

Oil & Natural Gas Technology

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Quarterly Progress Report

January 2012 – March 2012

ASSESSING THE EFFICACY OF THE AEROBIC METHANOTROPHIC BIOFIL- TER IN METHANE HYDRATE ENVIRONMENTS

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EXECUTIVE SUMMARY

In October 2008 the University of California at Santa 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 fourteenth quarter of this project was dedicated to the publication of four papers, and to continued work-up of data resulting from a series of cruises to the Santa Barbara and Santa Monica Basins, and the Gulf of Mexico.

During this period project personnel published four articles including one in Limnology and Oceanography, one in Continental Shelf Research, and two in the Proceedings of the National Academy of Sciences. We continue to polish a manuscript on methane oxidation in ice covered Arctic lakes and plan submission in the near future. We also continue to analyze the methanotrophic bloom from the Deepwater Horizon event, and conducted supportive laboratory analyses during this reporting period. We also continued with the preparation of two manuscripts analyzing methanotrophic activity in the Santa Barbara and Santa Monica Basins.

PROGRESS, RESULTS AND DISCUSSION

Task 1 - Project Management Plan (PMP)

This task was completed during the first quarter of this award.

Task 2 - Field Sampling of Microbial Mats

Subtask 2.1 - Coal Oil Point Sampling

Subtask 2.2 - Santa Monica Basin Sampling

Task 2 was completed during a previous reporting period.

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

Task 3 was completed during a previous reporting period.

Task 4 - Molecular Analyses of Methanotrophs

We continue to expand our approach for molecular analysis of methanotrophs during this reporting period, specifically using intergenic spacer analysis, quantitative PCR, and single cell genomics. We also continue manuscript preparation, but are paused awaiting data from single cell genomic analyses.

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

Subtask 5.3 - Stable Isotope Probing of Gulf of Mexico Water Samples

Task 5 was completed in a previous reporting period.

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

Task 6 was completed in a previous 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

We completed the data analysis for methane oxidation rates and turnover times for methane in the Santa Barbara Basin. These data are being prepared for publication in the peer reviewed literature. This task is now considered complete.

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

Task 8 was completed in a previous reporting period

Task 9 - Development of a methane budget for the Santa Barbara Basin

We continue to develop a draft methane budget for the Santa Barbara Basin. We also published a paper on the methane budget of the northern Santa Barbara Basin accepted with Continental Shelf Research.

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

Subtask 10.4 – Gulf of Mexico Water Sampling

This task was completed in a previous reporting period.

Task 11 - Sensitivity Testing of Methane Oxidation Rates

This task was completed during a previous reporting period.

Project personnel focused their primary efforts on data analysis and manuscript publication. We further analyzed samples using alternative approaches for analysis of mmo including restriction fragmentation and quantitative PCR, and are moving forward with single cell genomics to address questions of methanotrophic ecology.

Conclusion

The current period saw the continued analysis of data and the publication of four papers, including two in the Proceeding of the National Academy of Sciences. We continue to transition toward data analysis and publication as this award draws to a close.

COST STATUS

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

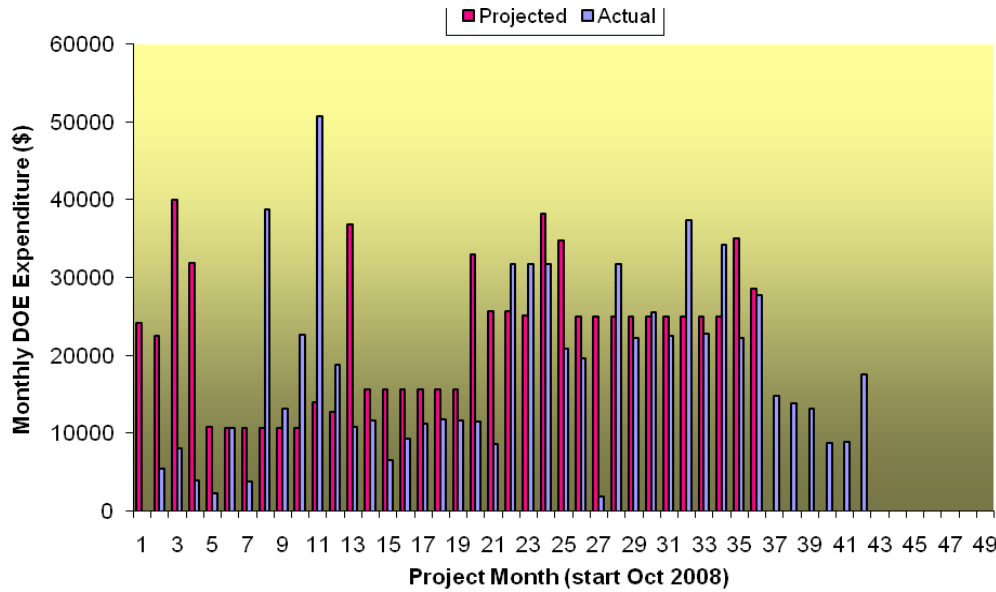


Figure 1. Project costing profile

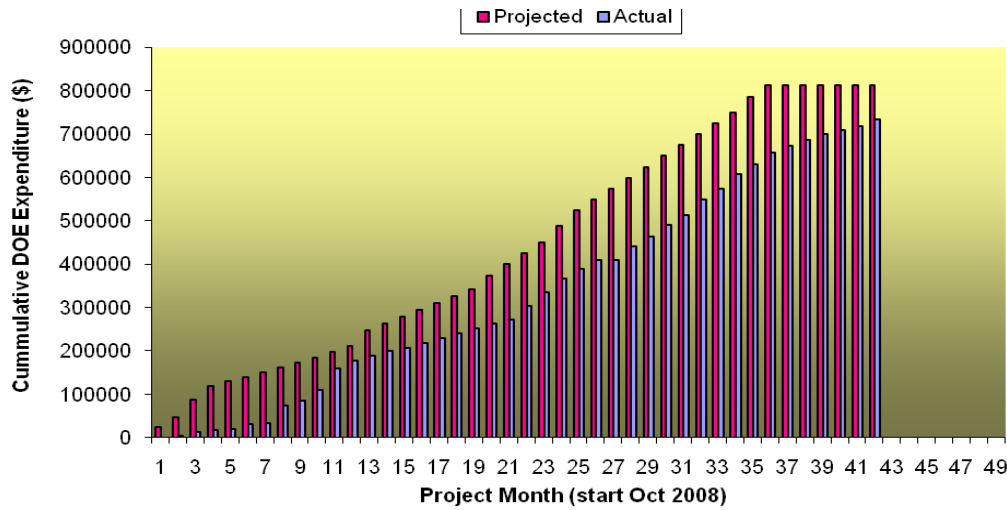


Figure 2. Project cumulative costs

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: This milestone was completed during a previous reporting period.

Milestone 2: Confirmation of $^3\text{H-CH}_4$ oxidation and $^{13}\text{C-CH}_4$ 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: This milestone was completed during a previous reporting period.

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: This milestone was completed during a previous reporting period.

Milestone 4: Completion of the Gulf of Mexico (GoM) cruise. The GoM cruise presents an unprecedented opportunity to track the fate of methane from a massive methane plume. During this cruise aboard the *R/V Cape Hatteras* samples will be collected for methane concentration, methane oxidation rates, methane stable isotopes, microbial cells, and large volume filtrates for DNA. The estimated completion of this milestone is 6/30/10 and is associated with tasks 5.3 and 10.4.

Status: This milestone was completed during a previous reporting period.

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 10/1/10.

Status: This milestone was completed during a previous reporting period.

Milestone 6: Conduct a preliminary analysis for mmo and 16SrRNA gene sequences for putative methanotrophs from the Santa Monica Basin, and compare to se-

quences 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 12/1/10.

Status: This milestone was completed during a previous reporting period.

Milestone 7: 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 4/1/11.

Status: This milestone was completed during a previous reporting period.

ACCOMPLISHMENTS

→ Published a paper in the journal Proceedings of the National Academy of Sciences (Valentine et al 2012) developing a coupled physical oceanographic and microbial metabolic model to explain the patterns, timing and impacts of hydrocarbon release to the deep ocean during the Deepwater Horizon event.

→ Published a paper in the journal Limnology and Oceanography (Heintz et al, 2012) on methanotrophy in the Basins offshore southern California. This work demonstrates important physical-oceanographic controls on the activity and efficacy of methane-eating bacteria.

→ Published a paper in the journal Continental Shelf Research highlighting a methane budget along the Northern margin of the Santa Barbara Channel.

→ Published a paper in the journal the Proceedings of the National Academy of Sciences (Ryerson et al, 2012) describing the magnitude and fate of hydrocarbon emissions from the Deepwater Horizon event. This manuscript was accepted and is now in press.

PROBLEMS OR DELAYS

None

PRODUCTS

→ Thirteenth Quarterly Report Submitted

→ Published: **Valentine DL, I Mezić, S. Maćešić, N. Črnjarić-Žic, S. Ivić, P Hogan, V Fonoberov and S Loire (2012) Dynamic auto-inoculation and the microbial ecology of a deep water hydrocarbon irruption Proceedings of the National Academy of Sciences, USA. doi/10.1073/pnas.1108820109.**

- Published: Heintz M, S Mau and DL Valentine (2012) Oceanographic Control on Methanotrophic Potential in the Santa Monica Basin, Southern CA Borderland. *Limnology and Oceanography* 57(2) 420-432. doi:10.4319/lo.2012.57.2.0420
- Published: Mau S, M Heintz and DL Valentine (2012) Quantification of CH₄ loss and transport in dissolved plumes of the Santa Barbara Channel, California. *Continental Shelf Research* 32, 110-120.
- Published: Ryerson T, Camilli R, Kessler J, Kujawinski EB, Reddy CM, Valentine DL et al. (2012) Chemical composition measurements quantify Deepwater Horizon hydrocarbon emissions and distribution in the marine environment. *Proceedings of the National Academy of Sciences, USA*, doi/10.1073/pnas.1110564109.

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