M³: Towards Long-Term Acoustic Monitoring of Gas Emissions using Underwater Cabled Observatory Technology

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Abstract

Natural methane gas release from the seafloor is a widespread phenomenon that occurs at cold seeps along most continental margins. Since their discovery in the early 1980s, seeps have been the focus of intensive research, partly aimed to refine the global carbon budget. However, deep-sea research is challenging and expensive and, to date, few works have successfully monitored the variability of methane gas release over long time periods (> 1 yr). Long-term monitoring is necessary to study the mechanisms that control seabed gas release. The M³ project, funded by the German Ministry of Education and Research, aims to study the temporal and spatial variability of gas emissions at the Southern Hydrate Ridge (SHR) by acoustically monitoring and quantifying gas effluxes over several years. Located 850 m deep on the Cascadia accretionary prism offshore Oregon, the SHR is one of the most studied seep sites and persistent but variable gas release has been observed for more than 20 years. Since 2015, the Ocean Observatories Initiative's (OOI) Cabled Array observatory, provides power supply and two-way communication to the SHR, making it an ideal site for continuous long-term monitoring work. In this work, we present how we will take advantage of the OOI infrastructure and deploy several instruments on the seabed for at least 1.5 year. A multi-beam "overview" sonar mounted on a rotor will identify every gas bubble stream located within 200 m from the sonar location. A scanning "quantification" sonar will be used to estimate the amount of gas that is released from discrete gas streams. A camera system and a CTD probe will help process and analyze the hydro-acoustic data. All instruments will be powered and controlled from land through the OOI infrastructure. We present the instrument design, the operation protocol, as well as the data processing steps and expected results.

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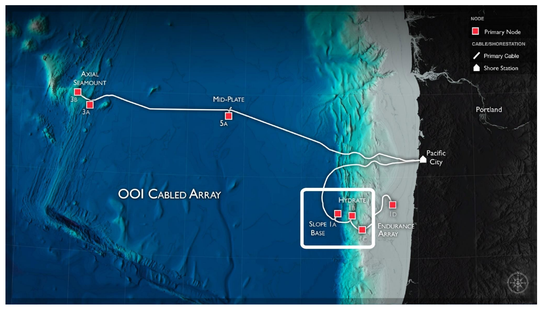
AIM

To study the variability of deep-sea methane gas release through continuous monitoring over long periods of time (> 1.5 year) using underwater sonars controlled in real-time from land.

CONTEXT

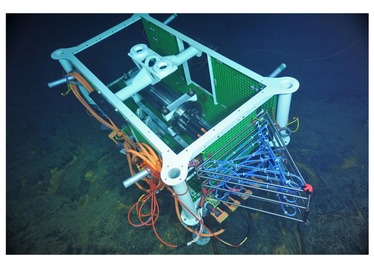
- Natural methane gas release from the seafloor is a widespread phenomenon that occurs at cold seeps along most continental margins.
- Persistent but variable gas release has been observed for more than 20 years at the Southern Hydrate Ridge (SHR), 800 m deep on the Cascadia accretionary prism.
- Possibly linked to current global warming trend, the mechanisms that control the gas release are still unclear.
- Deep-sea research is challenging and expensive and, to date, few works have successfully monitored the variability of methane gas release over long time periods (> 1yr).



Since 2015, the Ocean Observatories Initiative's (OOI) Cabled Array observatory provides power supply and two-way communication to the SHR, making it an ideal site for continuous long-term monitoring work.

(*Credit: University of Washington / NSF Ocean Observatories Initiative)*

- Long-term monitoring is necessary to forecast how seabed gas release may contribute to the global carbon budget.
- In 2015, the Ocean Observatories Initiative (OOI) completed the installation of the Cabled Array, making it an ideal site for continuous long-term monitoring work.



Scientific instruments can be connected to the OOI network via subsea junction boxes. *(Credit: University of Washington/NSF Ocean Observatories Initiative).*

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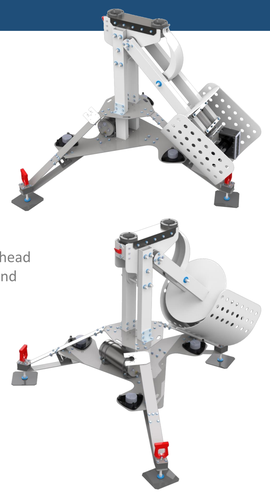


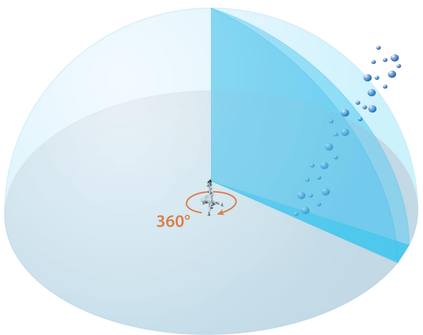
Folded position used for deployment and recovery with ROV JASON. The sonar mast can be tilted up/down with the ROV manipulator.

The **overview sonar** will document the location and strength of gas emissions over most of the SHR. Designed for long-term deployment, all metallic parts in contact with water are in titanium to prevent corrosion. With a height exceeding 3 m (10 ft.) the sonar will dominate the surrounding seafloor topography, thus minimizing noise in the data.

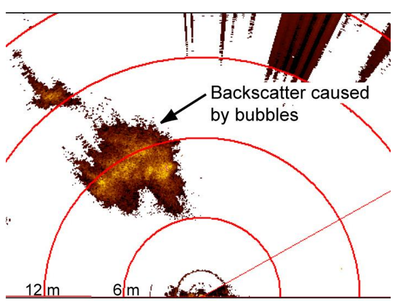
M³ PROJECT

The M³ project is funded by the German Ministry of Education and Research (BMBF) and conducted in close cooperation with the University of Washington and the National Science Foundation (NSF).

Started in January 2017, the project relies on the existing OOI underwater cabled infrastructure to study the temporal and spatial variability of gas emissions at the Southern Hydrate Ridge for at least 1.5 year.



The overview sonar will perform 360° scans of the water column every two hours. The sonar head is mounted so as to orientate the swath vertically. All gas bubbles present within a 150 m-radius hemisphere centred on the sonar will be detected.



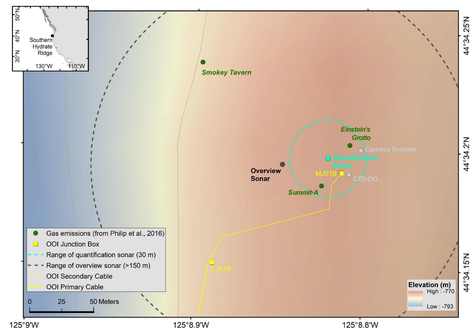
When insonified, gas bubbles generate strong backscatter anomalies (aka. flares), making them easy to detect with sonars.

TECHNOLOGY DEVELOPMENT

4 instruments connected to the NSF-OOI network

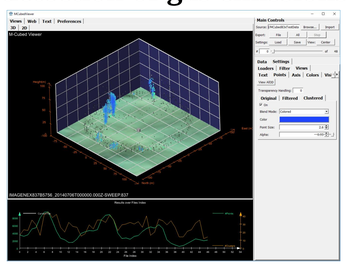
- Overview Sonar: a multibeam echosounder mounted on a rotor will identify every gas bubble stream located within 150 m or more from the sonar location. If required, the range may be increased up to 500 m.
- Quantification Sonar: a singlebeam scanning-sonar will estimate the methane fluxes from discrete gas streams.
- Camera System: mounted on a pan and tilt unit, the high resolution camera will document bubble size distributions.
- CTD-DO probe to monitor environmental parameters of the bottom water.

All instruments will be connected to the OOI network in June 2018 with ROV Jason. Depending on the range and resolution settings the detection area of the overview sonar may reach up to 700,000 m². With a range of about 30 m, the quantification sonar will focus on the strongest gas emissions.



Automated and near-realtime detection of gas emissions

Developed in cooperation with the Fraunhofer Institute for Medical Image Computing (MEVIS), the *MCubedViewer* software will identify gas emissions from raw sonar data scans. Results will published online after each 360° scan (every 2 hours).



PROJECTED RESULTS

- Understand controls on short-term variations (tide, seismic amplitude, bottom water temperature, etc.)
- Study the long-term variations of gas release and identify their causes
- Investigate the potential influence of increasing bottom water temperatures on gas hydrate dissociation

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