

Environmental Studies Program: Studies Development Plan | FY 2019–2021

Title	Potential effects of seismic airguns on zooplankton in the US OCS
Administered by	Headquarters
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Procurement Type(s)	Full and open competition
Approx. Cost	\$250 (in thousands)
Performance Period	FY 2019–2020
Date Revised	February 2, 2018
PICOC Summary	Write one or two sentences for each of the following elements, as appropriate.
<i>Problem</i>	Zooplankton may be adversely affected by seismic airguns.
<i>Intervention</i>	A single study demonstrating adverse effects is not sufficient for BOEM to evaluate impacts. The solution is to replicate the previous work, in the US OCS, in areas where BOEM authorizes seismic surveys.
<i>Comparison</i>	Within this study, we will compare results from experimental vs. control treatments. Our results will be compared to previous work to assess the relative impact to zooplankton species.
<i>Outcome</i>	This work will broaden our understanding of the effects of seismic airguns on lower-trophic level species, which will aid in our assessment of impacts to higher-trophic level (protected) species.
<i>Context</i>	This study needs to be conducted while real seismic surveys are operating, so it would take place in the GOM or off the Atlantic coast, if operations begin there.

BOEM Information Need(s): In order to adequately assess the potential impacts of BOEM activities on protected marine species under NEPA, we should consider impacts to the entire ecosystem. While low trophic-level animals are generally not protected under federal law, they serve as important prey for larger species that are under protection. Public comments from recent BOEM EISs have raised the issue of potential effects of seismic airguns on planktonic communities - both as direct impacts to plankton species, and as indirect impacts to their predators. In order to adequately address the comments and make accurate significance determinations in our NEPA, we need to improve scientific understanding around this topic.

Background: Very little research has been conducted on the impacts of noise to eggs, zooplankton, and larvae. It is possible that high-intensity noises can irreversibly damage internal anatomy and physiology of planktonic organisms if they are close enough to the source (de Soto et al. 2013, Govoni et al. 2008, Govoni et al. 2003), or could cause them to swim out of harm's way (Dalen and Knutsen 1987). However, most of the research in this topic focused on relatively small spatial scales and showed minimal effects (Kostyuchenko 1973, Bolle et al. 2012, Booman et al. 1996, Saetre and Ona 1996, Holliday and Institute 1987, Pearson et al. 1994). Therefore, due to the relatively innocuous nature of impacts in these early studies, BOEM NEPA documents have

generally concluded that impacts of seismic surveys on planktonic organisms would be non-significant.

Things changed in 2017, however, when investigators from Australia published a study that contradicted the findings of much of the previous work (McCauley et al. 2017). The team conducted an *in situ* experiment in the shallow waters near Tasmania, in which they deployed a single airgun over specific track lines. They conducted plankton tows at different distances from the track, both while the airgun was operational, as well as when it was in the water but not operational. They also used a sonar system to observe the movement of plankton throughout the water column.

Results showed a reduction in zooplankton abundance and an increase in mortality after air gun exposure. Fifty-eight percent of the zooplankton taxa counted in the plankton nets had a >50% reduction in abundance between control and exposure, and the median reduction in abundance was 64%. There was a significant increase (2–3 fold) in zooplankton mortality up to 1.2 km distance from the airgun's passage, with the most pronounced effects occurring closest to the airgun. In addition, on the first day, they observed the development of a "hole" in the sonar backscatter 15 minutes after the passage of the airgun, but this effect was not seen on the second day.

The results from this study contrast findings from previous work, which showed impacts on the order of 10s of meters. As a result, it has been taken very seriously by scientists, regulators, and industry; the IAGC and API even sought [independent reviews](#) from a team of scientists, which pointed out several flaws. BOEM's review stated that the direct applicability of the findings to BOEM activities on the US OCS is limited, since this work was conducted in very shallow water, which affects the propagation of sound from the airgun. Clearly there is a need for a follow-up study that addresses the experimental flaws and takes place in realistic water depths.

Objectives: To examine potential effects of seismic airguns on zooplankton in water depths that are typical for the US OCS.

Methods: Exact methods are open for discussion, so here I just provide a general framework. A Before-After-Control-Impact design utilizing a real seismic survey vessel would be ideal for this type of project. A team of plankton ecologists would work off of a small boat (or two) to conduct net tows (for plankton) and water grabs (for water chemistry) before and after the passage of the vessel, while tracking the movement of the relevant water mass with drogues and Acoustic Doppler Current Profilers (ADCPs). This process would need to be replicated over at least five days, with sampling occurring at a range of distances from the source (up to 1500 m). The drogues would be left in the water for repeated sampling at 2, 4, 6, and 8 hours post-exposure to see if there is a lingering effect (i.e., delayed mortality) of airguns. A similar process would be done for the control – with the seismic vessel running and airguns in the water, but not firing. The purpose is to compare bodies of water with similar water chemistry and similar zooplankton concentrations in order to isolate the effect of firing airguns from natural variability of the water and plankton. It is also important to measure the received sound level at the locations where the plankton are sampled, which could be achieved through

drifting hydrophones or spot measurements near the plankton tows. To determine whether there are any lingering effects, a similar sampling protocol could take place in the same area after a few weeks. This work could also be replicated across seasons to examine any interaction between natural temporal variability in plankton density and the effects of seismic airguns.

Upon retrieval of the net tows, plankton would be stained and examined under the microscope using the same method as in McCauley et al. Plankton that are dead on arrival appear cloudy or opaque, while those that are alive appear more transparent. Since the plankton can be preserved after staining, the microscope work could be done by an independent group, perhaps engaging the help of a high school or undergraduate class. First it would be important to have a plankton expert examine the samples, and compare their results to those of the citizen-scientists to ensure accuracy. Furthermore, photos of the microscope images could be made public, so the experiment remains completely transparent and open.

Specific Research Question(s):

- Does the operation of seismic airguns increase mortality in zooplankton?
 - Do the effects differ across species?
 - Does the effect change with distance from the airguns?
 - Is there a delayed effect observed several hours after the passage of the airguns?
- Does the operation of seismic airguns change the distribution of zooplankton in the water column?
- Does the effect of airguns change with water depth, vessel speed, or density of the plankton patch?

References:

- Bolle, L. J., C. A. de Jong, S. M. Bierman, P. J. van Beek, O. A. van Keeken, P. W. Wessels, C. J. van Damme, H. V. Winter, D. de Haan and R. P. Dekeling (2012). "Common sole larvae survive high levels of pile-driving sound in controlled exposure experiments." *PLoS One* 7(3): e33052.
- Booman, C., J. Dalen, H. Leivestad, A. Levsen, T. van der Meeren and K. Toklum (1996). "Effects of airguns on eggs, larvae, and fry."
- Dalen, J. and G. M. Knutsen (1987). Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. *Progress in Underwater Acoustics*. H. M. Merklinger. Boston, MA, Springer.
- de Soto, N. A., N. Delorme, J. Atkins, S. Howard, J. Williams and M. Johnson (2013). "Anthropogenic noise causes body malformations and delays development in marine larvae." *Scientific Reports* 3: 2831.

- Govoni, J. J., L. R. Settle and M. A. West (2003). "Trauma to juvenile pinfish and spot inflicted by submarine detonations." *Journal of Aquatic Animal Health* 15(2): 111-119.
- Govoni, J. J., M. A. West, L. R. Settle, R. T. Lynch and M. D. Greene (2008). "Effects of Underwater Explosions on Larval Fish: Implications for a Coastal Engineering Project." *Journal of Coastal Research* 2: 228-233.
- Holliday, D. V. (1987). The effects of airgun energy releases on the eggs, larvae, and adults of the northern anchovy (*Engraulis mordax*), American Petroleum Institute.
- Kostyuchenko, L. P. (1973). "Effect of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea." *Hydrobiological Journal* 9: 45-48.
- McCauley et al., 2017. *Widely used seismic survey air gun operations negatively impact zooplankton*. *Nature Ecology and Evolution* 1:0195.
- Martin, Nikki (IAGC) and Radford, Andy (API). [Letter to BOEM and NMFS dated November 17, 2017](#)
- Pearson, W. H., J. R. Skalski, S. D. Sulkin and C. Malme (1994). "Effects of seismic energy releases on the survival and development of zoeal larvae of Dungeness Crab (*Cancer magister*)." *Marine Environmental Research* 38: 93-113.
- Saetre, R. and E. Ona (1996). "The effects of seismic surveys on fish eggs and larvae." *Fiskens Og Havet* 8: 24.