Total BOEM Cost | TBD |
| Performance Period | FY 2023–2026 |
| Final Report Due | TBD |
| Date Revised | 2/3/2022 |
| PICOC Summary | |
| *Problem* | Pile-driving activity associated with offshore construction introduces substantial energy into the substrate, which has the potential to negatively impact marine life that spend their lives on, in, or near the seafloor. Very few studies exist on the potential behavioral effects of substrate-borne vibration on marine life. |
| *Intervention* | The proposed study would provide strategic insight into the magnitude and scope of the potential behavioral effects of substrate-borne vibration on susceptible species by examining 1) multiple fish and invertebrate species, 2) a suite of behavioral responses—acute, chronic, and/or biologically meaningful, and 3) behavioral responses in a realistic pile-driving scenario. |
| *Comparison* | There are few studies that have examined impacts of water-borne particle motion on demersal species, and even fewer studies focusing on substrate-borne particle motion. A selection of species representing a range of sensory and/or mobility abilities will be tested in order to broaden the applicability of the results of this work. |
| *Outcome* | The knowledge gained from this study will be used by several BOEM program and regional offices in assessing impacts of BOEM activities. The Center for Marine Acoustics (CMA) will use the results to help inform their 1) acoustic impact model, 2) technical papers provided to regional offices on acoustic issues, and 3) recommendations made to regulators on acoustic issues. The results will also be used in specific BOEM regulatory documents, such as environmental impact statements and Construction and Operations Plans. This study will directly address widespread concern raised by the fishing community that BOEM does not understand the effects of sound on commercially important fish and invertebrate species. |
| *Context* | Nation-wide relevance for activities involving marine construction but focused on species found in New England given timing of proposed wind farm construction |

**BOEM Information Need(s):** Offshore construction activities routinely involve sound and vibration-generating activities, such as pile-driving. Little is known about the effects of substrate-borne

vibroacoustic disturbances on marine life living on or in the substrate. The behavioral response information expected from this proposed study will be used by BOEM to make more informed assessments of the impacts of its activities, which will include species of ecological and commercial importance. The results will directly inform the animal behavior component of the CMA's acoustic impact model, as well as technical papers the CMA writes on acoustic issues, made available to other offices within BOEM to better inform environmental impact assessments, biological assessments, and inform decisions related to the National Environmental Policy Act and Endangered Species Act processes. Finally, the information will be used by the CMA to make recommendations to regulators responsible for updating acoustic impact thresholds with the best available science.

**Background:** Offshore construction activities, particularly impact pile-driving, produce significant energy that is transmitted into the water column and through the substrate. Substantial progress has been made in understanding the extent and magnitude of the effect that acoustic pressure waves in the water column have on marine life, especially on marine mammals. Acoustic energy is also coupled into the seafloor as substrate vibration that is well-described by directional particle motion (Hawkins *et al.* 2021). The scientific community has become increasingly aware that most fish and invertebrates sense sound through particle motion (Hawkins *et al.* 2021). Several studies, including ongoing BOEM-funded studies (AT 20-01/M20AC10009), have begun to explore study designs for assessing behavioral response in free-swimming fish (Spiga *et al.* 2017) and squid (Jones *et al.* 2020a, 2020b) to acoustic exposure that include measurements of particle motion. . But there are many species of fish and invertebrates that live at or within the substrate. Very little research has focused on behavioral responses of these species to the vibroacoustic disturbances in the substrate. Therefore, there is an explicit need for a study of demersal fish and invertebrate species to particle motion and substrate-borne vibration to fill this knowledge gap. In fact, at the 2020 workshop on the state of the science related to wildlife and offshore wind energy development, the expert working group identified behavioral response studies of priority taxa to particle motion and substrate vibration as a key research priority for the next five years (Popper *et al.* 2022). The fishing community has also raised concerns on this topic.

The proposed study builds on recent BOEM investments, like Real-Time Opportunity for Development of Environmental Observations (RODEO), which included preliminary but limited physical measurements of particle motion, during construction of the Block Island Wind Farm (Amaral *et al.* 2018, OCS Study BOEM 2018-029). It also builds on an ongoing BOEM study (AT-20-01) of behavioral effects of offshore construction sound on freely swimming black sea bass and squid. Neither of these studies were explicitly focused on the behavioral effects of demersal species to substrate-borne vibration and particle motion and so these questions remain unanswered. However, the methodological approaches—i.e., sound field measurement equipment, behavioral response study design—developed in these respective studies could be leveraged to address these outstanding research questions, thus capitalizing on the expertise and knowledge gained through those studies.

**Objectives:** The goal of this study is to provide insight about the potential effects of substrate-borne vibration from pile-driving activity on demersal fish and invertebrates through a dedicated empirical behavioral response study. The results will provide sufficient empirical evidence—by considering a range of behaviors that are acute, chronic, and/or biologically significant. Insight will also be gained on the relationship between changes in the vibroacoustic field and behavioral responses.

**Methods:** The proposed study is for a behavioral assessment of demersal fish and/or invertebrates during actual pile-driving (preferred) or simulated pile-driving activity (acceptable) and will include a control to assess baseline behavior without pile-driving activity. Measurements will be made of the

vibroacoustic field (must include particle motion), using appropriate tools for each type of vibroacoustic wave. The study output will provide appropriate context for assessing the cause of any observed changes in behavior by including measurements and/or documentation of other relevant disturbances and environmental factors. The objectives may be achieved through one or a combination of field or laboratory studies, with the intention of examining a vibroacoustic field that is representative of offshore construction pile-driving.

Potential field methods to observe animals near pile-driving may include, but are not limited to the following:

- Animal-mounted sensors (e.g., accelerometers) to measure fine-scale movements (e.g., startle responses, lateral movements, feeding behaviors).
- An acoustic telemetry array to monitor larger-scale movements (e.g., habitat-displacement).
- *In situ* cages equipped with video cameras and/or tagged animals.
- Simulated pile-driving or playback experiments* in a small bay or saltwater pond where animals can easily be observed and/or recaptured if tagged.

Potential laboratory methods may include, but are not limited to:

- Simulated pile-driving or playback experiments* under similar conditions to actual offshore wind vibroacoustic activity, conducted in large, acoustically isolated tanks equipped with video cameras and/or tagged animals to observe animal behavior (individuals or in groups).
- An approach where particle motion can be tested, and perceived pressure can be controlled for (in the case of species that are also pressure sensitive).

Potential species may include (listed by approximate priority, preference to include multiple species):

- Flatfish (e.g., common sole, winter flounder)
- Bivalves (e.g., scallop, clam, mussels)
- Crustaceans (e.g., American lobster, crabs)
- If multiple species are examined, species should represent a range of life history strategies, mobility, and hearing abilities, and preference to species with commercial/conservation importance (Popper *et al.* 2022).

*Approach will need to ensure the simulated vibroacoustic field has similar characteristics to actual pile-driving.

**Specific Research Question(s):**

Depending on the study design, possible research questions may include:

1) Does the activity elicit short-term behavioral response in the species (e.g., flee, startle, freeze)?
2) Does the activity interfere with reproductive behaviors (e.g., spawning, egg-guarding)?
3) Does the activity interfere with food finding behaviors (e.g., foraging, filtering, scavenging)?
4) Does the activity cause sustained behavioral shifts (e.g., habitat-abandoning)?
5) What is the threshold for behavioral response, is it behavior-specific?

6) Do individuals adapt, acclimate, or become sensitized to exposure and what are the characteristics that define those processes (e.g., onset, duration, etc.)?

7) Do changes in behavior correlate with changes in the vibroacoustic sound field?

**Current Status:** N/A

**Publications Completed:** N/A

**Affiliated WWW Sites:** N/A

**References:**


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