Oil & Natural Gas Technology

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Quarterly Report

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Remote Sensing and Sea-Truth Measurements of Methane Flux to the Atmosphere (HYFLUX project)

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Table of Contents

Contents

List of Figures

Executive Summary of HYFLUX Program Work

On 1 October 2008, Texas A&M University - Corpus Christi began work on the National Energy Technology (NETL) funded project Remote Sensing and Sea-truth Measurements of Methane Flux to the Atmosphere (HYFLUX). This portion of the project was Budget Period 1. Project management activities during Quarter 1 were dedicated to completing the project management plan and setting up sub-contracts with Scripps Oceanographic Institution, University of California, Santa Barbara, University of Southern Mississippi, and Texas A&M University-College Station. Discussion in relation to planning for the upcoming cruise were completed by email and conference call among the project investigators at the conclusion of Quarter 2. During Quarter 3, preparation for the seatruth cruise was the major focus of effort for all investigators. During Quarter 4, the investigators completed the seatruth cruise, currated the samples and data collected during the cruise, and submitted a report describing the results of the cruise.

Phase 2, budget period 2 for the project was initiated on 1 October 2009. Figure 1 shows a Gantt style chart outlining tasks during the quarterly period October through December 2009. This is the sixth quarter since the initiation of the project. The general work projects during this period were analyses for samples and other data collected during the Sea Truth cruise (tasks 14-18) and the continuation of satellite image acquisition and analysis (tasks 6 and 13). It also reports on presentations made at the NETL information exchange meeting on Gas Hydrate Research held in Atlanta GA 25-28 January 2010.

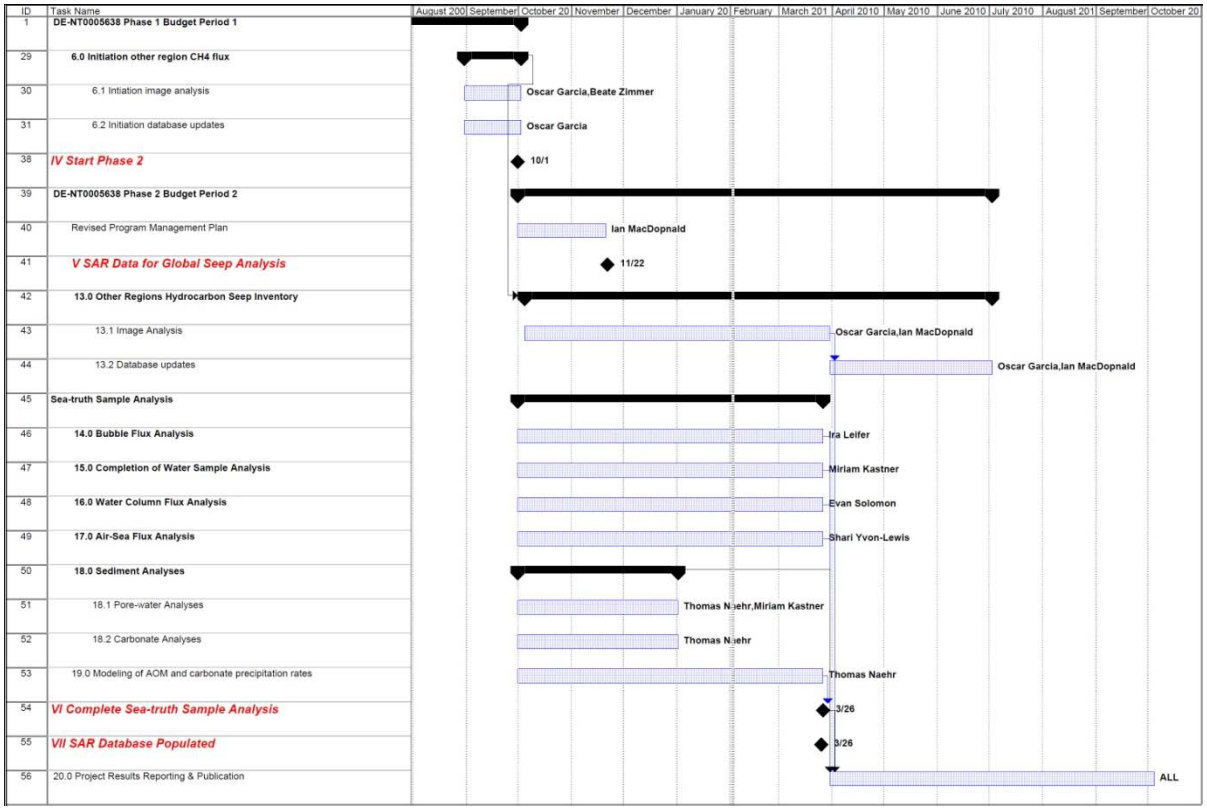


Figure 1 Gantt chart for 4th Quarter 2009 through anticipated project conclusion.

Progress, Results, and Discussion

Task 6 and 13 Other Regions Hydrocarbon Seep Inventory

Previous effort in this area involved the acquisition, review, and analysis of over 600 synthetic aperture radar (SAR) images. These images had been collected with the RADARSAT-1platform and were archived in the Alaska Satellite Facility at the University of Alaska, Fairbanks. The ongoing effort is intended to extend the methodology of detecting the location of natural seeps and probably gas hydrate deposits to other coastal margins. The team focused on operationalizing the acquisition of ENVISAT SAR images through the agreement with the European Space Agency.

Task 13.1 Image Analysis

This task requires obtaining images of satellite synthetic aperture radar (SAR) data and performing a series of image processing steps to identify floating oil layers released from natural sources. To date, the FSU team has accessed over 100 ENVISAT SAR images. In February, the a Ph.D candidate from the University of Bremen, Germany, Mr Jan Hendrik Korber visited FSU for two weeks. During this time, the team downloaded over 40 ENVISAT SAR images from the Black Sea area. Mr. Hendrik-Korber assisted by developing training sets for the neural network algorithm used to pick slick targets. The overall effort successfully identified oil slick targets in three areas of the Black Sea, including the western Black Sea (Figure 2).

Increased interest in the Eastern Gulf of Mexico resulting from President Obama's decision to lift the ban on exploration in part of that region caused a reappraisal of existing coverage in that area and an additional 100 images have been acquired to make sure that no small-scale seeps have been overlooked.

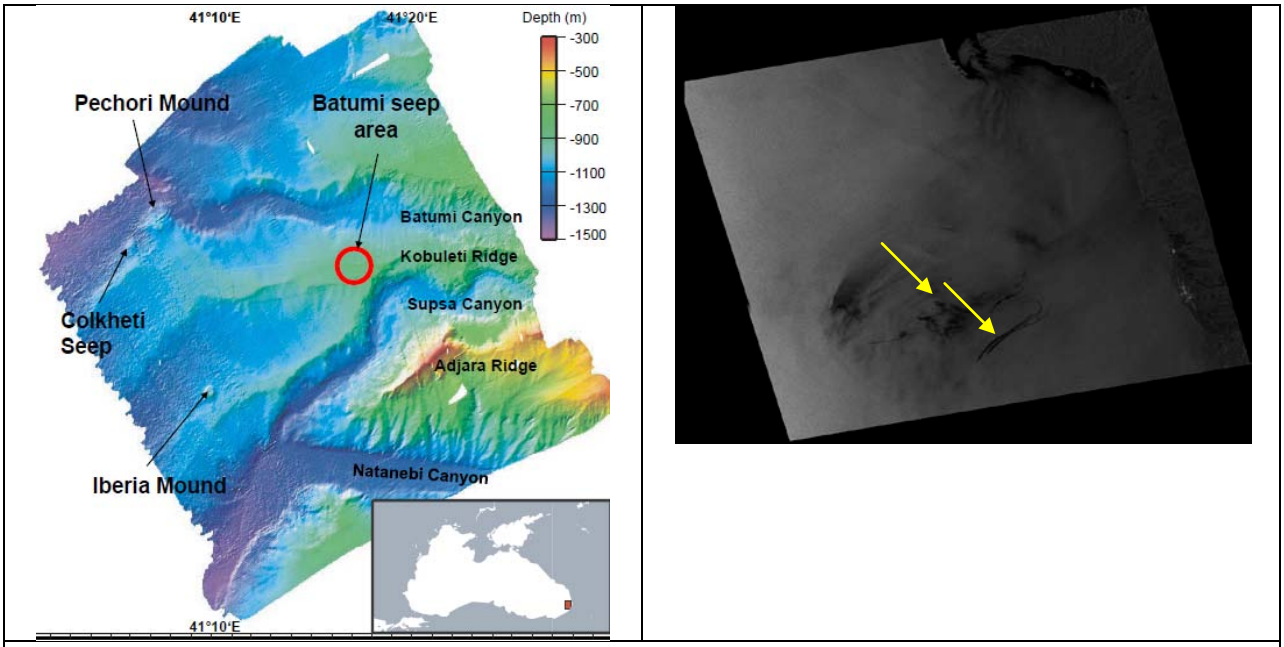


Figure 2. Left: Map of Batumi Seep area, western Black Sea. Right: Envisat image showing distinct seep targets (arrows) from the suspected seep area, confirming oil flux in region.

Task 13.2 Database Development and Update

This task requires disseminating interpreted satellite images and locations of probable seeps. The www.sarsea.org database of Gulf of Mexico has been expanded. The project has received significant assistance from the NOAA satellite group, which made collections of new SAR data during the sea-truth cruise and is supporting GUI development by sharing processing routines and procedures. The first phase of GUI development has been completed

Task 13 Bubble Flux Analysis

This task is being carried out by Leifer Lab at University of California, Santa Cruz. The bubble flux group deployed acoustic and visual-based instruments for determining bubble flux from gas venting. The acoustic results appear to be inconclusive due to problems with the equipment. However, extensive visual data were collected from each of the study sites. One of the digital video tapes has been converted to full resolution digital files on a hard disk. These images are being evaluated prior to analysis.

Task 14 Water Sample Flux Analysis

This task is being carried out by Kastner Lab at Scripps Oceanographic Institution. To date, they have completed laboratory analysis of samples collected from MC118 site and are continuing work on the balance of the samples. The DIC data are still pending. The following water samples were analyzed for C1-C5 concentrations: One submersible transect at GC 600, two transects at MC 118,and two shallow CTD casts at MC 118. 75 water samples were analyzed for d13C-CH4 from the 3 sites. The data range from -35 60 -55 permil, none is clearly biogenic methane.

Task 15 Water Column Flux Analysis

This task is being carried out by Evan Solomon at University of Washington in association with Kastner Lab. To date, they have completed the pore water analyses of 4 piston/gravity cores and one push core. Two of the pitson/gravity cores were analyzed via squeezing and Rhizon, for: Cl, one push core. All were analyzed for : alkalinity (on board, rest of the analyses were shore-based) Cl, Ca, Mg, sulfate/sulfide, K, Na, NH4 concentrations.

Task 16 Air-Sea Flux Analysis

The investigators have completed a preliminary draft of a manuscript describing their findings showing observed methane concentrations is air and water obtained during the Seatruth cruise. This result is under review by the team to coordinate findings.

Task 18 Completion of Sediment Analysis

This task is being carried out by Naehr Lab at Texas A&M University-Corpus Christi. Detailed sampling for high-resolution physical property (water content and porosity) and geochemical analysis of the sediments was carried out in 2-cm increments while paying special attention to high-resolution sampling across the sulfate-methane interface. Percent carbonate, bulk sedimentary carbonate ($\delta^{13}C$ and $\delta^{18}O$) and bulk sedimentary organic matter ($\delta^{13}C$ and $\delta^{15}N$) analyses are completed. Samples for total carbon, organic carbon, organic nitrogen, and sulfur were analyzed using an elemental analyzer at TAMUCC. Foraminifera radiocarbon (^{14}C) measurement have been conducted to constrain the age of the sediments. Pore fluid analyses on

sediments collected using push cores, piston cores and gravity cores in areas of active seepage have been completed in collaboration with M. Kastner's lab. Pore water analyses included measurements of SO_4^{2-}, alkalinity, HS^-, and Ca^{2+}. Cores taken at Mississippi Canyon site MC 118 showed sulfate concentration gradients typical of anaerobic oxidation of methane (AOM)-driven sulfate reduction. Accordingly, alkalinity concentrations increased with depth due to AOM. Calcium concentrations showed a decrease due to the precipitation of calcium carbonate in the shallow subsurface. Data from a 10 cm-long push core taken at site MC 118 showed the same trends in SO_4^{2-} reduction, a decrease in Ca^{2+} concentrations, along with an alkalinity increase and HS^- production. Two piston cores were taken at site GC (Green Canyon) 600. The first core showed SO_4^{2-} concentrations decreasing to 0 mM at 20 cm below seafloor (cmbsf), accompanied by an increase in HS^- concentrations in the same depth interval (Fig. XX). Alkalinity and Ca^{2+} concentrations both increased with depth, the latter potentially being the result of carbonate dissolution in the subsurface. The second piston core showed a typical concentration profile for seep areas. Sulfate concentration decreased to 3 mM at 44.5 cmbsf, coupled with the typical inverse relationship with HS^-. Alkalinity concentrations yielded a steady increase with depth, accompanied by Ca^{2+} depletion. One piston core was taken at site GC 185 (Bush Hill), which showed pore water gradients typical for background sediments in this area. Pore water and sediment data will be used to model carbonate precipitation rates using the numerical model C.CANDI (see Task 19).

Task 19 Completion of modeling of AOM and Carbonate Precipitation Rates

This task is being carried out by Naehr Lab at Texas A&M University-Corpus Christi. Pore water and sediment data are used to model carbonate precipitation rates using the numerical model C.CANDI. The investigators have acquired and installed the software, and compiled it for use in a PC environment. We have started using data from site GC 600 to model rates of AOM and authigenic carbonate precipitation. We are also exploring other modeling approaches to determine AOM and carbonate precipitation rates.

Presentations and publications

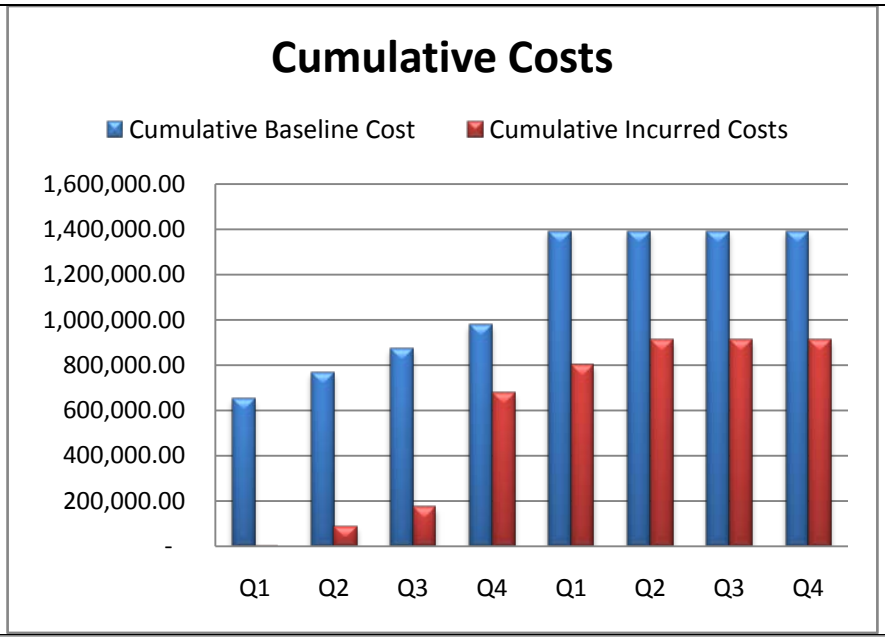
Members of the HYFLUX team attended the Atlanta Hydrate Meeting. MacDonald gave an oral presentation with an overview of the project. Individual team members provided posters detailing specific aspects of the project. Poster titles were as follows:

- Seafloor characteristics of a hydrate site detected by remote sensing (Garcia),
- Air-sea flux of methane from deep hydrocarbon seeps in the northern Gulf of Mexico during HYFLUX (Hu),
- Preliminary methane flux calculations from water column samples (Solomon / Kastner),
- Modeling carbonate precipitation at Gulf of Mexico hydrate sites (Naehr)

Collaborative effort

MacDonald will travel to Lawrence Livermore Labs in Berkeley the week of 11 May to begin collaborating with Dr. Matt Reagan on modeling hydrate stability in the Gulf of Mexico. The effort will combine the distribution and abundance results from the remote sensing effort with Reagan's expertise on stability fields.

Cost Status



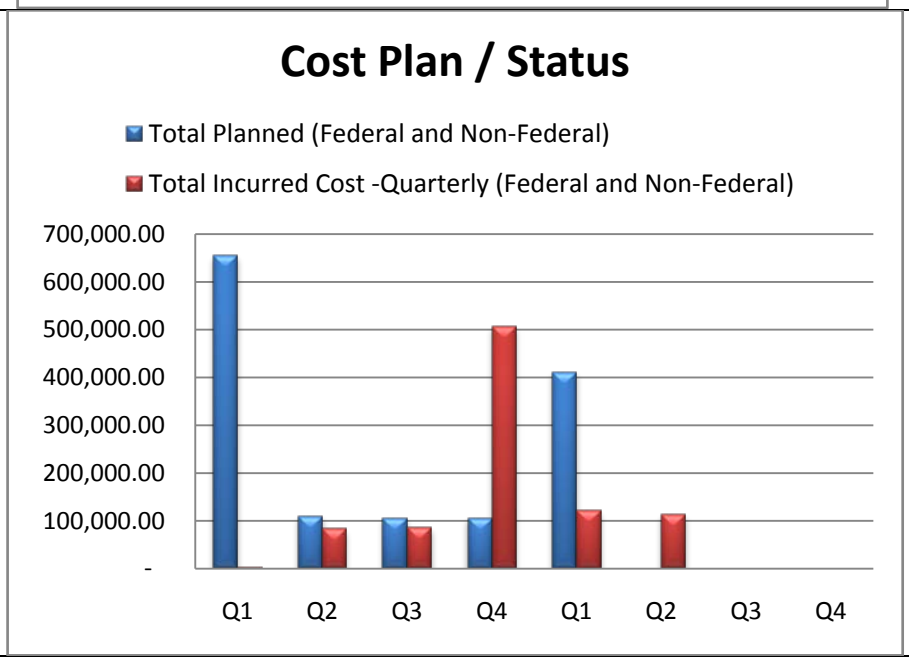


Figure 3 Expenditures by Quarter. Cummulative projected costs (upper panel) and cost status as of Quarter 6.

Milestone Status

No Milestones achieved during this reporting period.

Problems or Delays

There are ongoing problems converting the digital video recorded during the Seatruth cruise into a format that can be viewed and analyzed by available video players. A vendor who can convert the digital format has been found and all remaining tapes have been sent for conversion.