# Oil & Natural Gas Technology

**DOE Award No.: DE-NT0005667**

# Quarterly Progress Report

October 2008 – December 2008

## ASSESSING THE EFFICACY OF THE AEROBIC METHANOTROPHIC BIOFILTER IN METHANE HYDRATE ENVIRONMENTS

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Prepared for:
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National Energy Technology Laboratory

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**Office of Fossil Energy**

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## EXECUTIVE SUMMARY

In October 2008 the University of California at Stan Barbara (UCSB) initiated investigations of water column methane oxidation in methane hydrate environments, through a project funded by the National Energy Technology Laboratory (NETL) entitled: assessing the efficacy of the aerobic methanotrophic biofilter in methane hydrate environments. The first three months of the project were dedicated largely to project management and initial reporting requirements. Several documents were submitted to NETL including a revised Project Management Plan (PMP), a Project Summary and a review/synthesis of relevant technologies entitled a Technology Status Assessment.

During this period necessary steps were taken to initiate purchase of equipment, and to initiate employment of project personnel. Collaborations with other DOE-funded researchers were also initiated to add value to this and other DOE-sponsored projects, and to utilize emerging technologies developed by the DOE. Collaborations specifically include interactions with scientists at Lawrence Berkeley Lab to apply new phylochip technology to methane hydrate environments, and with another group funded by NETL to investigate the impact of methane oxidation on methane emissions from arctic permafrost. Delays in the timing of award announcements and in the receipt/processing of funds caused us to miss the Fall 2008 field season, which will lead to minor delays for some tasks and milestones, and a also led to a delay in employment of some prject personnel.

Preliminary sampling was conducted through pre-award spending in the summer of 2008 and did lead to successful growth of benthic microbial mats in methane seeps at Coal Oil Point. These mats were returned to the laboratory and fed 13C isotopically labeled methane. Analyses are ongoing to determine the success of these incubations. Among other purposes the samples will be used for phylochip analysis at LBL. One member of the project team also participated on an NSF-funded cruise to investigate methane cycling in the water column off the coast of Central America. This activity occurred at no cost to DOE, but will provide a significant benefit in that it provides additional environments to assist in discerning the major controls on methane oxidation in marine waters.

In addition to starting the proposed research, one presentation was given at the Fall meeting of the American Geophysical Union, in a special session on methane hydrates, highlighting our previous and proposed research.

## PROGRESS, RESULTS AND DISCUSSION

**Task 1 - Project Management Plan (PMP)**

During September and October the Principal Investigator revised and submitted a PMP, which was approved by DOE. This document outlined the course of the entire project. In addition to this document the PI worked with the Program Manager (PM) to develop a project summary suitable for general viewing. The PI further wrote and submitted a Technology Status Assessment highlighting the state of current technology in relation to methanotrophy and methane hydrates.

**Task 2 - Field Sampling of Microbial Mats**

**Subtask 2.1 - Coal Oil Point Sampling**

**Subtask 2.2 - Santa Monica Basin Sampling**

Nine samples of microbial mats were collected from the sea floor at Coal Oil Point in support of subtask 2.1. These samples were incubated in-situ at ~63 feet water depth for one month prior to collection – in the gas plume of a massive methane seep.

**Task 3 - Turnover Rates for Methane Oxidation in Microbial Mats**

**Subtask 3.1 - Turnover Rates for Coal Oil Point Samples**

**Subtask 3.2 - Turnover Rates for Santa Monica Basin Samples**

Preliminary experiments were conducted with the samples collected at COP to quantify the turnover rate of 13C methane by the microbial mats collected – in support of subtask 3.1. Analyses are ongoing.

**Task 4 - Molecular Analyses of Methanotrophs**

Extractions are being performed from samples collected at Coal Oil Point to enable further molecular analyses. These samples are also slated for analyses at Lawrence Berkeley Lab (LBL) using the DOE phylochip system.

**Task 5 - Stable Isotope Probing**

**Subtask 5.1 - Stable Isotope Probing of Coal Oil Point Samples**

**Subtask 5.2 - Stable Isotope Probing of Santa Monica Basin Samples**

13C-methane was added to samples from the COP field in preparatory experiments for subtask 5.1. Subsequent analyses of these samples are being planned.

**Task 6 - Field Measurements in the Santa Barbara Basin**

**Subtask 6.1 - Shallow Water Sampling and Measurements, Santa Barbara Basin**

**Subtask 6.2 - Deep and Bottom Water Sampling and Measurements, Santa Barbara Basin**

**Subtask 6.3 - Repeat Sampling, Santa Barbara Basin**

These tasks are scheduled for a future reporting period.

**Task 7 – Analysis of Methane Oxidation Rates and Methane Turnover Times Throughout the Santa Barbara Basin**

**Subtask 7.1 - Shallow Water**
**Subtask 7.2 - Interior Water**
**Subtask 7.3 –Targeted Measurements**
These tasks are planned for a future reporting period.

**Task 8 - Analysis of Current Velocity Data**
**Subtask 8.1 – Current Velocity Analysis for the Shallow Santa Barbara Basin**
**Subtask 8.2 - Current Velocity Analysis for the Deep Santa Barbara Basin**
These tasks are planned for a future reporting period.

**Task 9 - Development of a methane budget for the Santa Barbara Basin**
This task is planned for a future reporting period.

**Task 10 - Field Sampling of Waters**
**Subtask 10.1 - Santa Barbara Basin Water Sampling**
**Subtask 10.2 - Southern California Margin Water Sampling**
**Subtask 10.3 - Targeted Water Sampling**
This task is planned for a future reporting period.

**Task 11 - Sensitivity Testing of Methane Oxidation Rates**
This task is planned for a future reporting period.

In addition to the formal tasks associated with the project, two collaborations were formalized in this period with other DOE and DOE-funded researchers. First, collaboration was developed with scientists at Lawrence Berkeley Laboratory to apply DOE phylochip technology to samples from methane hydrate environments to provide a robust assessment of microbial community structure and population dynamics as it relates to methane oxidation. A second collaboration was formalized with a DOE-funded group investigating methane release from permafrost environments, in which we will conduct methane oxidation rate measurements in arctic lakes in order to better define the importance of methanotrophy to the release of methane from these hydrate environments. Both collaborations add value to current DOE projects.

One member of our project team, Ms Monica Heintz, also participated on a cruise to the Eastern Tropical North Pacific to investigate methane cycling in relation to the suboxic zone and methane plume originating from Central America. Participation was independently funded and this award did not pay any associated costs, but significant benefit is expected as this expedition provides important comparison results to the planned studies of water column methanotrophy.

## Conclusion

A majority of the work conducted during this first quarter was preparatory in nature and included the revised PMP and other DOE requirements. Initial scientific investigations were conducted with benthic mats at Coal Oil Point and in the water column of the Eastern Tropical North Pacific. Important collaborations were forged to advance this and other DOE projects, and one presentation was made at a national meeting.

## COST STATUS

There are no subcontracts to this award. All funds are being expended by UCSB. Financial report under separate cover.

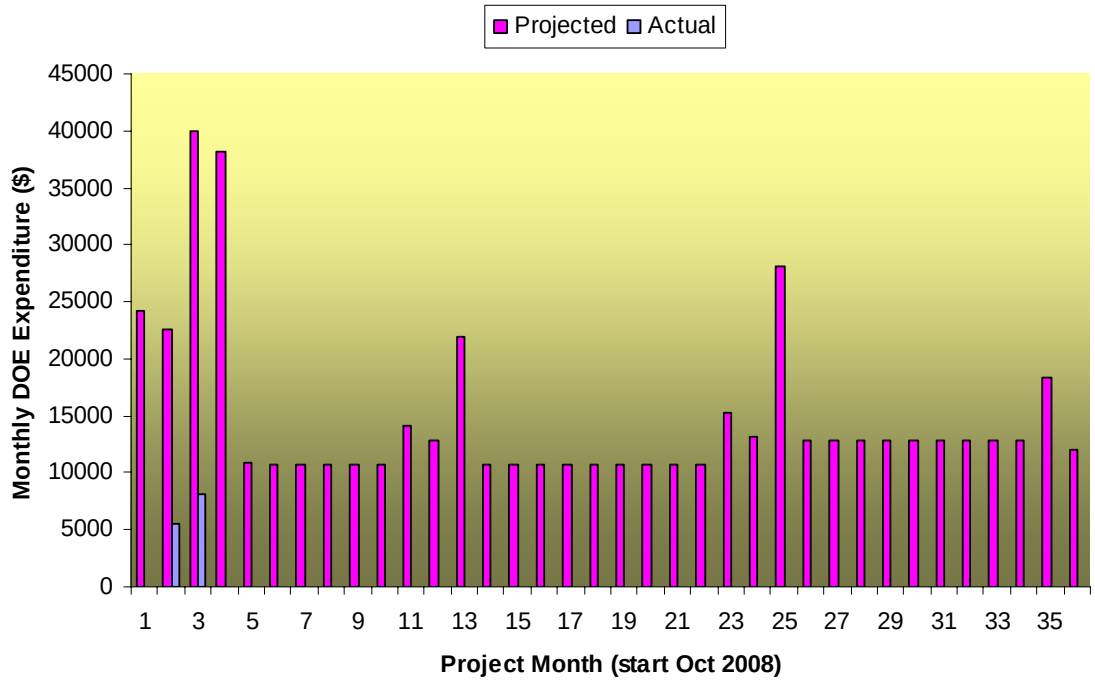


**Figure 1. Project costing profile**

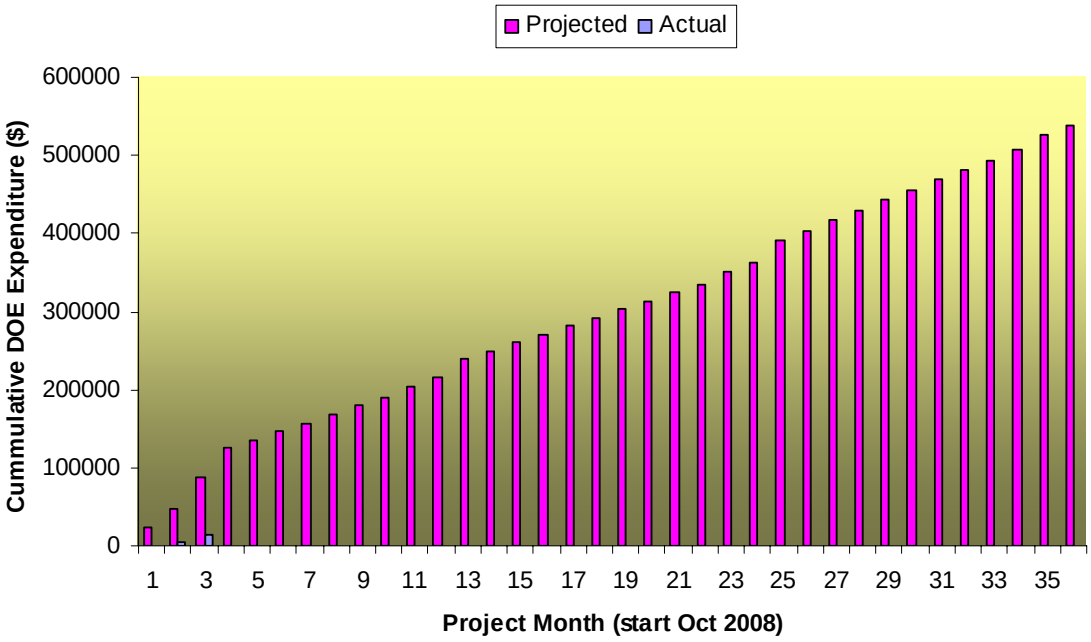


**Figure 2. Project cummulative costs**

## MILESTONE STATUS

*Milestone 1:* Successful installation and sea trial of the CTD rosette system and ADCP. This milestone relates closely to Tasks 6.1, 6.3, 10.1, and 10.3, and must be reached to enable sampling in support of tasks 7.1, 7.3, 8.1, and 11. The estimated completion date for this milestone is 4/1/09, but may be pushed back until June/July, 2009 on account of missing the fall, 2008 weather window.

Status: The purchase process for these items is ongoing. Missing the fall field season relieved the rush on these items, and it is anticipated they will be acquired and tested prior to the Spring field season.

*Milestone 2:* Confirmation of $^{3}H\text{-}CH_4$ oxidation and $^{13}C\text{-}CH_4$ uptake by benthic microbial mats from Coal Oil Point seeps. This milestone relates directly to Tasks 2.1, 3.1, and 5.1 and will further facilitate the completion of tasks 4, and 5.2. The estimated completion date for this milestone is 7/1/09.

Status: Samples collected during the pre-award time are being used in pursuit of this milestone. Missing the fall field season may delay this milestone slightly, depending on weather and storm conditions in the early spring that may set back in-situ colonization of sea floor deployments.

*Milestone 3:* Completion of the SEEPS 09 cruise. The SEEPS 09 cruise presents an unrivaled level of access to recently discovered methane hydrate sites in the Santa Monica Basin and to water column sites throughout the Southern California margin including the deep Santa Barbara Basin. The cruise and associated sampling relate closely to Tasks 2.2, 6.2, and 10.2, and will facilitate completion of tasks 3.2, 4, 5.2, 8.2, 9, and 11. The estimated completion date for this milestone is 1/1/10, but the timing will necessarily depend on the UNOLS scheduling of this (already approved) cruise.

Status: Planning began for the SEEPS 09 cruise, after the Atlantis schedule was finalized in November, 2008. Unfortunately, the schedule was later scrapped by UNOLS on account of delays in the production of components needed for a different cruise. Revised dates have not been finalized for SEEPS 09, but all indications point to September, 2009. An announcement is expected in Feb, 2009.

*Milestone 4:* Conduct a preliminary analysis for mmo and 16SrRNA gene sequences for putative methanotrophs from the Santa Monica Basin, and compare to sequences from Coal Oil Point seeps. This milestone relates directly to Tasks 4, 5.1, and 5.2, and will determine the approach taken in completing Tasks 4 and 5. The estimated completion date for this milestone is PY 7/1/10.

Status: This research has not yet begun and is on schedule.

*Milestone 5:* Complete a preliminary analysis of current velocity data and oxidation rate data from the SEEPS 09 cruise. This milestone must be achieved to address Tasks 6.3, 7.3 and 11. The estimated completion date for this milestone is PY 10/1/10.

Status: This research has not yet begun and is on schedule.

*Milestone 6:* Complete the ocean-going sampling program, and perform preliminary analysis of all physical and chemical data to ensure sufficient data for further analysis. This milestone relates directly to Tasks 6.3, 7.3, and 10.3 and will facilitate the completion of Tasks 9 and 11. The estimated completion date for this milestone is PY 4/1/11.

Status: This research has not yet begun and is on schedule.

## ACCOMPLISHMENTS

→ Organization of project personnel
→ Initial in-situ cultivation and harvesting of putative methanotrophic mat communities from Coal Oil Point.

## PROBLEMS OR DELAYS

Because of the delayed timing of award announcements and the delayed arrival/processing of funds, the Fall 2008 field season was missed. This pushes initial field work to the Spring of 2009, but will only cause minor delays in conducting tasks and meeting milestone deadlines. This delay was partially compensated by pre-award spending that enabled incubations during Summer/Fall 2008 in-situ at the Coal Oil Point seep field. This delay also caused a delay in employment of project personnel as key academic deadlines were missed. These issues have since been sorted out and will cause only a slight lag in the cumulative expenditure.

## PRODUCTS

→ Revised Project Management Plan
Task 1 of the project
→ Project Summary
A summary of the proposed research was written and submitted to DOE
→ Technology Status Assessment
A summary document was written and submitted to DOE outlining the state of technology in the area of research
→ Presentation – 2009 American Geophysical Union Fall meeting, Special Session on methane hydrates.

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