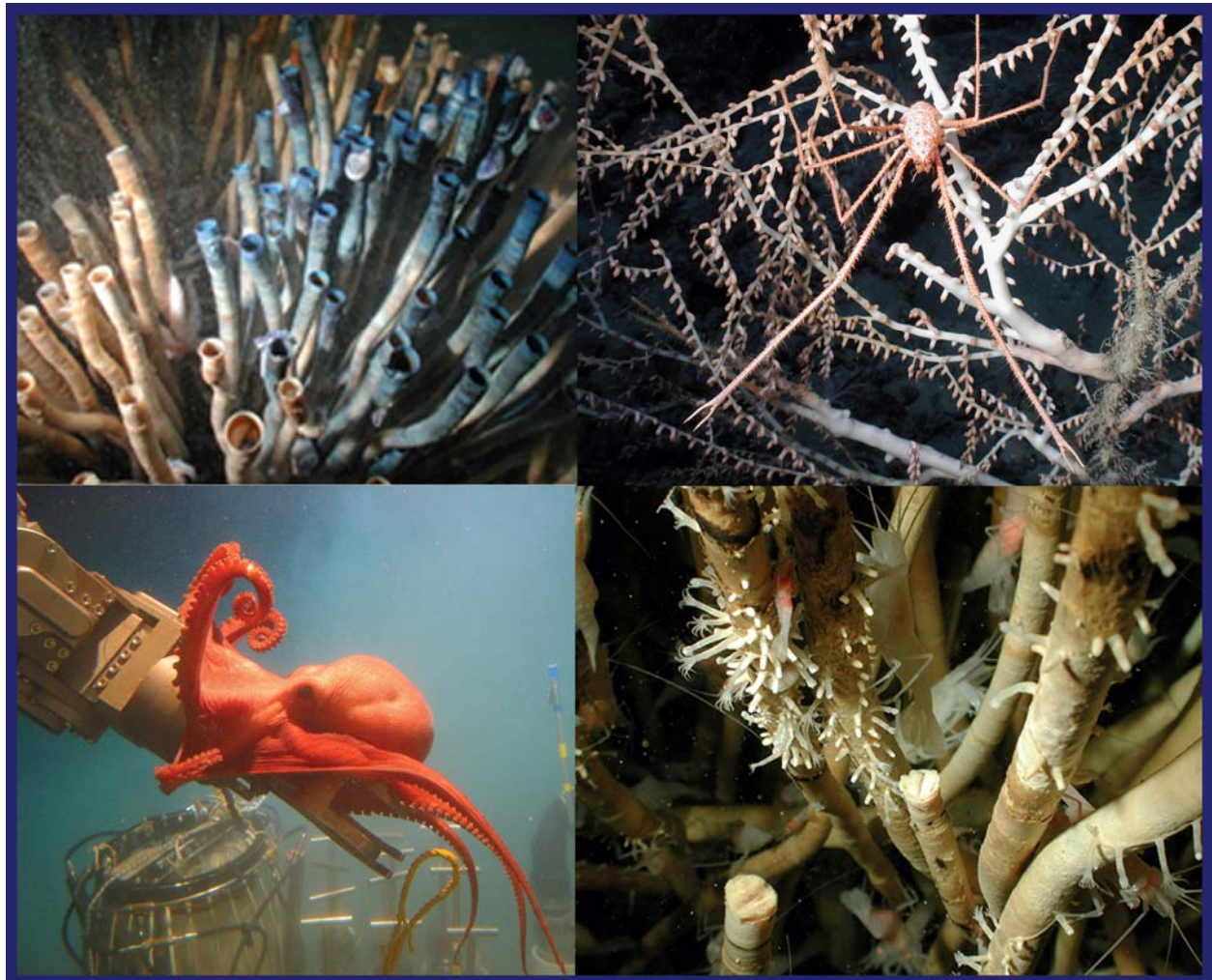




Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico

Interim Report 2



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COVER ART

Photographs from chemosynthetic communities visited during the program.

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OVERVIEW

This document represents TDI-Brooks International Inc. Second Interim Report for contract number: 1435-01-05-39187, issued by the U.S. Department of the Interior, Minerals Management Service “Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico” (CHEMO III). This report compiles detailed information regarding operational procedures, stations occupied, sampling activity and preliminary results. The information in this report is a compilation of three cruises. The Reconnaissance Cruise was conducted on the TDI-Brooks research vessel R/V GYRE from 11 to 25 March 2006 and was the initial cruise conducted for this contract. The cruise was completed in two week-long legs with an interim port call in Venice, LA. Leg I (11-18 March) was dedicated to drift camera work to survey the seabed at selected sites. Leg II (19-25 March) involved both drift camera and trawling/box core work efforts. The cruise mobilized and embarked from Freeport, TX. The objective was to provide timely input for the site selection process for the subsequent ALVIN expedition (May 2006). The Deep Chemosynthetic Community Characterization Cruise was conducted on the Wood’s Hole Oceanographic Institute (WHOI) research vessel R/V ATLANTIS and the ALVIN Deep Submergence Vehicle (DSV) from 7 May – 2 June 2006, and was the second cruise conducted for this contract. The cruise mobilized and embarked from Key West, Florida, and demobilized at Galveston, Texas. Results reported were obtained by analysis of the sampling information and data during the cruises and immediately afterward. Results could be revised. In February 2007, sampling sites were mapped in great detail using the C&C Technologies Autonomous Underwater Vehicle (AUV) in preparation for intensive sampling planned for the 2007 field season. The AUV is equipped with instrumentation for collecting high-resolution multibeam bathymetry, chirp sonar subbottom profiles, and side-scan sonar swaths. AUV data sets for AT340, GC852, WR269, and AC601 were acquired. The Deep Chemosynthetic Reconnaissance II Cruise (DCR2) was conducted on the NOAA Ship research vessel *Ronald H. Brown* and the ROV JASON from 4 June - 6 July 2007, and was the fourth cruise conducted for this contract. The cruise mobilized and embarked from Panama City, Florida, and de-mobilized at Galveston, Texas. Post-cruise reports were completed for all cruises and were submitted to MMS. The data from the cruises was up-loaded to a site located on the TDI-Brooks International Website. All program researchers have password-protected access to these data. This report is a preliminary product of the contract.

BACKGROUND

The largest oil reserves in the continental United States are found in the Gulf of Mexico. The Minerals Management Service (MMS) is responsible for overseeing the responsible extraction of these natural resources. By the early 1980s, energy companies had developed the technology to explore and extract oil and gas in waters up to 1,000 m deep.

During the mid to late 1980s, MMS contracted with the Geochemical and Environmental Research Group (GERG) at Texas A&M University (TAMU) to collect animals from areas of the deep sea floor associated with active oil and gas seeps. The original expectations of both the MMS and the scientists involved were that few animals would be found associated with these “toxic” sea floor environments, and that perhaps the few that were found would be unhealthy at best. However, when the trawls came to the surface over Bush Hill a site that became one of the best studied seep sites in the world, they were so full of animals the nets could only be brought

on board with the help of an extra crane. In addition, the animals were not the usual fauna of the deep Gulf of Mexico. The nets were full of giant tubeworms and mussels, which had only recently been discovered at deep-sea hydrothermal vents in the Pacific Ocean. Since that time similar (but different) cold-seep and hydrothermal-vent communities have been discovered in many different geological settings in the world's oceans.

Over the last 20 years these animals and communities have been studied at moderate depths in the Gulf of Mexico (GoM), along with the geology, geochemistry, and microbiology that allows them to flourish. As a result, the hydrocarbon seep communities in less than 1,000 m on the Upper Louisiana Slope of the Gulf of Mexico, are the most intensively studied and most understood of any deep-sea cold-seep communities in the world. The basic biology of the dominant animals, their life histories, and the biodiversity and biogeography of the seep and coral communities on the Upper Louisiana Slope is now understood. The successional processes that lead to the eventual development of coral communities on carbonates created during periods of active hydrocarbon seepage is understood. Also discovered are some amazing communities, such as the ice worms that inhabit methane ice and the mussels that ring the Brine Pool NR-1.

Meanwhile, energy companies have continued to develop the technology to extract oil and gas from deeper and deeper water and now have the capability to drill oil wells in all water depths in the GoM Outer Continental Slope. Although several GoM hydrocarbon seep sites at depths greater than 1,000 m have been visited by scientists, only a single site has been the focus of more than a few exploratory dives. This site, at 2,200 m in Alaminos Canyon, has lush communities of tubeworms and mussels that are reminiscent of the shallower sites that are well known. However, the underlying geology and almost all of the species present are different. Preliminary studies indicate that the structure of the communities associated with the tubeworms and mussels is also quite different. The normal "background" fauna are different at this depth, and different patterns of interaction between these animals and the seep specific animals are expected. Not only is the ecology of this deep community not understood, at this point the types of communities that exist at depths between 1,000 and 2,200 m are not known. Advances in this understanding and knowledge are the goal of this contract.

PURPOSE

The primary purpose of this research is to discover and characterize the sea floor communities that live in association with hydrocarbon seepage and on hard ground in the deep Gulf of Mexico. The sites studied are in areas energy companies will soon drill for oil and gas.

PREPARATION

Preparation for this program began in the fall of 2005, when Harry Roberts began to study a variety of types of information that would help discover new hydrocarbon seep and hard-ground communities in the deep Gulf of Mexico. Information was gathered from thousands of cores collected by the TDI-Brooks International, Inc. group, satellite images of persistent oil slicks on the surface of the Gulf, and extensive collections of geophysical data and maps of the sea floor that were made available for this project by the Minerals Management Service. Fourteen sites were identified with a high potential to host lush chemosynthetic and/or deep-water coral communities.

In March of 2006, the first cruise of this program, the Reconnaissance Cruise (RC), began on the RV GYRE. Thousands of pictures of the sea floor were taken at locations identified by Roberts and his team. These pictures provided the first look at the dive sites we were to dive on for the ALVIN mission. Some sites revealed little except a muddy sea floor. At most of the sites there was strong evidence of seepage, and at least scattered occurrence of the types of animals expected at seep sites. In one case there were abundant soft corals, and at a few, there were large communities of seep animals.

Based on the Reconnaissance Cruise Report, the images of the sea floor, previous knowledge of the geophysics and geochemistry of the sites, and a desire to explore over a wide depth and geographic range, the cruise and dives for the Deep Chemosynthetic Community Characterization (DCCC) expedition were planned and completed.

SAMPLING PROCEDURES

CTD and Associated Hydrography

The CTD was deployed at seven sites on the DCCC cruise. Samples were taken to within 2 m of the bottom to characterize the bottom water. The near bottom bottles were sampled for particulate matter, POC, plant pigments, dissolved inorganic nutrients, oxygen and salinity. The oxygen, temperature, salinity, *in vivo* fluorescence, light intensity and light transmission were measured continuously with sensors and recorded aboard ship in real time. The oxygen and salinity were calibrated aboard ship with samples from the bottles. The inorganic nutrients were run with an autoanalyzer aboard ship on the first leg and frozen on the second leg for analysis in the shore-based laboratory. The CTD and Niskin logs are shown in **Appendices 2 and 3**.

Photographic Imaging

Seafloor Imaging

During the first cruise (RC), the basic objective was to visually confirm the presence of a significant community of chemosynthetic or hard bottom fauna at the potential sites and to locate these communities as precisely as possible on the seafloor. The tool used for imaging the seafloor was the Drift Camera System (DCS). This combines a 3.2 mega-pixel Nikon digital camera with strobe illumination. The DCS was deployed on a frame lowered from the surface ship and held 2-5 m above the bottom based on feedback from a SeaBird CTD with altimeter. A rendered drawing of the camera system and the configuration used during the Photo Reconnaissance Cruise is shown in **Figure 1**. Lead weights were attached to the DCS in order to bring its weight in air to 400+ kg.

A 28 kHz depthfinder was used throughout the cruise. In previous efforts, this type of sensor has detected gas plumes in the water column associated with seeps. On this cruise, the high-resolution depth finder was not available until the second leg. Although some possible gas plumes were noted, the heavy seas experienced throughout the cruise precluded consistent sensing of gas plumes. Consequently, the water column imaging was not collected. Heavy seas also hampered the ability to observe natural oil slicks generated by oil and gas arriving at the surface. One active slick was observed at 27.371°N and 90.573°W.

During the second cruise (DCCC) the project used two major types of digital photographic images obtained during the ATLANTIS cruise. Down-looking images were taken with a digital camera mounted behind the ALVIN equipment basket and operated by a timer so that a picture was taken every 10 seconds. By merging the time each picture was taken with ALVIN's navigation records, an accurate record of the location of each picture could be compiled. Although image quality was generally excellent or good, it was sometime compromised by disturbed sediment or because the submarine was too far off the bottom to view the bottom. Additionally, when the submarine was at rest on the bottom the repeated images of a small area of seafloor were of no value. The complete set of down-camera images was screened to remove unusable images. The screened subset was termed and labeled "bottom in view" (BIV) images. A second set of digital images was taken using a macro-camera positioned by the ALVIN manipulator. These images show details of animals or geology at selected locations.

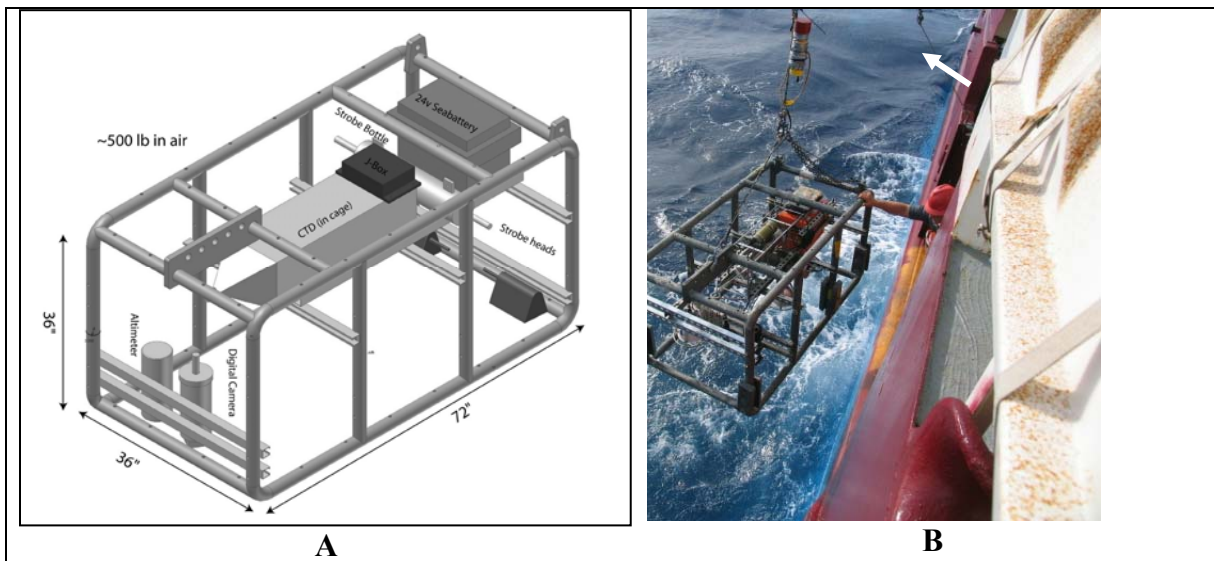


Figure 1. (A) Rendering of the drift camera system with components labeled. (B) DCS being deployed from GYRE during the survey cruise.

Time-Lapse Camera

This task requires developing a system for short- and long-term photographic sampling in the seep environment. The proposed methodology calls for use of a digital camera controlled by a time-lapse switch and mounted on a rotary platform. A prototype of this camera was deployed during the May 2006 ALVIN cruise for two short intervals to test the equipment, lighting, and battery. The deployments proved somewhat problematic, but were ultimately successful and a rotary time-lapse system was left at the GC852 site for recovery during the 2007 cruise.

During the intervening time, MacDonald and his students have been working to improve the design of the deployment/recovery system for the rotary time-lapse camera and to refine other aspects of this instrument. The present version of the rotary time-lapse camera is shown in **Figure 2**. Progress on the design can be summarized as follows:

- Glass housing was redesigned to permit deployment at all study sites.
- Compact battery housing was designed to facilitate deployment and recovery.
- Autonomous recovery platform was designed and successfully tested.
- Two rotary time-lapse systems have been acquired for use with the program.

In addition to work on the time-lapse camera, MacDonald's macro and survey digital camera systems were refurbished and checked in preparation of the 2007 cruise. Likewise, the CTD used during the March 2006 reconnaissance cruise was re-calibrated and checked for possible future use.

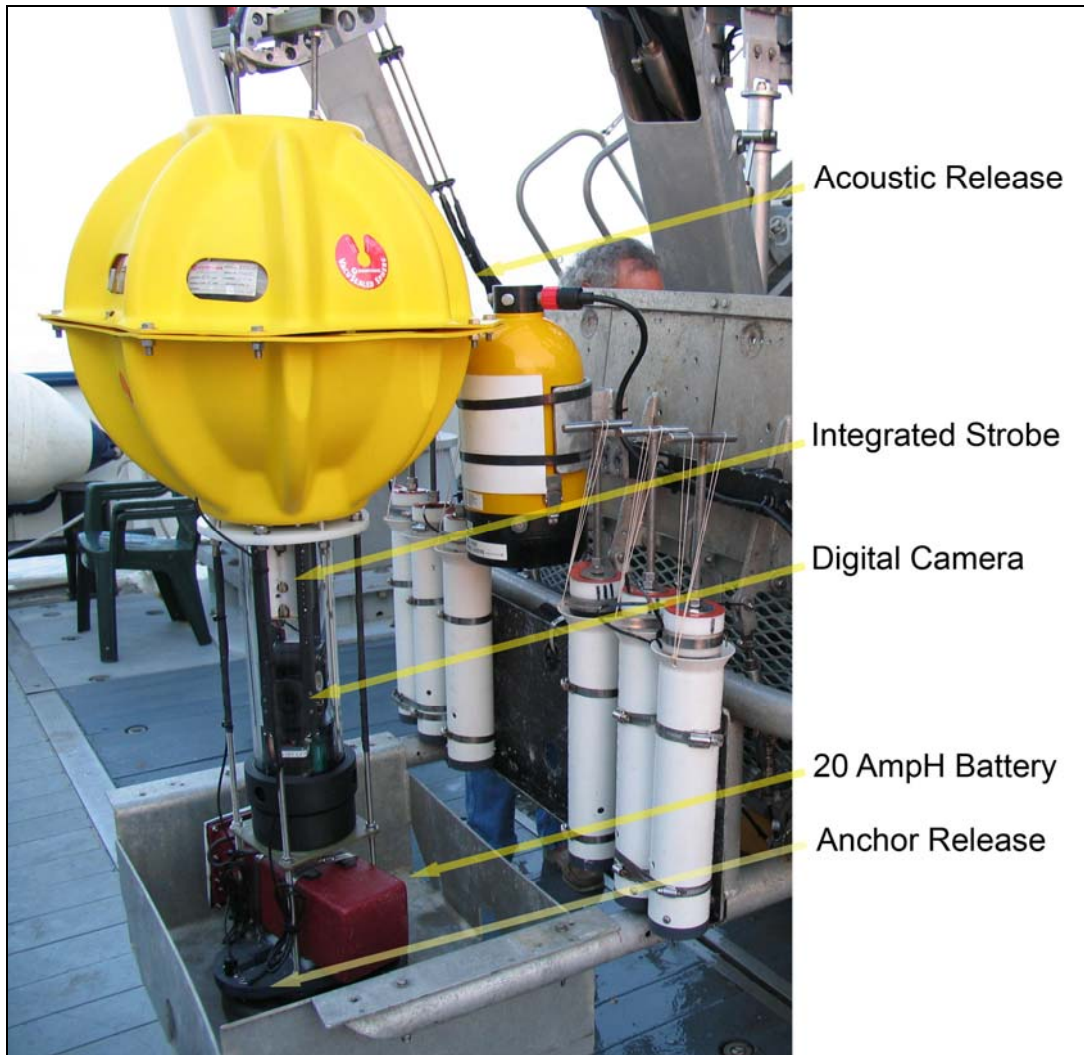


Figure 2. Rotary time-lapse camera and recovery platform.

Navigation

Precise navigation of the DCS was obtained from an ultra-short baseline (USBL) transponder calibrated with the ship's DGPS. The TDI-Brooks field group uses this system for taking piston and box cores at preset locations and is routinely able to do so within a 5 m radius of the target. TDI-Brooks has developed a system and technique for navigating a deployed tool weighing at least 400 kg over a precise location in X, Y, and Z in down to 3,000 m of water, in order to sample from that specified target.

In order to achieve the positioning and navigation requirements of this cruise, R/V GYRE was equipped with a C-Nav DGPS system with a moonpool-mounted Simrad HRP-410 USBL transceiver and Simrad MST-342 3,000 m beacons. The USBL transducer head can lock onto a beacon with a ± 15 degree cone of coverage, thus increasing resolution versus a wide coverage cone. When the head receives in the narrow beam range the geometry increases the noise immunity from four db to 15 db, effectively increasing the noise rejection by a factor of 16.

The HPR-410 USBL system was interfaced to a VSS DMS05 Motion Reference Unit (MRU), which is also interfaced to the WinFrog navigation system such that real time position of the transponder is displayed on the monitors for the navigator, the helmsman, and the winchman. NMEA output of heading from the vessel gyro and the DGPS were interfaced via RS-232 directly to the navigation computer as well as to the computer dedicated to USBL control. The transponder positions were processed and managed in real-time using Kongsberg APOS software. This arrangement provides an independent check on the WinFrog offsets and datum conversions. A schematic of this USBL system is shown in **Figure 3**.

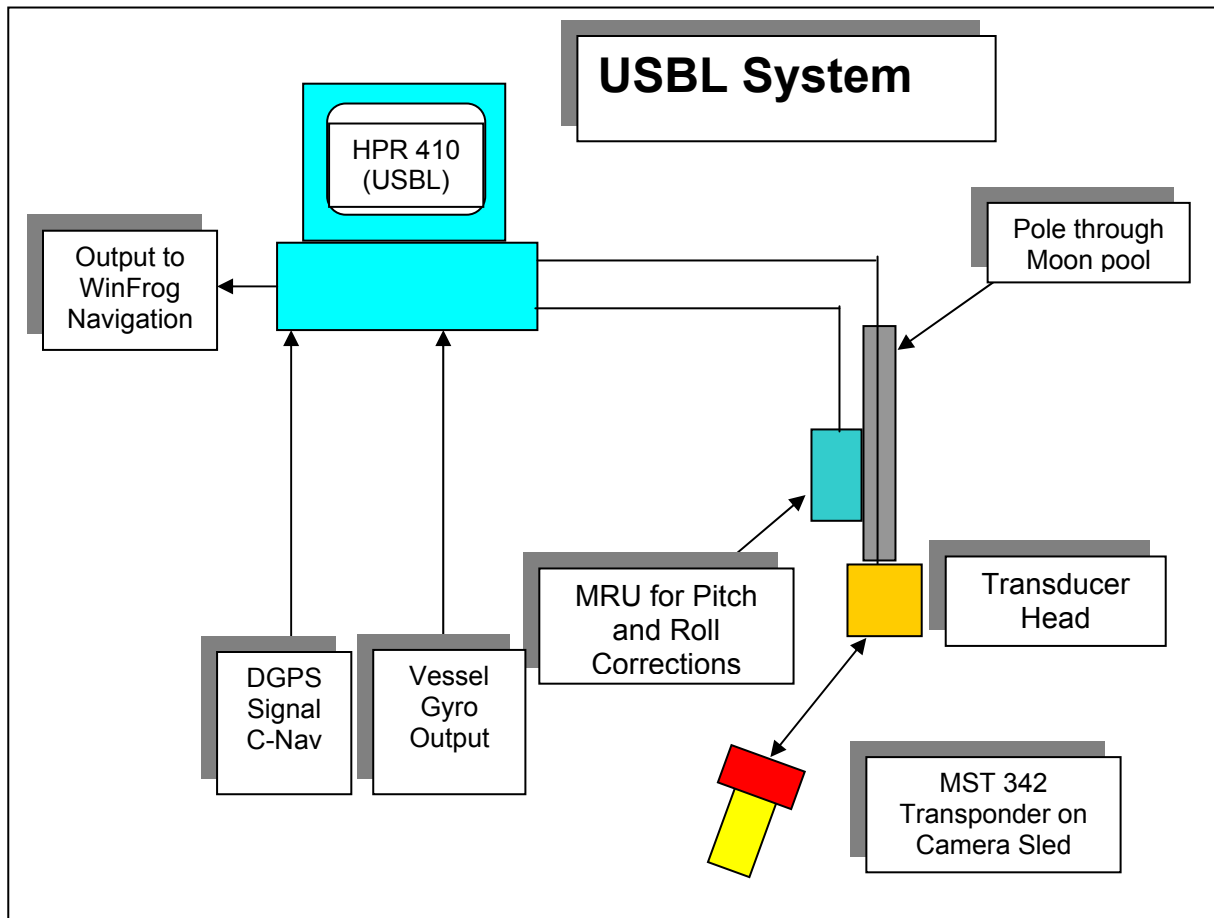


Figure 3. This Kongsberg HPR-410 system and WinFrog data logger collected detailed position information for the vessel and the DCS.

The standard operation procedure used to survey sites of interest was to locate a target area or areas based on the proprietary geophysical data provided from MMS. The bathymetric contours of the site and the targeted area were drawn as the background on the navigation computer monitor. The on-going track of the photoplatform was visually monitored and evaluated during the deployment period.

Trawling

A 40-ft, semi-balloon trawl was used during the RC cruise. It was towed at least 5 km from detailed study sites to obtain a large number of background species for isotopic characterization. The trawling was conducted during day and night operations on R/V GYRE.

All trawl samples on the DCCC cruise were taken with an eight foot Agassiz-type beam trawl that was lowered and recovered at 50 m/min as tension allowed. Towing speed was 1-2 kn over ground. The purpose of sampling was to obtain specimens for trophic analysis within 5 km of seep sites.

Trawling was concentrated at study sites AT340, GC825, and AC818. Sampling at GC825 proved problematic due to strong currents. Adequate material was obtained at all three sites.

Box Coring

A Gulf of Mexico type box core was used during the JC cruise to sample background benthic infauna at 1 km and 5 km from detailed study sites. Due to tissue requirements of isotope analysis, larger macrofauna were sought and samples processed through a 0.5-mm screen.

ADCP

Acoustic Doppler Current Profilers (ADCP) were operated on station and with the ship underway to obtain an integrated picture of current direction and velocity in the upper 1,000 m of the water column. A 38 kHz OS-ADCP was operated for the entire cruise. Data processing is ongoing.

Mapping

Maps were made during the sampling at each site at scales of 10 to 50 km around each site, with topography plotted at 50 m intervals. The locations of each sampling activity were plotted to show the spatial relationships between each sampling device and sampling replicates.

Macrofauna

Mussel Sampling Protocol

The mussel pot collection devices consist of a 'pot' made of 1/8" thick rolled aluminum with an interior diameter of 26 cm and a height of 29 cm. The inside is lined with a Kevlar bag that is closed by rotating a handle on the top of the pot that cinches the bag closed using a draw string. This can be done with a single manipulator capable of 360° rotation by using a hydraulic ram on the manipulator and an anti-rotation bar on the pot. When the bag is cinched shut a 10 cm high aluminum ring can be released that marks the collection location and allows photographic documentation of the collection scar (and therefore quantification of megafauna missed on uneven hard substrates).

One of the most challenging aspects of the community sampling in the first field season was the presence of extremely large (up to 25 cm in length) mussels that had a tendency to foul the

opening of the mussel pots. To overcome this problem, a 63 μm mesh nytex liner (similar to the liner of the Bushmaster) was fitted to the inside of a coarse-mesh net (the “scoop”) and used to sample a number of mussel beds. The manipulator of the submersible dragged the scoop through the mussel bed then placed the entire scoop into a biobox and closed the lid. In planning for the 2007 field season, the samples obtained by each method were compared to determine if the two methods sampled similar communities from the same habitats. There were 8 scoop samples taken at 6 sites and 12 mussel pots taken at 8 sites in 2006. Scoop samples contained an average of 9.0 species and 243 individuals per sample, while mussel pots contained an average of 7.2 species and 79 individuals per sample, and the scoop sampled species at a greater rate per sample. Statistical analyses were carried out on relative abundance data (proportion of individuals in each species) because not all scoop samples were lined with the finer mesh in 2006 and not all mussel individuals were measured in all scoop samples. Even with these differences in methodology, the relative abundance of species was not significantly different between the two sampling devices (ANOSIM, Global R = 0.055, P = 0.237). A multidimensional scaling (MDS) ordination confirmed this result, where similarity among mussel communities was more highly governed by site than by collection method. These results indicate that the scoop samples are a sufficient sampling method for determination of species richness and diversity indices for the mussel beds encountered, particularly for the mussel beds composed of large *B. brooksi* individuals. Therefore, these two sampling devices were combined in the subsequent analyses.

Tubeworm Sampling Protocol

Sampling of tubeworm aggregations was carried out using the Bushmaster Jr. collection device. This device is a net that is suspended and held open by a framework of flexible ribs, with a “drawstring” stainless steel cable that can be hydraulically actuated to close the net completely. The inside of the net is lined with a 63 μm nylon mesh and retains all fauna above that size. The open diameter of the Bushmaster Jr. is 0.7 m.

Sample Processing

Samples from the bushmaster and mussel pots were placed in containers lined with 63 μm mesh on the front of the submersible while the mussel scoops were twisted closed and placed into a biobox. Upon retrieval of the submersible the sampling gear were labeled and transferred to designated bins for immediate processing. Tubeworms and mussels were rinsed and removed and were measured. Large macrofauna was removed and the remaining fauna retained on a 1 mm sieve sorted with subsamples of the remaining material taken for meiofauna investigations. All tubeworms and mussels were measured and subsamples taken for genetic and stable isotope investigations. Macrofauna were sorted into morphospecies on board ship, or were preserved in higher taxonomic groups if identification was impractical (primarily small polychaete species). All macrofauna that could be reliably sorted into morphospecies on board ship were also sampled for isotopic and genetic analyses.

Microbiology/Biogeochemistry

Water Column Biogeochemistry

Sample Collection and Analysis – DCCC Cruise

At the intensively sampled stations, during the DCCC cruise, water samples were collected at 20 depths between the surface and about 3 m above the sediment column using a rosette package.

The rosette package consisted of:

- 1) 20 (10 liter go-flo trace-metal) clean water sampling bottles,
- 2) SBE9+ CTD (dual SBE3T/SBE4C sensor system plus extra SBE3T temp, SBE4C conductivity, and SBE43 oxygen sensor),
- 3) Benthos - Datasonics PSA-916 altimeter;
- 4) 100x gain Wetlabs C-Star transmissometer, and
- 5) 660 nm wavelength, 25 cm pathlength Wetlabs ECO-AFL chlorophyll fluorometer.

Physical data from sensors 1 through 4 were collected during descent and ascent. The go-flo bottles were remotely triggered at select depths during ascent of the rosette except for the second cast at AC601, where bottles were tripped on the descent as well as on the ascent.

Once on deck, the go-flo bottles were opened carefully to collect samples for subsequent quantification of concentrations of dissolved oxygen, dissolved methane, inorganic nutrients (ammonium, nitrate+nitrite, phosphate, and silicate) and dissolved organic carbon. Microbiological samples were also collected to determine microbial abundance (*i.e.*, cell counts) and diversity (detail on these samples is provided in **Microbiology and Molecular Biology**). Oxygen concentrations were determined with a high-sensitivity galvanic oxygen sensor in a closed circulation cell. To quantify dissolved methane concentrations, sonication/vacuum extraction was used to isolate methane and quantify its concentration using gas chromatography (Suess et al., 1999). Nutrient (NO_3^- , PO_4^{3-} , and SiO_2) concentrations were determined using automated flow-injection on a Lachat QuickChem 8000. NH_4^+ concentrations were measured using the phenol hypochlorite method (Solarazano 1969). Dissolved organic carbon was determined using a Shimadzu TOC 5000 (Sharp et al., 1993). Rates of aerobic methane oxidation were measured by incubating triplicate live and dead (Hg-killed) samples in the presence of $^{14}\text{CH}_4$ (Joye et al., 1999) for 48 hours. Unreacted $^{14}\text{CH}_4$ tracer was removed by purging samples with water-saturated CH_4 and the oxidation product, $\text{H}^{14}\text{CO}_3^-$, was quantified by liquid scintillation counting (Joye et al., 1999).

Sample Collection and Analysis – JASON Cruise

Water samples were collected using Niskin bottles fired from the JASON at GC697, AT340, GC852, GB647, AC645 and AC601.

Once on deck, the niskin bottles were opened carefully to collect samples for subsequent quantification of concentrations of dissolved oxygen, dissolved methane, inorganic nutrients (ammonium, nitrate+nitrite, phosphate, and silicate) and dissolved organic carbon. Microbiological samples were also collected to determine microbial abundance (*i.e.*, cell counts). Oxygen concentrations were determined with a high-sensitivity galvanic oxygen sensor in a closed circulation cell. To quantify dissolved methane concentrations, headspace extraction followed by gas chromatography was employed. Nutrient (NO_3^- , PO_4^{3-} , and SiO_2) concentrations were determined using automated flow-injection on a Lachat QuickChem 8000. NH_4^+ concentrations were measured using the phenol hypochlorite method (Solarazano 1969). Dissolved organic carbon was determined using a Shimadzu TOC 5000 (Sharp et al., 1993). Rates of aerobic methane oxidation were measured by incubating triplicate live and dead (Hg-killed) samples in the presence of $^{14}\text{CH}_4$ (Joye et al., 1999) for 48 hours. Unreacted $^{14}\text{CH}_4$ tracer

was removed by purging samples with water-saturated CH₄ and the oxidation product, H¹⁴CO₃⁻, was quantified by liquid scintillation counting (Joye et al., 1999). Nitrification rates were determined by measuring the increase in nitrate concentration over time.

Sample Inventory – DCCC Cruise

Seven CTD casts at three stations (two at AT340, three at GC852, and two at AC601; **Table 1**) generated 148 samples for oxygen, methane, nutrient and DOC concentration analyses. Six rate samples were generated for 100 of these water samples, yielding 600 additional samples.

Table 1.

Summary of Water Column Sampling Program--DCCC Cruise

Date	Site	CTD Cast #	Go-flo bottles tripped
5/15/06	AT340	1	23
5/17/06	AT340	2	20
5/20/06	GC852	3	18
5/22/06	GC852	4	20
5/22/06	GC852	5	21
5/29/06	AC601	6	23
5/31/06	AC601	7	23

Sample Inventory – JASON Cruise

Six sets of water samples were collected, generating 18 samples for oxygen, methane, nutrient and DOC concentration analyses. Six to ten rate samples were generated each water sample, yielding 100 additional samples.

Table 2.

Summary of Water Column Sampling Program – JASON Cruise

Date	Site	CTD Cast #
6/16/07	GB697	J2-274
6/21/07	AT340	J2-277
6/23/07	GC852	J2-278
6/26/07	GB647	J2-280
6/28/07	GC645	J2-281
7/2/07	AC601	J2-283

Sediment Biogeochemistry

Sample Collection and Analysis – DCCC Cruise

Sediment push cores were collected into polycarbonate core liner by positioning the core liner over an appropriate site with the ALVIN's manipulator arm (**Appendices 4 - 7**). Up to 12 cores were collected on each of the coring dives (14 of the 24 dives were coring dives; **Table 3**). Some degassing of methane-laden cores occurred during return to the surface and this was particularly notable at the deepest sites (*e.g.*, AC601). Once the submersible was secure in the hanger, cores (or brine samples) were transferred immediately to the 4 °C environmental room. Geochemistry cores were sectioned under anaerobic conditions and sub-samples were collected at 2 cm depth intervals for determination of concentrations of the following components: pH, salinity, dissolved gases, dissolved and particulate carbon and sulfur species, dissolved nutrients, metals, and redox metabolites (*e.g.*, hydrogen sulfide and dissolved inorganic carbon). Salinity was determined using a hand-held refractometer. Measurements of pH were done on board ship using an Accumet high precision electrometer that was calibrated with N.B.S. standards (pH 4, 7 and 10).

Concentrations of C₁ to C₅ hydrocarbons were determined on a sediment sub-sample via headspace extraction (done on board the ship) and gas concentration was quantified using gas chromatography (Joye et al., 2004). Concentrations of dissolved hydrogen in the sediment porewater were determined following sediment incubations (~10 days) using a reduction gas

analyzer (Orcutt *et al.*, 2005). Sediment porosity was determined as weight loss after drying (Joye *et al.*, 2004). Concentrations of dissolved inorganic carbon in the pore water were determined using a high sensitivity infrared gas analyzer.

Concentrations of hydrogen sulfide were determined colorimetrically (Cline 1969). Concentrations of anions (sulfate, chloride, iodide, and bromide) and cations (sodium, potassium, calcium, magnesium and barium) were determined using ion chromatography (Joye *et al.*, 2004). Concentrations of Fe^{2+} and Mn^{2+} were analyzed colorimetrically using the ferrozine and formaldoxime methods, respectively (Stookey 1970; Armstrong *et al.*, 1979). Concentrations of volatile fatty acids (*i.e.*, formate, glycolate, acetate, propionate, butyrate, lactate, and succinate) were determined following derivitization using HPLC (Albert and Martens 1997). Concentrations of dissolved organic carbon were determined with a Shimadzu TOC 5000 (Sharp *et al.*, 1993). Nutrient concentrations (nitrate+nitrite, phosphate, silicate) were determined using a LACHAT autoanalyzer (Joye *et al.*, 2004) and concentrations of ammonium were determined using the phenol hypochlorite technique (Solarazano 1969). Concentrations of solid phase, organic and inorganic, carbon, nitrogen and sulfur were determined using standard methods on a ThermoFinnigan Flash Elemental Analyzer. Concentrations of methane were determined on board the ship. Nutrient concentrations were determined the week after the cruise. Other geochemical analyses are on-going.

Two to three cores from each set of cores collected were sub-sampled to determine rates of microbial metabolic activity. Rates of sulfate reduction (SR) and the anaerobic oxidation of methane (AOM) were determined for all core sets, while rates of methanogenesis from acetate (Ac-MOG) or bicarbonate/hydrogen (H₂-MOG) were determined in about half of the core sets. For SR and AOM rate measurements, six plexiglass sub-cores (2.54-cm i.d. x 30 cm long) were collected from a core (~8 cm i.d.) by manual insertion. Three sub-cores were used for SR rate assays while the other three were used for AOM rate assays. The overlying water phase was maintained during sub-coring and the ends of each tube were sealed with black rubber stoppers. Radiotracer (either $^{35}\text{S-SO}_4^{2-}$ or $^{14}\text{CH}_4$ dissolved in filter-sterilized (0.1 μm filtered) seawater) was added to pre-drilled, silicone filled holes at 0.5 cm intervals down the length of the core (Joye *et al.*, 2004; Orcutt *et al.*, 2005). For AOM, 100 μL of dissolved $^{14}\text{CH}_4$ tracer (about 60,000 dpm) was injected into each silicone-filled port. Cores were incubated for 12 to 24 hours at bottom water temperature. Following incubation, cores were extruded and sub-samples were collected at 1 cm intervals and immediately transferred to a 50 mL plastic centrifuge tube containing 2 mL of 2M NaOH (which served to arrest biological activity and fix $^{14}\text{C-CO}_2$ and $^{14}\text{C-HCO}_3^-$). Each vial was sealed, vortexed to mix the sample and base, and immediately frozen. Time zero samples were fixed immediately after tracer injection. The specific activity of the tracer ($^{14}\text{CH}_4$) was determined by injecting 100 μL directly into scintillation cocktail (Scintiverse BD) followed by liquid scintillation counting. The accumulation of ^{14}C product ($^{14}\text{CO}_2$) was determined by acid digestion following the method of Joye *et al.* (1999). The AOM rate was calculated using a standard equation (Orcutt *et al.*, 2005).

For SR rate measurements, 100 μL of tracer containing about 2 μCi of $\text{Na}_2^{35}\text{SO}_4$ was added to each port. Cores were incubated and sectioned as described above. Each sediment section was transferred to a 50 mL centrifuge tube containing 10 mL of 20 percent zinc acetate to halt microbial activity and fix H_2^{35}S as Zn^{35}S . The accumulation of H_2^{35}S product was recovered in a

one-step hot chromous acid digestion. The activity of ZnS and sulfate fractions was determined by scintillation counting. The sulfate reduction rate was calculated using a standard equation (Orcutt et al., 2005).

Rates of methanogenesis, both Ac_MOG and H_MOG, were determined by incubating samples in gas-tight, closed-tube vessels without headspace, to prevent the loss of gaseous $^{14}\text{CH}_4$ product during sample manipulation. For collection of sub-samples, a polycarbonate manifold containing eight pre-drilled holes that were slightly larger than the diameter of the sample tubes was placed on top of the sediment core. The sediment was extruded into the manifold at two cm intervals and then a stainless steel blade was inserted at the base to isolate the section from the remaining sediment. Next, six to eight glass tubes (20 ml Pyrex[®] Hungate culture tubes with the rounded end removed) were inserted through the pre-drilled holes into the sediment, stopping at the blade. Tubes were sealed using custom-designed plungers (black Hungate stoppers with the lip removed containing a plastic “tail” that was run through the stopper) inserted at the base of the tube. The sediment was then pushed via the plunger to the top of the tube until a small amount protruded through the tube opening. A butyl rubber septa was then eased into the tube opening to displace sediment in contact with the atmosphere and close the tube. It was sealed with an open-top screw cap. The rubber materials used in these assays were boiled in 1N NaOH for one hour, followed by several rinses in boiling milliQ water, to leach potentially toxic substances.

A volume of radiotracer solution (100 μL of $^{14}\text{C-HCO}_3^-$ tracer ($\sim 1 \times 10^7$ dpm) or 1,2- $^{14}\text{C-CH}_3\text{COO}^-$ tracer ($\sim 5 \times 10^6$ dpm)) was injected into each sample. Samples were incubated as described above and then 2 ml of 2N NaOH were injected through the top stopper into each sample to terminate biological activity (time zero samples were fixed prior to tracer injection). Samples were mixed to evenly distribute NaOH through the sample. Production of $^{14}\text{CH}_4$ was quantified by stripping methane from the tubes with an air carrier, converting the $^{14}\text{CH}_4$ to $^{14}\text{CO}_2$ in a combustion furnace, and subsequent trapping of the $^{14}\text{CO}_2$ in NaOH as carbonate. Activity of $^{14}\text{CO}_2$ was measured subsequently by liquid scintillation counting. The rates of Bi-MOG and Ac-MOG rates were calculated using standard equations (Orcutt et al., 2005). Laboratory processing of rate samples is on-going but will be completed by October 2006.

Sample Collection and Analysis – JASON Cruise

Sediment push cores were collected into polycarbonate core liner by positioning the core liner over an appropriate site with the JASON's manipulator arm. Up to 12 cores were collected per dive. A total of 193 cores were attempted. Of those, 42 cores failed to retrieve sediment or lost sediment during return to the ship; eleven were used by biologists; 7 were used by geologists. Of the remaining 130, the deepest cores (80 in all) were sampled for biogeochemistry and microbiology. Sediment from twenty-five cores was stored anaerobically for subsequent laboratory experiments. The other cores were too short to work with and were discarded.

Once the JASON was secured on deck, cores (and/or water samples) were transferred immediately to the 4 °C environmental room. Geochemistry cores were sectioned under anaerobic conditions and sub-samples were collected at 2 cm depth intervals for determination of concentrations of the following components: pH, salinity, dissolved gases, dissolved and particulate carbon and sulfur species, dissolved nutrients, metals, and redox metabolites (*e.g.*, hydrogen sulfide and dissolved inorganic carbon). Salinity was determined using a hand-held

refractometer. Measurements of pH were done on board ship using an Accumet high precision electrometer that was calibrated with N.B.S. standards (pH 4, 7 and 10).

Concentrations of C₁ to C₅ hydrocarbons were determined on a sediment sub-sample via headspace extraction (done on board the ship) and gas concentration was quantified using gas chromatography (Joye et al., 2004). Concentrations of dissolved hydrogen in the sediment porewater were determined following sediment incubations (~10 days) using a reduction gas analyzer (Orcutt *et al.*, 2005). Sediment porosity was determined as weight loss after drying (Joye et al., 2004). Concentrations of dissolved inorganic carbon in the pore water were determined using a high sensitivity infrared gas analyzer.

Concentrations of hydrogen sulfide were determined colorimetrically (Cline 1969). Concentrations of anions (sulfate, chloride, iodide, and bromide) and cations (sodium, potassium, calcium, magnesium and barium) were determined using ion chromatography (Joye et al., 2004). Concentrations of Fe²⁺ and Mn²⁺ were analyzed colorimetrically using the ferrozine and formaldoxime methods, respectively (Stookey 1970, Armstrong et al., 1979). Concentrations of volatile fatty acids (*i.e.*, formate, glycolate, acetate, propionate, butyrate, lactate, and succinate) were determined following derivitization using HPLC (Albert and Martens 1997). Concentrations of dissolved organic carbon were determined with a Shimadzu TOC 5000 (Sharp et al., 1993). Nutrient concentrations (nitrate+nitrite, phosphate, silicate) were determined using a LCHAT autoanalyzer (Joye et al., 2004) and concentrations of ammonium were determined using the phenol hypochlorite technique (Solarazano 1969). Concentrations of solid phase, organic and inorganic, carbon, nitrogen and sulfur were determined using standard methods on a ThermoFinnigan Flash Elemental Analyzer. Concentrations of methane were determined on board the ship. Nutrient concentrations were determined the week after the cruise. All solid phase analyses have been completed. The only remaining analyses to be done are the HPLC analyses of VFAs.

Eight sub-samples from each geochemistry core were used to determine rates of microbial metabolic activity. Rates of sulfate reduction (SR) and the anaerobic oxidation of methane (AOM) were determined for all core sets. Rates of methanogenesis from acetate (Ac-MOG) or bicarbonate/hydrogen (H_MOG) were determined in about 15 additional cores. For SR and AOM rate measurements, 5-cc sub-cores were collected from each depth interval by manual insertion. Four sub-samples (3 live, 1 control) were used for SR rate assays while the other four (3 live, 1 control) were used for AOM rate assays. Radiotracer (either ³⁵S-SO₄²⁻ or ¹⁴CH₄ dissolved in filter-sterilized (0.1 μm filtered) seawater) was added to pre-drilled, silicone filled holes at 0.5 cm intervals down the length of the core (Joye et al., 2004, Orcutt et al., 2005). For AOM, 100 μL of dissolved ¹⁴CH₄ tracer (about 200,000 dpm) was injected into each sample. Cores were incubated for 12 to 24 hours at bottom water temperature. Following incubation, cores were extruded and sub-samples were collected at 1 cm intervals and immediately transferred to a 50 mL plastic centrifuge tube containing 2 mL of 2M NaOH (which served to arrest biological activity and fix ¹⁴C-CO₂ and ¹⁴C-HCO₃⁻). Each vial was sealed, vortexed to mix the sample and base, and immediately frozen. Time zero samples were fixed immediately after tracer injection. The specific activity of the tracer (¹⁴CH₄) was determined by injecting 100 μL directly into scintillation cocktail (Scintiverse BD) followed by liquid scintillation counting. The accumulation of ¹⁴C product (¹⁴CO₂) was determined by acid digestion following the method of

Joye et al. (1999). The AOM rate was calculated using a standard equation (Orcutt et al., 2005). For SR rate measurements, 100 μL of tracer containing about 2 μCi of $\text{Na}_2^{35}\text{SO}_4$ (about 5,000,000 dpm) was added to each sample. Cores were incubated and sectioned as described above. Each sediment section was transferred to a 50 mL centrifuge tube containing 10 mL of 20 percent zinc acetate to halt microbial activity and fix H_2^{35}S as Zn^{35}S . The accumulation of H_2^{35}S product was recovered in a one-step hot chromous acid digestion. The activity of ZnS and sulfate fractions was determined by scintillation counting. The sulfate reduction rate was calculated using a standard equation (Orcutt et al., 2005).

Rates of methanogenesis, both Ac_MOG and H_MOG, were determined by incubating samples in gas-tight, closed-tube vessels without headspace, to prevent the loss of gaseous $^{14}\text{CH}_4$ product during sample manipulation. For collection of sub-samples, a polycarbonate manifold containing eight pre-drilled holes that were slightly larger than the diameter of the sample tubes was placed on top of the sediment core. The sediment was extruded into the manifold at two cm intervals and then a stainless steel blade was inserted at the base to isolate the section from the remaining sediment. Next, six to eight glass tubes (20 ml Pyrex[®] Hungate culture tubes with the rounded end removed) were inserted through the pre-drilled holes into the sediment, stopping at the blade. Tubes were sealed using custom-designed plungers (black Hungate stoppers with the lip removed containing a plastic “tail” that was run through the stopper) inserted at the base of the tube. The sediment was then pushed via the plunger to the top of the tube until a small amount protruded through the tube opening. A butyl rubber septa was then eased into the tube opening to displace sediment in contact with the atmosphere and close the tube. It was sealed with a open-top screw cap. The rubber materials used in these assays were boiled in 1N NaOH for one hour, followed by several rinses in boiling milliQ water, to leach potentially toxic substances.

A volume of radiotracer solution (100 μL of $^{14}\text{C-HCO}_3^-$ tracer ($\sim 1 \times 10^7$ dpm) or $1,2\text{-}^{14}\text{C-CH}_3\text{COO}^-$ tracer ($\sim 5 \times 10^6$ dpm)) was injected into each sample. Samples were incubated as described above and then 2 ml of 2N NaOH were injected through the top stopper into each sample to terminate biological activity (time zero samples were fixed prior to tracer injection). Samples were mixed to evenly distribute NaOH through the sample. Production of $^{14}\text{CH}_4$ was quantified by stripping methane from the tubes with an air carrier, converting the $^{14}\text{CH}_4$ to $^{14}\text{CO}_2$ in a combustion furnace, and subsequent trapping of the $^{14}\text{CO}_2$ in NaOH as carbonate. Activity of $^{14}\text{CO}_2$ was measured subsequently by liquid scintillation counting. The rates of Bi-MOG and Ac-MOG rates were calculated using standard equations (Orcutt et al. 2005). Laboratory processing of rate samples is on-going but will be completed by October 2006.

Sample Inventory – DCCC Cruise

Twenty-seven sets (a ‘set’ is used here to denote four to six replicate cores) of sediment cores were collected from nine sites (**Table 3**):

1. AT340: five sets of cores;
2. GC600: four sets of cores;
3. GC852: four sets of cores;
4. MC853: two sets of cores;
5. MC640: three sets of cores;
6. WR269/270: one set of cores;
7. AC818: two sets of cores;

8. AC645: two set of cores ;
9. AC601: six sets of cores.

For each set of cores, one core was used to generate pore water and solid phase geochemical data; one to two cores were used for rate assays to determine rates of sulfate reduction, methane oxidation and methanogenesis; and one to two sets of cores were sectioned to collect microbiology samples (see **Microbiology** section). For each geochemistry core, 11 different subsamples were collected from 4 to 11 depth intervals. A total of 254 depth intervals were sampled in the 27 geochemistry cores, generating 2,794 individual geochemistry samples.

Thirty-eight cores were used for determination of rates of microbial activity (**Table 4**). About 380 depth intervals were sampled, generating 3,000 individual samples (~1,200 sulfate reduction rate samples, 1,200 methane oxidation rate samples, and 600 methanogenesis rate samples).

Table 3.**Summary of Samples Used for Geochemistry**

Site	Dive	Core Designation	Depth of Sediment (cm)
1. AT340	4173	R1	14
2. AT340	4173	Y1	20
3. GC600	4174	Y2	20
4. GC600	4174	R4	12
5. GC852	4177	R1	22
6. MC853	4178	R4	20
7. MC853	4178	Y2	16
8. AT340	4181	R3	10
9. MC640	4182	R2	18
10. MC640	4182	Y4	16
11. MC640	4182	Y3	6
12. AT340	4183	Y2	22
13. AT340	4183	R2	18
14. GC600	4184	Y6	16
15. GC600	4184	R2	14
16. GC852	4189	Y1	12
17. GC852	4189	R3	12
18. GC852	4189	Y6	16
19. WR269/270	4191	Y5	20
20. AC818	4192	R5	18
21. AC818	4192	Y3	20
22. AC601	4193	Brine fluid	Brine fluid
23. AC601	4193	Y1	20
24. AC601	4193	R2	22
25. AC601	4193	Y6	20
26. AC645	4194	Y6	20
27. AC601	4196	Y5	20
28. AC601	4196	R5	18
29. AC601	4196	Brine Fluid	Brine fluid

Table 4.

Summary of Samples Used for Microbial Rate Assays

Site	Dive	Core Designation
1. AT340	4173	Y4
2. AT340	4173	R4
3. GC600	4174	R4
4. GC600	4174	R1
5. GC852	4177	R5
6. GC852	4177	R6
7. MC853	4178	Y4
8. MC853	4178	Y5
9. MC853	4178	R1
10. MC853	4178	R6
11. AT340	4181	R3
12. AT340	4181	R4
13. MC640	4182	Y5
14. MC640	4182	R3
15. MC640	4182	R4
16. AT340	4183	Y1
17. AT340	4183	R4
18. AT340	4183	R5
19. GC600	4184	Y1
20. GC600	4184	Y3
21. GC600	4184	Y5
22. GC852	4189	R2
23. GC852	4189	Y5

Table 4. Summary of Samples Used for Microbial Rate Assays (continued).

Site	Dive	Core Designation
24. WR269/270	4191	R2
25. WR269/270	4191	R3
26. AC818	4192	R6
27. AC818	4192	Y5
28. AC601	4193	Y5
29. AC601	4193	Y2
30. AC601	4193	R6
31. AC645	4194	Y2
32. AC645	4194	Y5
33. AC601	4196	R1
34. AC601	4196	R2
35. AC601	4196	R4
36. AC601	4196	Y1
37. AC601	4196	Y2
38. AC601	4196	Y3

Sample Inventory – JASON Cruise

Sediment cores were collected from 10 sites:

1. AT340: 48 cores (8 biology; 2 geology; 16 geochem/micro; 8 failed)
2. MC462: 9cores (3 geochem/micro; 4 failed)
3. GC415: 9 cores (3 geochem/micro; 6 failed)
4. GC852: 23 cores (15 geochem/micro; 1 geology; 1 failed)
5. GB697: 8 cores (3 geochem/micro; 2 failed)
6. WR269/270: 13 cores (8 geochem/micro; 1 failed)
7. GB647: 8 cores (3 geochem/micro; 4 failed)
8. AC645: 8 cores (4 geochem/micro)
9. AC601: 41 cores (18 geochem/micro; 14 failed)
10. AC818: 26 cores (16 geochem/micro; 2 failed)

Four replicate cores were processed for each habitat. We attempted to sample 4 to 5 key habitats (Brines, Urchins, Microbial Mats, Pogonophorans and/or an off site Control) at each site (if the habitat was present at the site). Pore water samples, solid phase samples, samples for rate assays (sulfate reduction, methane oxidation and methanogenesis) and microbiology samples were collected from each replicate core. A total of 70 cores were processed for geochemical analyses,

generating 356 solid phase, pore water and microbiology samples and about 4000 samples for metabolic activity measurements.

Microbiology and Molecular Biology

Sample Collection, Inventory, and Discussion – DCCC Cruise

During the cruise, two types of microbiology samples were collected: water column and sediment. While shipboard, the microbiology samples were fixed for subsequent analysis at the University of Georgia (UGA), Athens, Georgia and the Max Planck Institute (MPI), Bremen, Germany. A summary of the microbiology sample inventory, shipboard preparations, and methods in progress at shore-based facilities, and a discussion of how these procedures contribute to the goals of the CHEMO III program follows.

Approximately 125 water column microbiology samples were collected during seven CTD casts at three different sites. A majority of the water column samples were acquired during night-time CTD operations. Some additional samples were obtained from niskins mounted on the DSV ALVIN. Water column microbiology samples were from niskin bottles, which were sampled immediately after the rosette was secured on the deck. A 10 mL sub-sample was fixed with a four percent formaldehyde solution for 30 minutes and then frozen at -20 °C. All water column samples were analyzed using epifluorescence microscopy to determine microbial abundance (via Acridine Orange-Direct Count, AODC) and to determine the abundance of methanotrophs (via Fluorescence *in situ* Hybridization, FISH).

Approximately 140 microbiology sediment samples were collected during 23 dives at a diverse group of sites (*e.g.*, brines, mussel beds, clam beds, oil seeps, bacterial mats) (**Table 5**). Molecular sediment samples were collected and fixed for a variety of molecular analyses: AODC, Catalyzed Auto-Reporter Deposition Fluorescence *in situ* Hybridization (CARD-FISH), DNA extraction and sequencing, and biomarker analysis. Sediment samples were collected from cores in 2 cm intervals for each of these analyses. At each depth, one cm³ of sediment was fixed in four percent formaldehyde in filter-sterilized (0.1 µm filtered) Sargasso seawater. The fixed portion was then split for AODC and CARD-FISH. The CARD-FISH split was stored in an ethanol/phosphate buffer at -20 °C. From each two cm interval, 20-30 grams of wet sediment were stored at -20°C for DNA extraction. The remainder of the two cm intervals was collected for biomarker analysis. At approximately six sites, live mud was collected and stored under an argon atmosphere at 4 °C for subsequent laboratory enrichment experiments.

Because one of the major themes of the program is to investigate the biogeography and ecology of the Lower Continental Slope, microbiology methods that allow quantification of microbial abundance as well as the determination of individual microbial (type) distributions (*i.e.*, how many microbes and which microbes are there) were selected. The two cm intervals from which all microbiology samples were collected are paired directly with geochemical and rate samples described in **Sediment Biogeochemistry**. The ability to link all these data is pivotal to revealing what microbes are doing in their environment.

For a general determination of total microbial abundance in sediment, epifluorescence microscopy (AO-DC, Hobbie et al., 1977) was used. Since this is a non-specific method (*i.e.*, the dye illuminates all cells indiscriminately) and the interest is to describe microbial community

structure and associations, CARD-FISH will be used to identify specific groups of bacteria and archaea (*e.g.* specific sulfate reducing bacteria and methane oxidizing archaea) and visualize their associations (Amann et al., 1990). In CARD-FISH, probes are used to selectively illuminate microbial cells based on functional genes or 16S rDNA for that specific cell type. CARD-FISH will be used to determine the abundance of the anaerobic methane oxidizers (ANME) and sulfate reducing bacteria (SRB) consortium (Boetius et al., 2003, Orcutt et al., 2005).

The final method used to investigate sediment microbial abundance and identity at the Lower Continental Slope is an analysis of biomarkers. Each microbe has a specific lipid membrane make-up (*i.e.*, glycerol fatty acid esters, isoprenoid glycerol ether, or isoprenoid hydrocarbons). Much like humans, the biomarker composition of a sample offers a microbial ‘fingerprint.’ The biomarker method quantifies specific lipids to determine which microbes are present and thereby their relative abundance. This method also helps determine the abundance and occurrence of the ANME/SRB consortia, and which ANME archaeans (ANME-1, ANME-2, and ANME-3) and SRB are responsible for the consortia (Niemann, et al., 2005).

‘Live mud’ will be used for manipulating constituent microbes to gain an understanding of their limitations, genetic makeup, and activities in the environment. Preliminary analysis of geochemical samples shows that along the Lower Continental Slope sulfide concentrations are, at some sites, extremely high. One of the potential uses of ‘live mud’ would therefore be to test the tolerance of *in situ* microorganisms to high sulfide concentrations. Sulfide inhibits the activity of microbes, including SRB that produce sulfide. Locally, the sulfide concentrations can greatly impact the ecology at the respective sites.

Table 5.

Inventory of Sediment Microbiology Samples

Dive #	Core ID	# Depths	FISH	DNA	AODC	Biomarker
1. 4173	R5	13	x	x	x	x
2. 4173	Y2	11	x	x	x	x
3. 4174	Y4	4	x	x	x	x
4. 4174	R5	10	x	x	x	x
5. 4177	R2	5	x	x	x	x
6. 4178	Y4	9	x	x	x	x
7. 4178	R2	6	x	x	x	x
8. 4183	Y6	3	x	x	x	x
9. 4184	Y1	7	x	x	x	x
10. 4189	R1	4	x	x	x	x
11. 4191	Y4	10	x	x	x	x
12. 4192	Y4	10	x	x	x	x

Table 5 Inventory of Sediment Microbiology Samples (continued)

Dive #	Core ID	# Depths	FISH	DNA	AODC	Biomarker
13. 4192	R4	5	x	x	x	x
14. 4193	R1	12	x	x	x	x
15. 4193	R5	8	x	x	x	x
15. 4193	Y5	9	x	x	x	x
16. 4194	Y3	6	x	x	x	x
17. 4196	Y6	5	x	x	x	x
18. 4196	R1	5	x	x	x	x

Sample Collection, Inventory, and Discussion – JASON Cruise

During the cruise, two types of microbiology samples were collected: water column and sediment. While shipboard, the microbiology samples were fixed for subsequent analysis at the University of Georgia (UGA), Athens, Georgia.

Approximately 18 water column microbiology samples were collected during collections at six different sites (**above**). Water column microbiology samples were from niskin bottles, which were sampled immediately after the rosette was secured on the deck. A 10 mL sub-sample was fixed with a four percent formaldehyde solution for 30 minutes and then frozen at -20 °C. All water column samples were analyzed using epifluorescence microscopy to determine microbial abundance (via Acridine Orange-Direct Count, AODC) and to determine the abundance of methanotrophs (via Fluorescence *in situ* Hybridization, FISH).

Approximately 300 microbiology sediment samples were collected (*e.g.*, brines, oil seeps, bacterial mats, pogonophorans and controls). Molecular sediment samples were collected and fixed for a variety of molecular analyses: AODC, Catalyzed Auto-Reporter Deposition Fluorescence *in situ* Hybridization (CARD-FISH), DNA extraction and sequencing, and biomarker analysis. Sediment samples were collected from cores in 2 cm intervals for each of these analyses. At each depth, one cm³ of sediment was fixed in four percent formaldehyde in filter-sterilized (0.1 µm filtered) Sargasso seawater. The fixed portion was then split for AODC and CARD-FISH. The CARD-FISH split was stored in an ethanol/phosphate buffer at -20 °C. From each two cm interval, 20-30 grams of wet sediment were stored at -20°C for DNA extraction. The remainder of the two cm intervals was collected for biomarker analysis. At approximately six sites, live mud was collected and stored under an argon atmosphere at 4 °C for subsequent laboratory enrichment experiments.

Because one of the major themes of the program is to investigate the biogeography and ecology of the Lower Continental Slope, microbiology methods that allow quantification of microbial abundance as well as the determination of individual microbial (type) distributions (*i.e.*, how many microbes and which microbes are there) were selected. The ability to link all these data is pivotal to revealing what microbes are doing in their environment.

For a general determination of total microbial abundance in sediment, epifluorescence microscopy (AO-DC, Hobbie et al., 1977) was used. Since this is a non-specific method (*i.e.*, the dye illuminates all cells indiscriminately) and the interest is to describe microbial community structure and associations, CARD-FISH will be used to identify specific groups of bacteria and archaea (*e.g.* specific sulfate reducing bacteria and methane oxidizing archaea) and visualize their associations (Amann et al., 1990). In CARD-FISH, probes are used to selectively illuminate microbial cells based on functional genes or 16S rDNA for that specific cell type. CARD-FISH will be used to determine the abundance of the anaerobic methane oxidizers (ANME) and sulfate reducing bacteria (SRB) consortium (Boetius et al., 2003, Orcutt et al., 2005).

‘Live mud’ will be used for manipulating constituent microbes to gain an understanding of their limitations, genetic makeup, and activities in the environment.

Most of the sediment FISH samples have been processed. Clone libraries for a sub-set of sites are being constructed by a post doc.

RADARSAT Synthetic Aperture Radar Images

Satellite remote sensing images have been used to delineate persistent patches of floating oil slicks released by natural seeps and to predict the seafloor locations of chemosynthetic communities (MacDonald et al., 1996; MacDonald et al., 2002). Remote sensing data on slicks were part of the material reviewed to select the sites explored during the reconnaissance cruise and subsequently sample with ALVIN. In addition, under a data-sharing agreement with NASA, a series of new RADARSAT synthetic aperture radar images were obtained while R/V ATLANTIS was at sea conducting sampling operations with ALVIN. The data were obtained along orbital paths that covered the individual sampling sites (**Figure 4**). Each frame along the path covers approximately 100x100 km of area. A total of 64 satellite images have been ordered from the data acquisition (**Table 6**). Additional images may be ordered to fill in gaps in coverage.

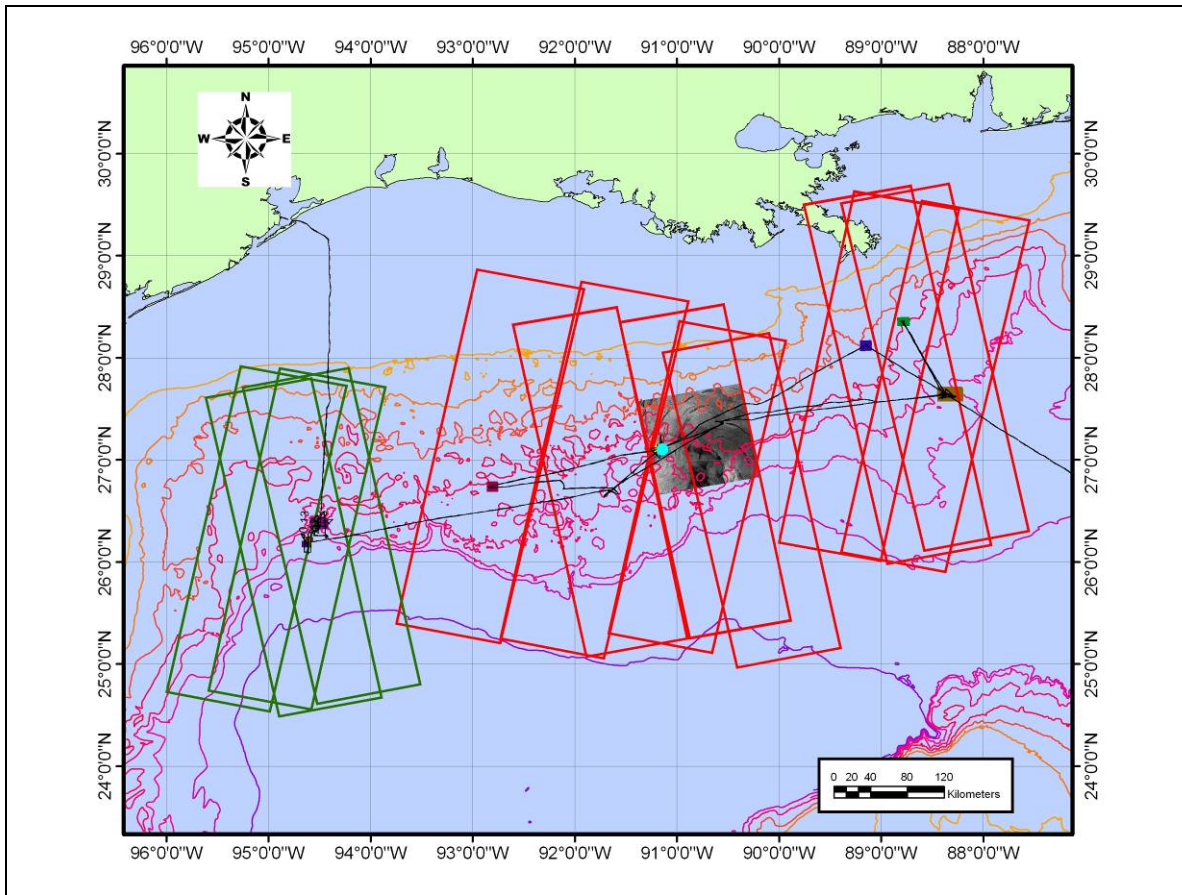


Figure 4. Image swaths covered by the RADARSAT satellite are shown over the northern Gulf of Mexico region.

Analysis of these data will provide information on the occurrence of persistent oil seeps associated with the sampling sites. An example of the application and an illustration of the coverage provided by each SAR image is shown in **Figure 5**. An image (ID R155058_ST3_068) was collected on 23 May at 00:02:14 UTC (22 May 19:00:14 local) while ATLANTIS was operating near the GC852 site. This image is one of four that were taken while ATLANTIS was within the image coverage area. The GC852 site is captured in the western edge of the image. Numerous oil slicks can be seen throughout the image. A strong clockwise rotation is indicated by the drift path of the oil slicks. More than likely this corresponds to a warm-cored eddy that was located in the region at that time and is consistent with observations of strong currents on the surface and in the submarine. Detail from this image indicates that the georectification data supplied with the image was slightly biased to the east northeast. ATLANTIS shows in the image as a strong radar target. However the GPS position logged by ATLANTIS places it about 3 km to the west of this target. Additional processing will have to be performed on the images to correct these issues.

Table 6

Inventory of Satellite Images Obtained

Leg	Granule (imageID)	Time	Date	Lat	Lon	Sites Covered
1	R154915_ST1_064	23:53:29	12-May-06	25.6	-90.02	GC600 GC868 GC296 GC817
1	R154915_ST1_066	23:53:42	12-May-06	26.4	-90.2	GC600 GC868 GC296 GC817
1	R154915_ST1_068	23:53:56	12-May-06	27.2	-90.39	GC600 GC868 GC296 GC817
1	R154915_ST1_069	23:54:03	12-May-06	27.6	-90.49	GC600 GC868 GC296 GC817
1	R154922_ST1_379	12:14:08	13-May-06	28.4	-92.56	KC514 Kc333 KC243 KC129
1	R154922_ST1_380	12:14:14	13-May-06	28	-92.66	KC514 Kc333 KC243 KC129
1	R154922_ST1_382	12:14:28	13-May-06	27.2	-92.84	KC514 Kc333 KC243 KC129
1	R154922_ST1_384	12:14:42	13-May-06	26.4	-93.03	KC514 Kc333 KC243 KC129
1	R154922_ST1_395	12:15:56	13-May-06	22	-94.04	Campeche Seeps
1	R154922_ST1_396	12:16:03	13-May-06	21.6	-94.13	Campeche Seeps
1	R154958_ST3_064	00:06:00	16-May-06	25.6	-91.47	WR269/270 WR268 WR265 KC216
1	R154958_ST3_066	00:06:14	16-May-06	26.4	-91.65	WR269/270 WR268 WR265 KC216
1	R154958_ST3_068	00:06:27	16-May-06	27.2	-91.82	WR269/270 WR268 WR265 KC216
1	R154958_ST3_070	00:06:41	16-May-06	28	-92	WR269/270 WR268 WR265 KC216
1	R154979_ST1_377	11:57:05	17-May-06	29.2	-88.17	AT340 AT342 MC640
1	R154979_ST1_379	11:57:19	17-May-06	28.4	-88.36	AT340 AT342 MC640
1	R154979_ST1_381	11:57:32	17-May-06	27.6	-88.55	AT340 AT342 MC640
1	R154979_ST1_383	11:57:46	17-May-06	26.8	-88.74	AT340 AT342 MC640
1	R154979_ST1_394	11:59:00	17-May-06	22.4	-89.75	Alacran Reefs
1	R155015_ST2_067	23:49:34	19-May-06	26.8	-88.59	AT340 AT342MC640
1	R155015_ST2_069	23:49:47	19-May-06	27.6	-88.77	AT340 AT342MC640
1	R155015_ST2_070	23:49:54	19-May-06	28	-88.86	AT340 AT342MC640
1	R155015_ST2_071	23:50:01	19-May-06	28.4	-88.95	AT340 AT342MC640
1	R155015_ST2_072	23:50:07	19-May-06	28.8	-89.05	AT340 AT342MC640
1	R155022_ST1_380	12:10:00	20-May-06	28	-91.6	WR269/270 WR268 WR265 KC216
1	R155022_ST1_382	12:10:14	20-May-06	27.2	-91.79	WR269/270 WR268 WR265 KC217
1	R155022_ST1_383	12:10:21	20-May-06	26.8	-91.88	WR269/270 WR268 WR265 KC218
1	R155022_ST1_385	12:10:34	20-May-06	26	-92.07	WR269/270 WR268 WR265 KC219
1	R155022_ST1_387	12:10:48	20-May-06	25.2	-92.25	WR269/270 WR268 WR265 KC220
1	R155022_ST1_390	12:11:08	20-May-06	24	-92.53	Vioska Knolls
1	R155022_ST1_391	12:11:15	20-May-06	23.6	-92.62	Vioska Knolls
1	R155022_ST1_392	12:11:21	20-May-06	23.2	-92.71	Vioska Knolls
1	R155058_ST3_066	00:02:00	23-May-06	26.4	-90.6	GC852 GC812 GC767 GC817 GC868
1	R155058_ST3_068	00:02:14	23-May-06	27.2	-90.77	GC852 GC812 GC767 GC817 GC868
1	R155058_ST3_070	00:02:27	23-May-06	28	-90.95	GC852 GC812 GC767 GC817 GC868

Table 6. Inventory of Satellite Images Obtained (continued)

Leg	Granule (imageID)	Time	Date	Lat	Lon	Sites Covered
1	R155079_ST3_377	11:52:56	24-May-06	29.2	-88.84	MC853 MC640 MC548 MC462
1	R155079_ST3_379	11:53:10	24-May-06	28.4	-89.02	MC853 MC640 MC548 MC463
1	R155079_ST3_381	11:53:23	24-May-06	27.6	-89.2	MC853 MC640 MC548 MC464
1	R155079_ST3_383	11:53:37	24-May-06	26.8	-89.37	MC853 MC640 MC548 MC465
1	R155115_ST1_067	23:45:24	26-May-06	26.8	-88.2	AT340 AT342 MC640
1	R155115_ST1_069	23:45:38	26-May-06	27.6	-88.38	AT340 AT342 MC640
1	R155115_ST1_071	23:45:51	26-May-06	28.4	-88.57	AT340 AT342 MC640
1	R155115_ST1_073	23:46:05	26-May-06	29.2	-88.77	AT340 AT342 MC640
1	R155122_ST1_380	12:05:50	27-May-06	28	-90.55	GC852 GC600
1	R155122_ST1_382	12:06:03	27-May-06	27.2	-90.74	GC852 GC600
1	R155122_ST1_383	12:06:10	27-May-06	26.8	-90.83	GC852 GC600
1	R155122_ST1_384	12:06:17	27-May-06	26.4	-90.93	GC852 GC600
1	R155122_ST1_386	12:06:30	27-May-06	25.6	-91.11	GC852 GC600
1	R155122_ST1_395	12:07:31	27-May-06	22	-91.94	Campeche Seeps
2	R155065_ST1_381	12:22:43	23-May-06	27.6	-94.84	AC601 AC775 AC818
2	R155065_ST1_383	12:22:56	23-May-06	26.8	-95.03	AC601 AC775 AC818
2	R155065_ST1_385	12:23:10	23-May-06	26	-95.21	AC601 AC775 AC818
2	R155065_ST1_387	12:23:24	23-May-06	25.2	-95.4	AC601 AC775 AC818
2	R155101_ST2_063	00:14:19	26-May-06	25.2	-94.52	AC601 AC775 AC818
2	R155101_ST2_065	00:14:32	26-May-06	26	-94.7	AC601 AC775 AC818
2	R155101_ST2_067	00:14:46	26-May-06	26.8	-94.89	AC601 AC775 AC818
2	R155165_ST2_382	12:18:41	30-May-06	27.2	-94.54	AC601 AC775 AC818
2	R155165_ST2_384	12:18:54	30-May-06	26.4	-94.72	AC601 AC775 AC818
2	R155165_ST2_386	12:19:08	30-May-06	25.6	-94.9	AC601 AC775 AC818
2	R155165_ST2_387	12:19:15	30-May-06	25.2	-94.99	AC601 AC775 AC818
2	R155201_ST1_063	00:10:09	2-Jun-06	25.2	-94.12	AC601 AC775 AC818
2	R155201_ST1_065	00:10:23	2-Jun-06	26	-94.31	AC601 AC775 AC818
2	R155201_ST1_067	00:10:37	2-Jun-06	26.8	-94.5	AC601 AC775 AC818
2	R155201_ST1_068	00:10:43	2-Jun-06	27.2	-94.59	AC601 AC775 AC818

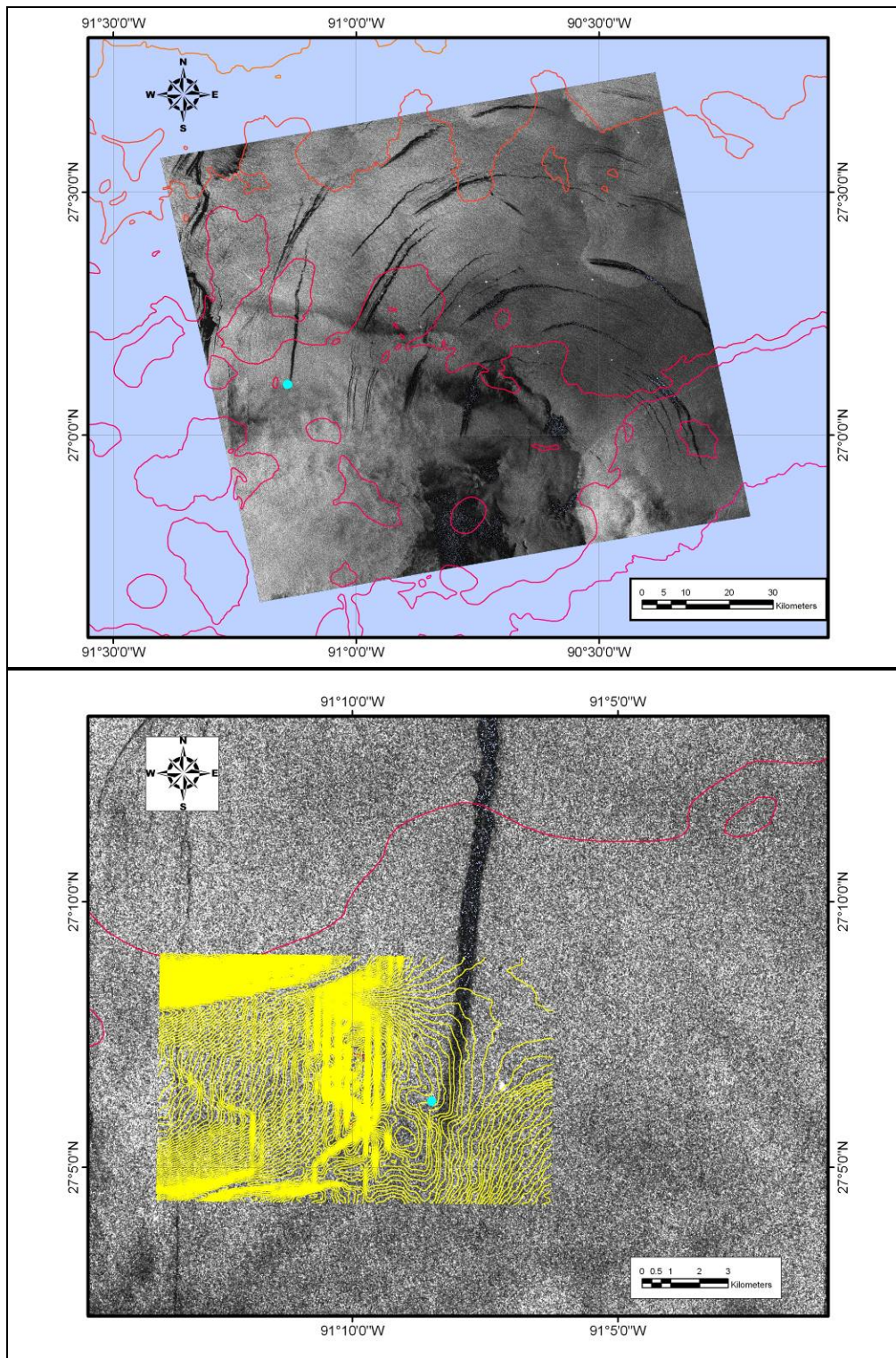


Figure 5. SAR image collected 22 May at 19:02 local time.

SAR Image Acquisition and Analysis

Data Acquisition

Extensive satellite SAR imagery covering the Gulf of Mexico have been made available to the project through a data-sharing agreement with MacDonald' lab. A total of 64 RADARSAT SAR images were obtained during the May 2006 cruise (**Figure 6**). These data confirmed the presence of natural oil slicks on the surface near many of the project sampling sites (**Figure5**). Additionally, the data show how the oceanic environment is impacted by the dynamics of the Loop Current and resultant eddies. The SAR image group has been occupied with a number of project-related tasks during 2006. In addition to acquiring and processing the SAR images, the group has obtained access to several related data sets that show oceanographic processes in the overall study region.

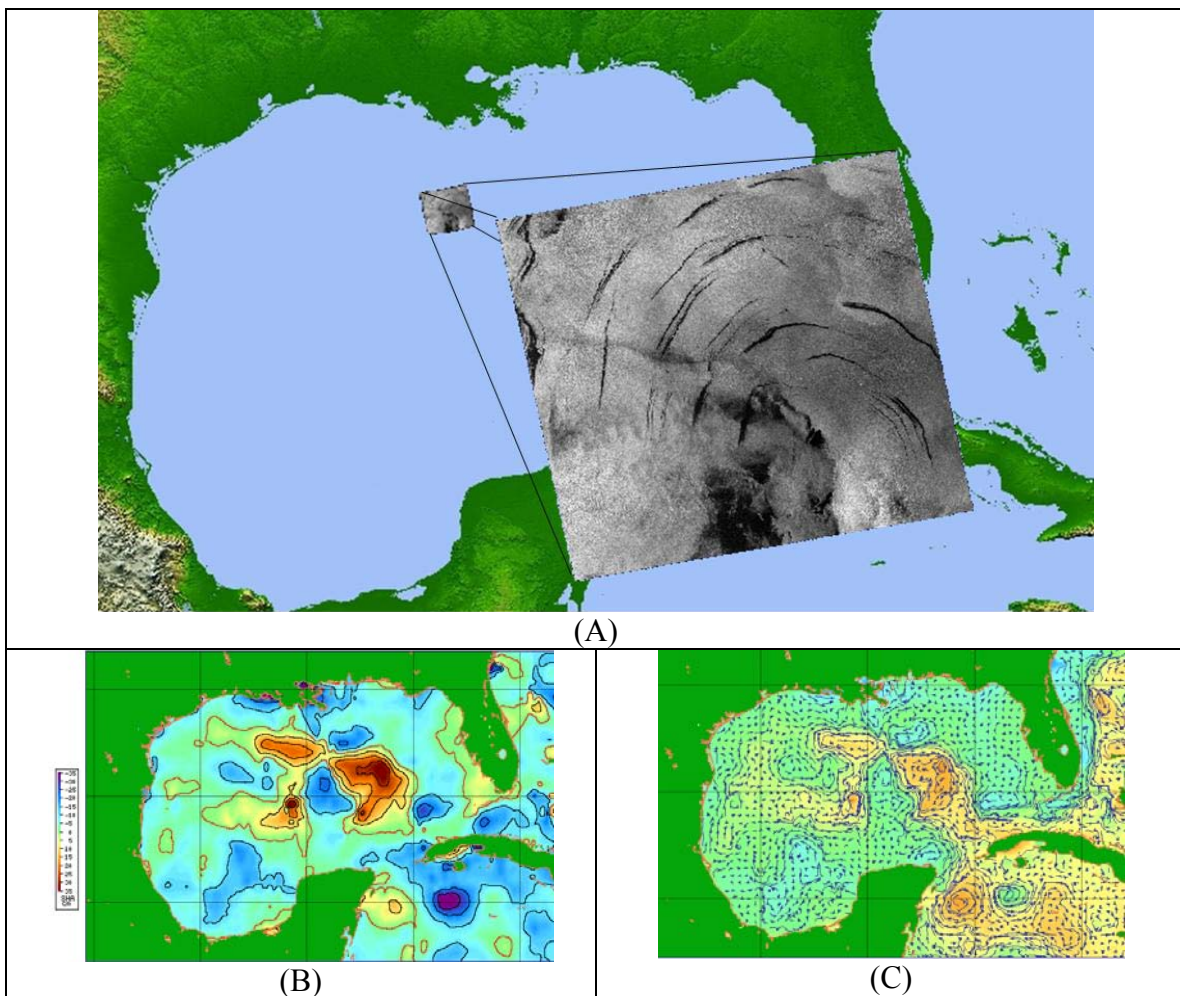


Figure 6. SAR and related oceanographic data assembled for study of natural seeps in study region. (A) Image collected by Radarsat on May 23 2006. The full image shows multiple slicks in a rotating gyre. (B) Sea-surface height anomalies from the same data show presence of a warm-cored eddy (Eddy Xtreme). (C) Geostrophic currents generated by Eddy Xtreme and related features.

The principal objectives of this effort are to acquire and analyze SAR data concurrent with project field activities. In a related effort, we have compiled a complete inventory of SAR data collected in the Gulf of Mexico since 1992 when the major SAR platforms became operational. The goal of this effort is to provide a historical context for the extent and magnitude of natural oil seep across the Gulf of Mexico, with a focus on the CHEMO III study area. **Figure 7** shows a summary of ~31,000 SAR image—believed to be the complete inventory of all SAR data ever collected over the Gulf of Mexico. This inventory is intended to provide MMS with an overview of available data for assessing the magnitude and extent of natural seepage in the region.

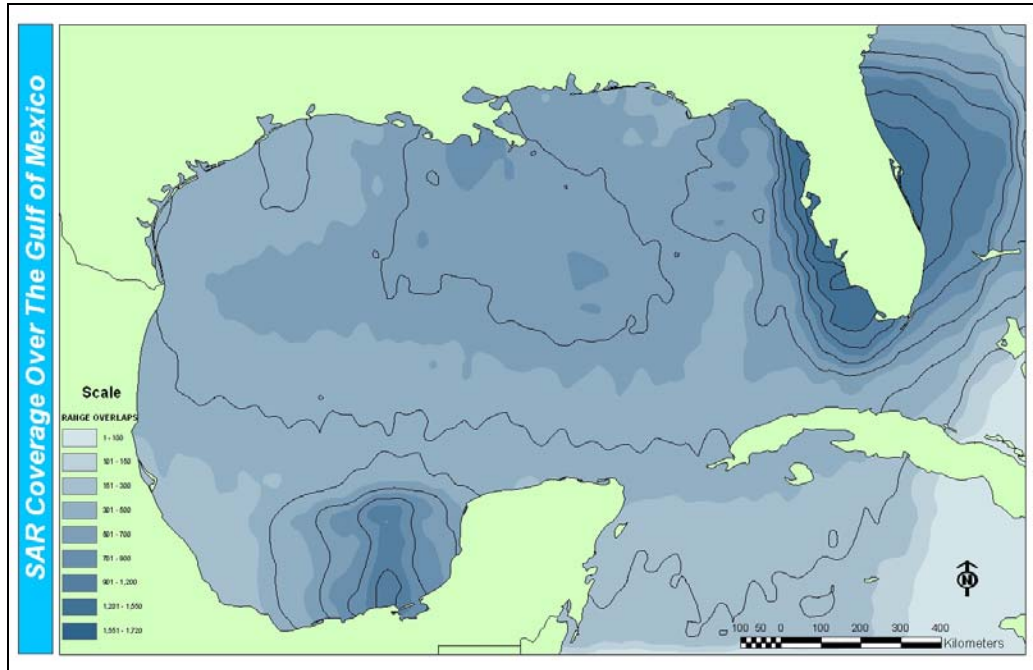


Figure 7. Summary figure showing spatial coverage for complete inventory of SAR images from the Gulf of Mexico (~31,000 images) that have been collected since 1992.

Automated Slick Detection Methods

Ongoing work includes development of algorithms and routines to automate the recognition of natural slicks under the expected range of imaging conditions. Approaches tested to date employ texton filters that iteratively scan the SAR images (**Figure 8**). Results provide a robust and time-efficient means for detecting targets similar to the slicks a human analyst would delineate. Future application will expand the range of viewing conditions that the textons can handle and further automate the detection procedures.

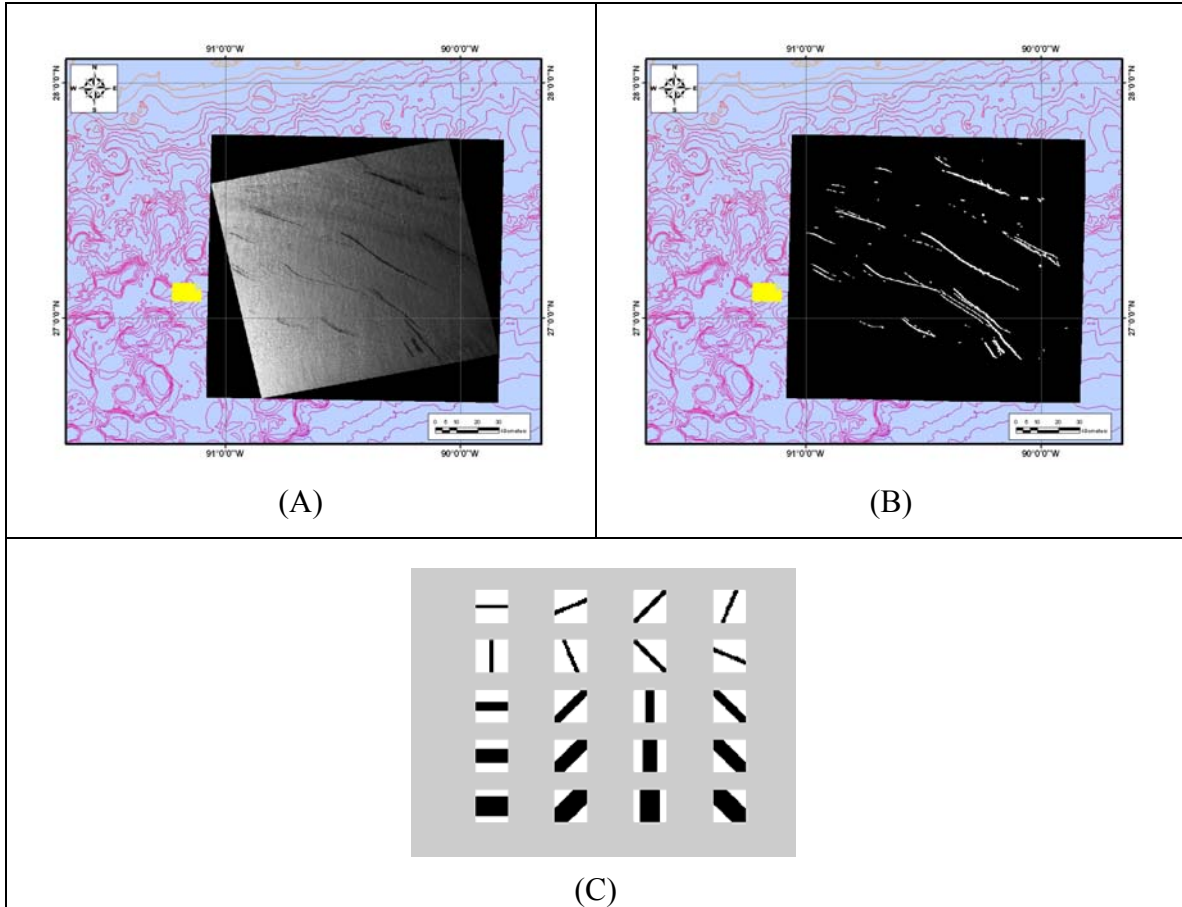


Figure 8. Automated slick detection with use of texton filter array. (A) SAR image obtained on 12 May 2006 shows numerous slicks near the GC852 site. (B) The outlines of these slick targets were extracted from the original image by iterative edge detection routines using the (C) filter array.

EDUCATION OUTREACH SUMMARY

DCCC Cruise Activities

Liz Goehring, education outreach coordinator, and Cindy Petersen, middle schools science teacher, participated in the DCCC cruise and worked with the science party to develop "Classroom to Sea" labs and related classroom materials. The education team interviewed scientists to better understand the background for their specific research as well as the purpose of the activities during the cruise. The purpose was to find applications for the science classroom. Three "Classroom to Sea" labs were identified: one an existing lab that will be modified to include the seep environment and two new labs. Goehring is also working to incorporate the labs into the new FLEXE (From Local To Extreme Environments) project – as part of the GLOBE program (www.GLOBE.gov).

The existing lab, referred to as the Mussel Lab, involves students in a comparison of shallow-water mussels to deep-sea mussels, in particular focusing on differences in feeding strategies. During the cruise, the education team dissected and measured 152 mussels, from six locations and ten dives. Three mussel species (*Bathymodiolus brooksi*, *B. childressi*, and *B. heckerae*) are included. This dataset will be added to an existing dataset on vent mussels (*B. thermophilus*) along with new support materials featuring research specific to seeps, and will be added to the SEAS Web site for use in the coming academic year. A new "Scientist Spotlight" page will be created to feature the mussel-related research associated with this cruise, including collection techniques (*e.g.*, Mussel Pots) and photomosaics to study mussel communities. In addition to volume measurements for the "Classroom to Sea" lab, the team collected tissue samples and shell measurements for other members of the science party.

The education team worked on a second lab, referred to as the RUST Lab. The idea behind this lab is to help students understand oxidation by examining different rates of metal oxidation, as well as some of the factors affecting those rates (*e.g.*, water chemistry, temperature, microbial-facilitated activity). During the cruise, the team set up two deployments of metal strips (Fe, Al, Zn, and Cu), placed in areas near seep flow to expose the metals to sulfides, and retrieved after 9 and 13 days. Change in mass was measured as well as photodocumentation of surface corrosion. The team also set up a parallel experiment on board, soaking metal strips in petri dishes with seawater, "Instant Ocean," distilled water and sediment. The purpose of this parallel trial was to work out details of the classroom version of the lab. Many individuals in the science party were consulted to help explain results from these trials. Data collected during the cruise were analyzed and used. The lab was piloted by C. Petersen in her science classes in the 2007-08 academic year.

A third lab was identified, referred to as the Biodiversity Lab. This lab will feature the community ecology work of the science party, focusing students on understanding measures of biodiversity and community processes. During the cruise, the team focused on collecting background information on community studies; images and video of sampling (*e.g.*, Bushmaster collections), sorting and measuring; and images of specific organisms with associated information. The lab will be developed in the upcoming year.

In addition Fisher was the Keynote presenter for the week of November 12, 2006 for an on-line teachers workshop offered for credit by National Geographic and the NOAA Ocean Exploration Program as part of their “College of Exploration” (www.coexploration.org/ceo2006/index.html). For this Fisher prepared an online (image-rich) presentation and worked with the organizers on associated materials, and then spent several hours each day that week answering questions from the teachers around the country. Over 1,200 teachers participated in this workshop and approximately 50 of these teachers asked at least one question during the offering.

JASON Cruise Activities

Outreach deliverables for this project include the development and dissemination of *Classroom to Sea* comparative labs, originally to be delivered to secondary school students through the SEAS (*Student Experiments at Sea*) program (<http://www.ridge2000.org/SEAS>), with teacher workshops offered through the COSEE-CGOM. Support for the SEAS program ended in 2006 however the concepts of SEAS have been transitioned to a larger project, FLEXE, with a more extensive dissemination network. FLEXE (*From Local to EXtreme Environments*) uses the same comparative approach of SEAS to help students understand remote deep-sea environments through comparison with analogous local systems. FLEXE is one of four new Earth System Science Projects (ESSPs) of the GLOBE program (www.globe.gov), is developed in partnership with GLOBE personnel, and is disseminated through the extensive GLOBE network of Partners, Trainers, Teachers and Students worldwide. Materials originally developed for SEAS are currently being repurposed for use in the FLEXE program.

FLEXE is a web-based interactive program for middle and high school students in which they engage in various learning activities and protocol-based investigations around a particular topic, and in facilitated interactions with scientists around topic-related deep-sea datasets through the FLEXE Forum. Topics are determined by concepts listed in the National Science Education Standards to ensure applicability to classrooms. A prototype unit, the “Energy Unit”, focuses on the processes of energy transfer between components of the Earth system, a topic taught in most middle school curricula, and was developed to test various pedagogical aspects of FLEXE. The second unit, “Extreme Life”, features the ecology of deep-sea cold seeps and hydrothermal vents and is scheduled to be tested with teachers and students in Spring 2009. This unit explores topics such as biodiversity, food webs and trophic structures, microbial interdependencies, and adaptations to environmental challenges.

In past reports, we described the development of *Classroom to Sea* labs: the Mussel Lab, the Rust lab, and a Biodiversity lab. Two of these labs are included in the FLEXE “Extreme Life” Unit - the Mussel lab and Biodiversity lab. The Mussel lab involves students in a comparison of shallow-water mussels to deep-sea symbiont-containing mussels, in particular focusing on differences in feeding strategies. Students use a FLEXE protocol to examine shallow-water mussels and then examine deep-sea mussel data via a FLEXE Forum. Dissection data from three seep mussel species (*Bathymodiolus brooksi*, *B. childressi*, and *B. heckerae*) from the first ChemoIII cruise have been added to an existing dataset on vent mussels (*B. thermophilus*). These data along with support materials featuring the collection techniques (*e.g.*, Mussel Pots) and the broader research questions associated with the CHEMOIII project will be featured in the FLEXE Forum presented by Dr. Chuck Fisher. The second lab focuses on biodiversity, how it is measured and interpreted, and the broader context of community ecology studies. Following a

FLEXE protocol, students will practice techniques for determining biodiversity in their local environment and then using the FLEXE Forum, will examine how biodiversity is measured in the deep-sea environment. This FLEXE Forum, featuring Dr. Erik Cordes, will engage students in analysis of seep biodiversity data and will feature imagery of specific organisms in the seep environment, along with the sampling (*e.g.*, Bushmaster collections) and sorting techniques used to measure biodiversity. Both FLEXE Forums are currently in development and are scheduled for pilot-testing with in the spring of 2009.

At this phase of the project, we are also developing the teacher professional development necessary to use these materials successfully in the classroom. We have begun working with the COSEE-CGOM personnel (Dr. Sharon Walker and Dr. Sheila Brown) to arrange a two-day teacher training on the FLEXE program, scheduled for July 2008. Dr. Ian MacDonald will participate to present extreme environments of the deep-sea before teachers explore existing FLEXE materials. Additionally, Dr. Walker is helping identify teachers in the Gulf area interested in testing the new “Extreme Life” materials in Spring 2009. A second teacher workshop featuring the Extreme Life unit will be scheduled for Spring/Summer 2009 to train a larger number of teachers in the Gulf area interested in using FLEXE the following school year. We will also use the existing GLOBE network to disseminate the “Extreme Life” unit throughout the US, featuring this unit during GLOBE Partner and Trainer Trainings in the summer of 2009.

The Rust lab, which features the concept of oxidation and its importance in the deep-sea environment, is not currently scheduled to be incorporated within a FLEXE unit at this time. Results from pilot testing with middle school students in C. Petersen’s (CHEMOIII Teacher-at-Sea) Earth Science course indicate that the educational concepts necessary for this unit are best suited for higher level students, and are not typical of GLOBE studies. Nonetheless, we are exploring the possibility of another FLEXE Unit targeting high school Chemistry and Environmental Science students.

TRAWLS AND BOX CORES - RC CRUISE

Trawls were completed at three sites, MC685, MC548 and AT209. Two box cores were collected at site WR265. **Table 7** summarizes the trawling and box coring activities during the Reconnaissance Cruise. Following **Table 7** is a narrative of the trawling activities with a brief description of the trawl contents. The two box cores were sieved for isotopic analysis of the faunal contents.

Table 7.

Summary of Trawling and Box Core Activities

Site	Date	Start-End Time (hrs)	Depth (m)	Latitude (N)	Longitude (W)	COMMENTS	Activity
MC685	3/19/06	1815-2145	1,500	28.287575	-88.739185	Bottom snag trawl at MC685	Trawl 3
MC548	3/19/06	1330-1600	1,000	28.404987	-88.967487	20 kg of assorted benthic fauna including fishes, echinoderms, and crustaceans.	Trawl 1
MC908	3/20/06	1800-2,200	2,000	28.065796	-88.582635	Attempted box core. Reached bottom, but core did not trigger.	
AT209	3/21/06	1030-1400	2,500	27.778787	-88.321719	Completed trawl of AT209 station	Trawl 4
WR265	3/23/06	1500-2100	1,820	26.682572	91.885683	This was a non-seep site chosen for box coring to collect background tissue samples of benthic fauna. Two 30-cm x 30-cm box cores were successfully collected at this site.	Box Cores 1&2

Trawl/Box Core Narrative

19 March

MC548 - Initial haul missed bottom due to depth readout problem. Second attempt was highly successful with approximatey 20 kgs. of material dominated by fish, holothuroids, and the golden crab *Chaceon*. Tissues sampled for background measurements.

- 91 frozen samples for isotope trophics to Carney LSU
- 19 holothurioid
- 32 crustacean
- 38 fish
- 1 polychaete
- 1 bag seastars for lab prep

MC685 - Trawl 3: The net hung on bottom but pulled free w/out damage. Small sample included large paralithodid crab, fish, and infaunal holothurians. All were processed for tissue samples. Small sample due to bottom obstruction of the net.

- *5 frozen samples for isotope trophics to Carney LSU*
- *1 holothuroid*
- *3 crustaceans*
- *1 fish*

21 March

AT209 - A successful trawl with ophidioid fishes, holothuroids and ophiuroids typical of depth. There were noticeably differences from the shallower station.

- *62 frozen samples for isotope trophics to Carney LSU*
- *44 holothuroid*
- *10 crustaceans*
- *7 fish*
- *1 bag with 17 seastars and ophiuroids for lab prep*

23 March

WR265 - This was an added station at WR265 to collect additional samples from the ~2,000 m bathymetric interval. Difficult to determine precise depth acoustically, but designate depth as 1,828 m. Sea state prevented safe trawling operations. Two box cores sieved for fauna samples to Carney LSU. Sediment was typical of deep hemipelagics. Fauna at 500 micron were very sparse and insufficient biomass was collected for isotope analysis.

BEAM TRAWL NARRATIVE – DCCC CRUISE

The following is the trawl narrative as taken from the log. Additional trawl information is given in **Appendix 8**.

Beam Trawl Sampling #1

Date 5/9/06

Overall Characterization:

The trawl came up with a large amount of mud in the bag itself. The mud did contain a fairly large amount of fauna, which was sieved to separate the mud from the organisms.

Some samples of the *Psychropodes*, *Benthodytes typica* and *B. lingua* were further processed for muscle tissue. The *Psychropodes* was also processed for gonad tissue.

Number of Lots: 79

Table 8.

Samples from Beam Trawl #1

2 Anemones	Large Shrimp
Brisingid arms	<i>Pseudostichopus</i>
Gastropods	<i>Psychropodes</i>
Hermit Crabs	<i>Radiella sol</i>
<i>Hymenaster spp.</i>	<i>Scalpe num</i>
Limpit	Sponge
Ophioroids	Sea stars
Peniagone	Vase sponges
Plant Material → Including: Cane, Rhizome, Sargasum and Shallow Epifauna	<i>Benthodytes typica</i>
	<i>Benthodytes lingua</i>
	Fish

Beam Trawl Sampling #2

Date 5/11/06

Overall Characterization:

This trawl came up with some mud, but significantly less when compared to the first trawl.

There was also less fauna overall. The *Psychropodes*, *Benthothuria*, *Mesothuria* and *Anemone* were sub-sampled for tissue. The *Holothurians* were sampled for muscle tissue.

Number of Lots: 23

Table 9.

Samples from Beam Trawl #2

<i>Benthodytes typical</i>	<i>Molpadia blakei</i>
Bivalves	Ophiuroids
Brachipod	Plant Material
Hermit Crab	<i>Psychropodes longicaclata</i>
<i>Hymenaster spp.</i>	Sponges
Mesothuria	

Beam Trawl Sampling #3

Date 5/15/06

Overall Characterization:

This trawl came up with some mud, along with a fairly large number of fauna. The *Benthodytes typical*, *B. lingua* and *Psychropodes* were processed for muscle tissue, and *Psychropodes* were processed for gonad tissue. A fish was also processed for tissue samples.

Number of Lots: 66

Table 10.

Samples from Beam Trawl #3

Assorted Shells	<i>Pseudostichopus spp.</i>
<i>Radiella sol</i>	<i>Paroriza spp.</i>
<i>Brisingidae</i>	<i>Benthodytes lingua</i>
Penoids	<i>Psychropodes</i>
Hermit Crab	Bulk Mud
<i>Dytaster spp.</i>	<i>Umbellula</i>
Sea Stars	Polychaetes
Fish	<i>Hymenaster spp.</i>
Anemone	<i>Molpadia blakei</i>
Gastropods	Ophiroids
	Plant Material

Beam Trawl Sampling #4

Date 5/16/06

Overall Characterization:

This trawl came up with little mud and relatively few fauna. The Octopus and *Benthodytes typica* were processed for tissue samples, the latter specifically being muscle tissue.

Number of Lots: 21

Table 11.

Samples from Beam Trawl #4

Sea Stars	Holothurian
Ophiuroids	Plant Material
<i>Umbellula</i>	<i>Benthodytes lingua</i>
Octopus	Tripod fish
Penaid	Hard “mud stone” bulk
<i>Radiella sol</i>	<i>Benthodytes typica</i>

Beam Trawl Sampling #5

Date 5/21/06

Overall Characterization:

This trawl came up with minimal sample suggesting little or no bottom contact, and everything was subsequently bagged and frozen as a collective sample.

Number of Lots: 1

Entire Sample – penaid and polychelid shrimp

Beam Trawl Sampling #6

Date 5/22/06

Overall Characterization:

This trawl came up with little mud but a fairly large amount of faunal diversity. Samples were frozen whole.

Number of Lots: 32

Table 12.

Samples from Beam Trawl #6

Iron stone/ Rust scale	Unknown
Rock	Pen aids
Wood	Ophioroids
Asteroidea	Hermit Crabs
Bone	Shells
<i>Psychropodes</i>	<i>Radiella sol</i>
<i>Pseudostichopus</i>	<i>Molpadia blakei</i>
Scaphapods	Echiuroid
Bivalves	<i>Arca</i>
<i>Pseudostichopus depressus</i>	Viperfish

Beam Trawl Sampling #7

Date 5/23/06

Overall Characterization:

This trawl came up with net inverted, no mud, and a comparative paucity of fauna. There were a large number of *Umbellula* caught by the lower chain of the trawl net. The *Umbellula* specimens were separated between the polyps and the stalks. Other material was frozen whole.

Number of Lots: 24

Table 13.

Samples from Beam Trawl #7

Viperfish	Penaeids
Hatchetfish	<i>Benthodytes typical</i>
<i>Pseudostichopus depressus</i>	<i>Umbellula</i>

Beam Trawl Sampling #8

Date 5/25/06

Overall Characterization:

This trawl came up with no mud and a fair number of seemingly different fauna. Samples were frozen whole. Numerous small *Benthodytes typical* were present

Number of Lots: 25

Table 14.

Samples from Beam Trawl #8

Viperfish	Urchins
<i>Pseudostichopus depressus</i>	Braciopods
Penaeids	<i>Radiella sol</i>
<i>Benthodytes typical</i>	Holothurian
<i>Umbellula</i>	Sea star
<i>Mesothuria</i>	<i>Molpadia blakei</i>
Sponge	Carridian
Bivalves	<i>Polycheleas</i>

Beam Trawl Sampling #9

Date 5/27/06

Overall Characterization:

This trawl came up with no mud and a comparatively large number of seemingly different fauna. Only the *Benthothurian* was processed for muscle tissue. Other material was frozen whole. Number of Lots: 28

Table 15

Samples from Beam Trawl #9

Penoids	<i>Ophiomusium lymani</i>
Hermit Crabs	Tar
Brachipod	Scaphapods
Bivalve	<i>Benthodytes lingua</i>
Moldanids	<i>Psychropodes</i>
Sponges	<i>Asteroidea</i>
Plant Material	<i>Molpadia blakei</i>
Echiurans	<i>Benthodytes typical</i>
Sea pens	<i>Benthothuria</i>

Beam Trawl Sampling #10

Date 5/30/06

Overall Characterization:

This trawl came up with no mud and a comparatively large number of seemingly different fauna. All samples were frozen whole.

Number of Lots: 37

Table 16.

Samples from Beam Trawl #10

Trpodfish	Rat-tail fish
Sponges	Scaphapods
Hermit Crabs	Galatheid
Bivalves	Pyroosome
Plant Material	Hatchetfish
Tar	Viperfish
Maldanids	Sea pens
<i>Radiella sol</i>	Fish
<i>Benthodytes lingua</i>	Dumbo Octopod
<i>Ophiomusium lymani</i>	Squid
Anemone	Pompanao
Ophiuroids	<i>Benthodytes typica</i>
Penaeids	

MACROFAUNA

Community and Population Analyses

This portion of the study is focused on the characterization of communities associated with tubeworms, mussels, and corals and their relation to abiotic and biotic factors. These species form biogenic habitat that supports a variety of fauna at these sites. Among the goals of this portion of the study are to determine the bathymetric and biogeographic patterns in community structure, document sites of rare or unique species composition, and examine hypotheses derived from previous investigations of succession in upper slope seep communities. This includes (1) a more precise characterization of the depth of the shift in community composition and structure known to occur somewhere between 800 and 1400 m; (2) examination of the applicability of trends seen in the predominately soft-bottom background communities to hard-grounds, including declines in abundance and biomass with depth and a diversity maximum at mid-slope depths, and (3) a test of the upper slope seep-community succession model. This model describes a progression from bacterial mats to mussel beds harboring a low diversity but high biomass community to young tubeworm aggregations with lower biomass but higher diversity as background species begin to colonize the seeps, to old tubeworm aggregations with a low biomass, low diversity community composed mainly of background species. There is also a general trend towards heavier tissue carbon and nitrogen stable isotope values in the associated community over time indicating a decline in relative importance of seep primary productivity to the non-symbiotic fauna on the upper slope.

With completion of the last field campaign the team's efforts have moved into laboratory work, data analyses, and preparation of results for publication. Some of the highlights from the research have already been published, or are in press, in high visibility scientific journals. Dr. Roberts took the lead on an EOS article summarizing many of the highlights from the 2006 expedition and this was published in August 2007 (Roberts et al., 2007). Drs. Fisher, Roberts, Cordes and Bernard published a review of the Gulf of Mexico cold seep research funded by MMS and OE in the December issue of Oceanography Magazine, which included highlights from both the 2006 and 2007 expeditions (Fisher et al., 2007). Cordes and Fisher have also completed an invited review on the Ecology of the Cold Seep Communities of the Gulf of Mexico for the inaugural issue of the Annual Reviews in Marine Science to be published in January 2009 (Cordes et al., 2007). In addition, Fisher, Brooks, Roberts, and Boland organized a session titled "Interrelations among the chemistry, geology and biology of hydrocarbon seep communities in the deep Gulf of Mexico" for the ASLO Ocean Sciences meeting in Orlando Florida in February 2008. Sixteen talks or posters were presented by members of the CHEMO III team in this session. In the upcoming year, Dr. Roberts will be editing a special topical edition of Deep Sea Research on the cold seep and hard bottom communities of the deep Gulf of Mexico and we expect to have numerous papers in that volume that are direct results of this MMS/OE project.

Photomosaic Community Characterizations

Imagery for photomosaics were obtained in 2006 and repeated in 2007 at four sites for the construction of quantitative mosaics, and physically sampled using a variety of collection devices. Appropriate sets of images for four well-navigated large photomosaics were obtained during the May 2006 Deep Gulf cruise. Photomosaics were compiled from overlapping still digital images obtained using a down-looking camera on ALVIN during a series of overlapping

parallel lines. These efforts were complicated by the inability of ALVIN to maintain constant heading and precise track lines. This should not be an issue with JASON II.

Two mosaics were obtained at Atwater Valley 340 (AT340). One of these covers the largest mussel bed (15 x 20 m) found during the expedition (**Figure 9**), and also includes scattered tubeworm aggregations, carbonate rock and sediment near the periphery of the mussel bed. The other AT340 mosaic followed a long narrow “river” of seep macrofauna with several communities of mussels and tubeworms, as well as stained sediment and bacterial mats (the “Mussel Brick Road”). Both of these mosaics appear to include at least two species of mussels, although we did not physically sample them in 2006 because we did not want to compromise analysis of temporal change in these communities between cruises.

Another mosaic was obtained at Green Canyon 852 (GC852) of the “Coral Gardens” site. The currents at this site were at the upper limit for this kind of work with Alvin, however five mosaic lines were obtained with sufficient navigational information and distinctive substrate that spatially explicit re-imaging in 2007 will be possible. The fourth large mosaic was of a pogonopheran field at WR269.

Also, a very large mussel bed (Big Mussel Bed) and along an apparent shallow fault lined with mussel patches (Mussel Brick Road) at AT340, a cluster of boulders with a mixture of scleractinian and multiple species of soft corals (Coral Garden) at GC852, and a mixed assemblage of tubeworms, mussels and urchins near a Chevron wellhead (Wellhead) at AC818. In addition, a site at AC645 where a video mosaic was obtained in 1992 over a cluster of tubeworms and mussels was re-imaged in 2007. A photomosaic over a field of tubeworms banded in 1992 was also collected in 2007 from AC645.

Of these, the 2006 and 2007 mosaics of the Big Mussel Bed, Mussel Brick Road, and the Wellhead have been constructed, placed in a GIS, digitized and analyses are underway (**Figures 10-12**). The photomosaic lines from AC645 and GC852 have all been compiled, but not yet entered into a GIS or digitized.



Figure 9. Partial photomosaic of five images from AT340 of a large mussel bed.

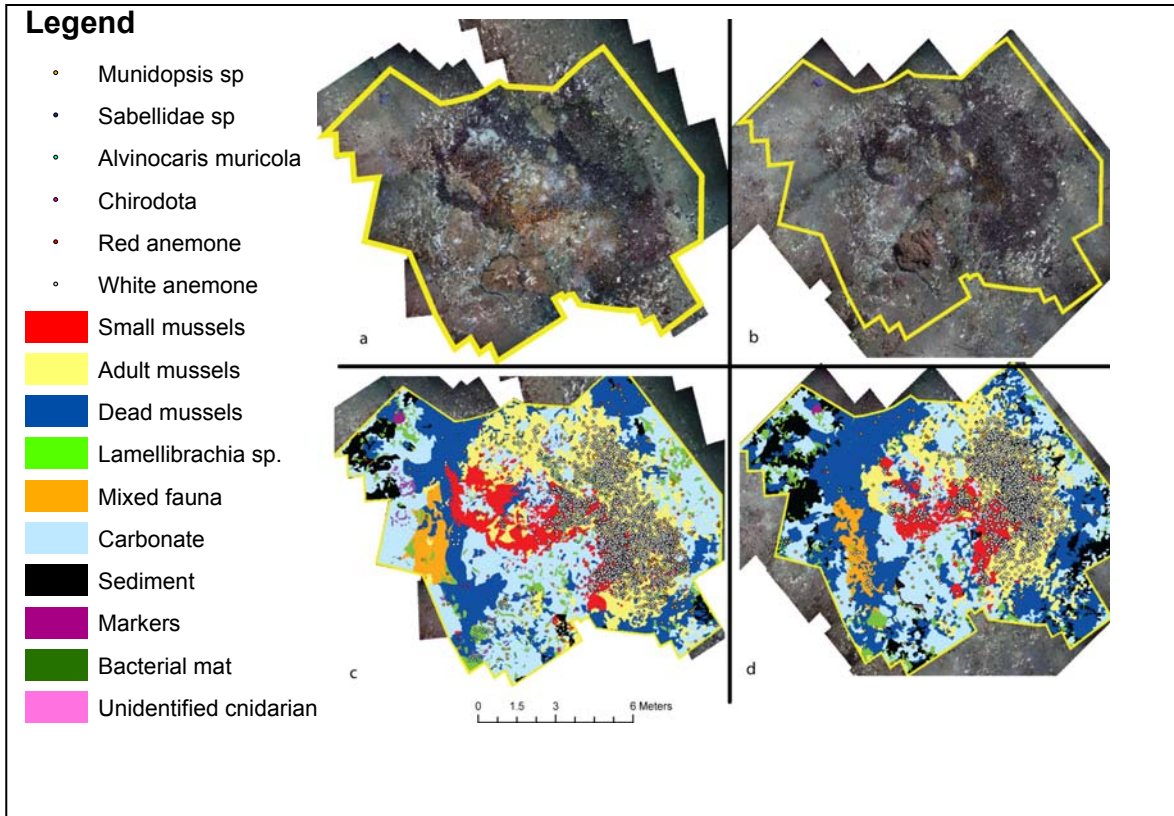


Figure 10. (A) 2006 photomosaic of the Big Mussel Bed at AT340. The yellow line indicates the overlap with the 2007 photomosaic at the same site. (B) 2007 photomosaic of the Big Mussel Bed at AT340. (C) The 2006 photomosaic digitized in ArcGIS v 9.1, with polygons representing substrate-forming fauna such as tubeworms and mussels, and points representing mobile fauna. (D) The digitized 2007 photomosaic.

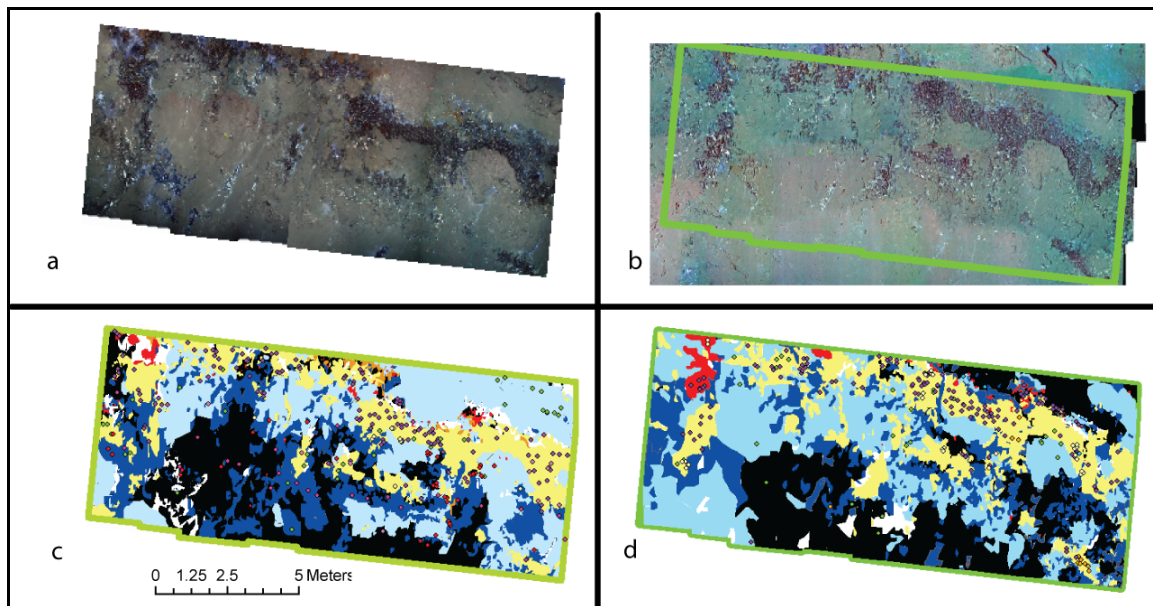


Figure 11. (A) 2006 photomosaic of Mussel Brick Road at AT340. (B) 2007 photomosaic of the Mussel Brick Road at AT340. (C) Digitized 2006 Mussel Brick Road. (D) Digitized 2007 Mussel Brick Road. For legend, see Figure 1.

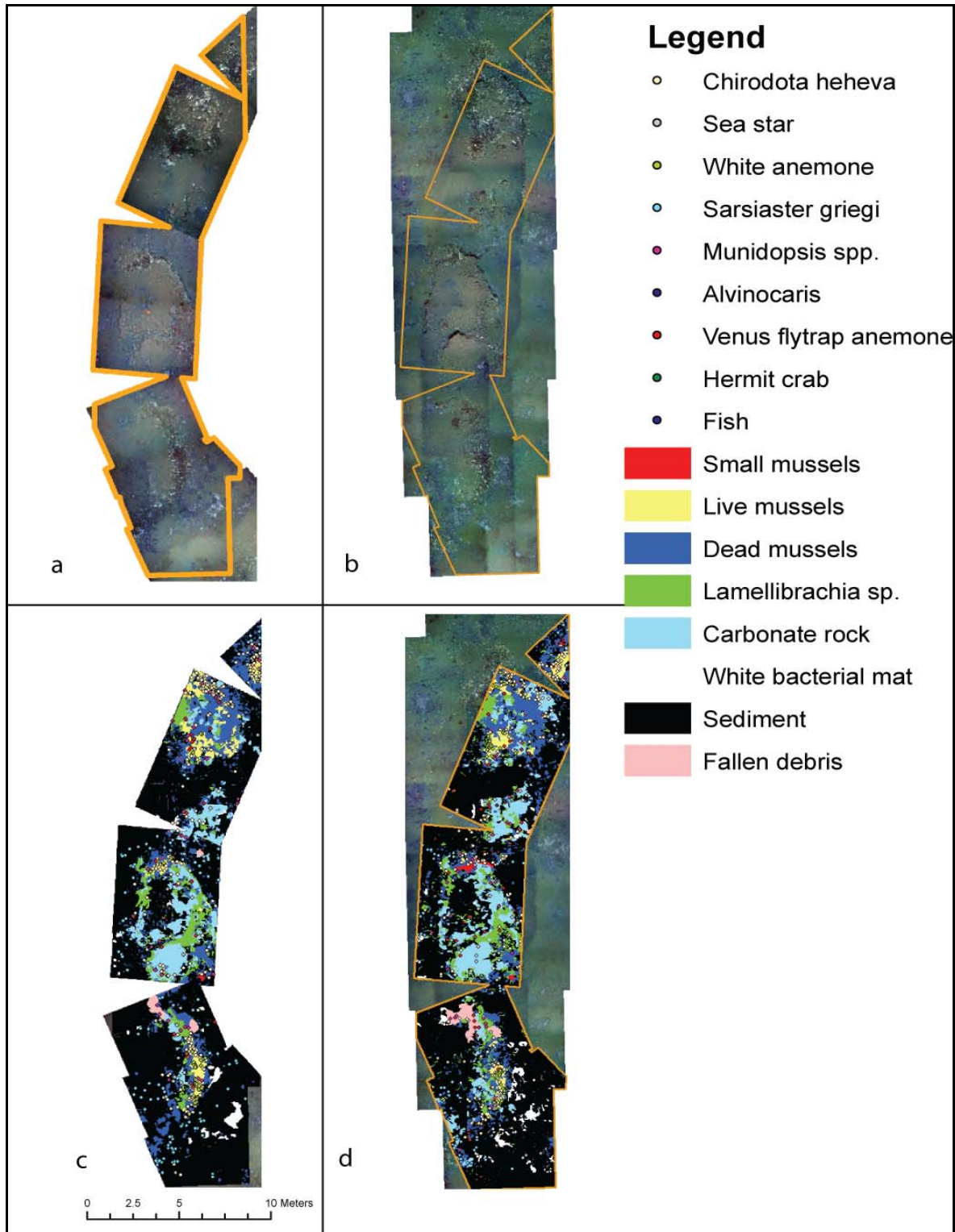


Figure 12. (A) 2006 photomosaic of Wellhead site at AC818. (B) 2007 photomosaic of the Wellhead site at AC818. (C) Digitized 2006 Wellhead. (D) Digitized 2007 Wellhead.

Images were also collected for mosaics at Alaminos Canyon 818 (AC818) of tubeworms and urchins, at AT340 of an urchin and holothurian field, and at AC-601 of the shore of a brine lake. In these cases there is insufficient overlap between images for construction of large mosaics, however smaller mosaics will be constructed for these sites if they are re-located and re-imaged in 2007.

Preliminary results, based on the photomosaics from both years at AC818 and AT340, indicate that the trends in succession of foundation fauna that have been observed at shallow water seeps are consistent with patterns observed at these deeper sites. At one of AT340 sites (Mussel Brick Road), bacterial mats are decreasing in area, and there is increased coverage by small mussels, indicating that mussel recruitment is occurring. No tubeworms are present at this site, which may mean that this community is at an early successional stage, based on the progression at shallow seeps from bacterial mats to mussel beds to tubeworm dominance. At the other AT340 site (Big Mussel Bed), there are fewer small mussels and more dead mussels in 2007 than in 2006, with abundant tubeworms and no bacterial mats. This suggests that seepage is declining at this site, and that it is at a later successional stage. Both sites have abundant anemones, crabs and holothurians associated with the presence of live mussels. At AC818, small tubeworm clumps are found near cracks in carbonate rock. Scattered bacterial mats were observed in the sediment near these cracks, and there are aggregations of small mussels and patches of dead mussels. From 2006 to 2007, bacterial mats decreased in size, and small mussel numbers increased. *Sarsiaster griegi* heart urchins are found in the sediment surrounding the carbonate slabs and tubeworm and mussel aggregations.

Mussel and Tubeworm Community Analyses from Physical Collections

A total of 47 quantitative community samples were obtained in 2006 and 2007 (**Table 17**). The Bushmaster collection device was successfully used 12 times, sampling 7 tubeworm-associated communities in 2006 and 5 in 2007. For the mussel bed communities, both mussel pot and mussel scoop samplers were used. Additional samples of a variety of habitats were collected with nets, push-cores, grabs of fauna or rock samples with the manipulator arm, and suction samples of mobile fauna.

Samples from the bushmaster and mussel pots were placed in containers upon retrieval of the submersible and the fauna retained on a 1 mm sieve were included in the community analyses. Subsamples of the remaining material were taken for meiofauna investigations. All tubeworms and mussels were measured and subsamples taken for genetic and stable isotope investigations. Macrofauna were sorted into morphospecies on board ship, or were preserved in higher taxonomic groups if identification was impractical (primarily small polychaete species). All macrofauna that could be reliably sorted into morphospecies on board ship were also sampled for isotopic and genetic analyses.

Table 17

Quantitative community samples obtained in 2006 and 2007

Name	Sample	Dive	Site	Lat	Long	Depth (m)	Tube/shell area (m ²)
KC243m1	mp	4176	KC243	26:43.841	92:49.828	1,651	0.131
MC853m1	mp	4178	MC853	28:07.645	89:08.585	1,076	0.043
AT340t1	bm	4179	AT340	27:38.677	88:21.879	2,185	0.859
AT340m1	ms	4180	AT340	27:38.692	88:21.888	2,183	0.569
AT340t2	bm	4180	AT340	27:38.696	88:21.879	2,184	0.468
AT340m2	mp	4181	AT340	27:38.835	88:22.206	2,199	0.093
AT340m3	ms1	4181	AT340	27:38.863	88:22.423	2,170	0.099
AT340m4	ms2	4181	AT340	27:38.835	88:22.206	2,199	0.179
MC640m1	mp	4182	MC640	28:21.421	88:47.546	1,399	0.161
MC640m2	ms	4182	MC640	28:21.383	88:47.585	1,398	0.251
AT340t3	bm	4183	AT340	27:38.832	88:22.437	2,179	1.286
GC852m1	mp	4186	GC852	27:06.357	91:09.974	1,410	0.167
GC852t1	bm	4186	GC852	27:06.371	91:09.968	1,409	1.506
GC852m2	mp	4187	GC852	27:06.656	91:09.937	1,406	0.163
GC852t2	bm	4187	GC852	27:06.676	91:09.932	1,406	0.498
WR269m1	mp	4191	WR269	26:41.174	91:39.750	1,908	0.048
AC818m1	mp	4192	AC818	26:10.819	94:37.380	2,744	0.290
AC818m2	ms	4195	AC818	26:10.851	94:37.374	2,745	0.185
AC818t1	bm	4195	AC818	26:10.811	94:37.379	2,745	1.584
AC601t1	bm	4196	AC601	26:23.419	94:30.862	2,323	2.465
AC645m1	mp1	4197	AC645	26:21.233	94:29.762	2,195	0.130
AC645m2	mp2	4197	AC645	26:21.233	94:29.762	2,195	0.101
AC645m3	ms	4197	AC645	26:21.232	94:29.761	2,195	0.296
AT340t4	bm	J2-270	AT340	27:38.694	88:21.843	2,192	1.687
GC852m3	ms1	J2-273	GC852	27:07.088	91:09.919	1,407	0.029
GC852m4	ms2	J2-273	GC852	27:06.692	91:09.926	1,407	0.102
GB697m1	mp	J2-274	GB697	27:18.754	92:06.385	1,005	0.260
GB697m2	ms	J2-274	GB697	27:19.2	92:06.666	1,015	0.190
WR269m2	mp1	J2-275	WR269	26:41.187	91:39.780	1,909	0.154
WR269m3	mp2	J2-275	WR269	26:41.174	91:39.797	1,910	0.241
WR269m4	ms	J2-275	WR269	26:41.175	91:39.797	1,910	0.374
AT340m5	mp	J2-276	AT340	27:25.197	88:21.853	2,190	0.219
AT340t5	bm	J2-276	AT340	27:25.199	88:21.862	2,188	1.429
AT340m6	mp1	J2-277	AT340	27:38.697	88:21.851	2,190	0.177
AT340m7	mp2	J2-277	AT340	27:38.700	88:21.859	2,190	0.162
AT340t6	bm	J2-277	AT340	27:38.839	88:22.429	2,175	1.274
GC852m5	mp1	J2-278	GC852	27:06.668	91:09.922	1,407	0.412
GC852m6	mp2	J2-278	GC852	27:06.380	91:09.953	1,408	0.214
GC852t3	bm	J2-278	GC852	27:06.355	91:09.969	1,412	1.432
GB829m1	mp	J2-279	GB829	27:11.156	92:07.515	1,258	0.252
AC645m4	mp	J2-281	AC645	26:21.255	94:29.833	2,197	0.460
AC818m3	mp1	J2-282	AC818	26:10.847	94:37.463	2,745	0.131
AC818m4	mp2	J2-282	AC818	26:10.875	94:37.490	2,744	0.181
AC818t2	bm	J2-282	AC818	26:10.783	94:37.290	2,746	0.621
AC601m1	mp1	J2-283	AC601	26:22.171	94:31.140	2,284	0.302
AC601m2	mp2	J2-283	AC601	26:22.175	94:31.155	2,284	0.153
AC818m5	mp	J2-284	AC818	26:10.843	94:37.377	2,745	0.170

A total of 130 species of macrofauna were sampled in the 117 collections obtained on the 2006 and 2007 submersible cruises (**Table 18**). These species included five or six species of vestimentiferan tubeworms, potentially four species of bathymodiolin mussels, and one vesicomyid clam. The tubeworms included the common shallow water species, *Lamellibrachia luymesii* and *Seepiophila jonesii*, at least one and perhaps 2 new species of *Lamellibrachia*, *Escarpia laminata*, and potentially a second species of *Escarpia* in some of the shallower collections (see Siboglinid phylogeny section below). The mussels collected include *Bathymodiolus brooksi* (1,080-3,290 m), which was found throughout the sampling depth range, *B. childressii* (525-2,220 m), *B. heckerae* (2,180-3,290 m), and what appears to be another species that we have not yet been able to amplify for genetic analysis. A species of *Calyptogena*, now identified as *Calyptogena ponderosa* according to its mitochondrial COI sequence, was present in collections as deep as 2,750 m extending its known bathymetric range. Another morphotype was imaged in AC818 in 2006, and a morphologically similar species sampled at AC601 in 2007, but these specimens await genetic analysis.

Table 18

Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling

	Depth (m)		Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280
	Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
			647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
	Porifera																		
	porifera spp.		x								x					x	x		
	Cnidaria																		
	<i>Acanthogorgia armata</i>			x															
	Alcyonacean sp.										x								
	Anemone spp.	x		x		x				x	x			x	x	x	x	x	x
	<i>Callogorgia americana delta</i>																		
	<i>Caryophyllia</i> sp.			x															
	Cerianthid sp.					x	x				x								
	<i>Corallium medea</i>										x								
	<i>Crysogorgia fewkesii</i>				x														
	<i>Enallopsammia rostrata</i>										x								
	Hydroid spp.	x	x	x							x				x	x	x		x
	<i>Iridogorgia pourtalesii</i>										x								
	<i>Isidella</i> sp.										x					x			
	<i>Keratoisis</i> sp.										x								
	<i>Lepidisis</i> sp.															x			
	<i>Lophelia pertusa</i>	x																	
	<i>Madrepora oculata</i>	x		x							x								
	Paramuriceid sp.	x		x							x								
	<i>Placogorgia</i> sp.		x																
	Siphonophore sp.					x													
	<i>Solenosmilia variabilis</i>										x								
	Stolonifera sp.										x				x	x			x
	<i>Villogorgia</i> sp.		x																
	Zoanthid sp.										x								

Table 18. Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling (continued).

	Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280	2,750	3,290
	Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
			647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
	Platyhelminthes																		
	unid. flat worm	x														x			
	Nematodes																		
	nematode spp.							x							x				
	Nemertea																		
	nemertean sp.	x					x							x	x	x		x	
	Echiura																		
	<i>Bonilla viridis</i>					x													
	Sipunculida																		
	<i>Phascolosoma turnerae</i>	x			x	x	x			x	x			x	x	x	x	x	
	Annelida																		
	Polychaeta																		
	Ampharetidae sp. nov.				x	x		x							x				x
	<i>Amphiduros</i> sp.																	x	
	<i>Asychis</i> sp.					x													
	<i>Bathymoorea</i> sp.										x								
	<i>Branchinotogluma</i> sp. uls	x																	
	<i>Branchinotogluma</i> sp.				x	x		x		x	x				x	x	x	x	x
	<i>Branchipolynoe seepensis</i>	x									x				x	x	x	x	x
	<i>Capitella</i> sp.	x					x	x		x	x			x	x	x	x	x	
	<i>Cirratulid</i> sp.							x			x			x					
	Ctenodrilid sp.	x																	
	Dorvilleid sp.	x						x											
	<i>Escarpia laminata</i>		x					x	x		x		x	x	x	x	x	x	x
	<i>Eteone</i> sp.	x																	
	<i>Eulalia</i> sp.	x																	
	<i>Eumida sanguinea</i>	x																	

Table 18. Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling (continued).

Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280	2,750	3,290
Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
		647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
Eunicidae	x													x				
<i>Eunice</i> sp. nov.	x																	
<i>Euratella</i> sp.	x																	
<i>Eurythoe</i> sp.	x									x			x	x				x
<i>Euthalenessa</i> sp.	x																	
<i>Euthelepus</i> sp.	x																	
<i>Flabelliderma</i> sp.													x	x				
Flabelligerid sp.													x	x	x	x	x	x
<i>Genetyllis</i> sp.	x																	
<i>Glycera tessellata</i>	x				x	x			x	x			x	x		x	x	
<i>Glycera</i> sp.	x									x			x					
<i>Haploscoloplos</i> sp.						x												
<i>Harmothoe</i> sp.	x			x	x	x	x		x	x	x		x	x		x	x	
<i>Hesciocaeca methanicola</i>	x			x			x		x	x				x	x	x	x	
<i>Hesionides</i> sp.														x				
Hesionid sp.									x					x		x	x	
<i>Heteromystides</i> sp.										x				x		x	x	
<i>Lamellibrachia luymesii</i>	x																	
<i>Lamellibrachia</i> sp. nov. 1				x		x	x	x		x		x	x	x	x	x		
<i>Lamellibrachia</i> sp. nov. 2						x		x		x				x				
<i>Linopheris</i> sp.										x								
<i>Lumbinereis</i> sp.	x			x	x	x				x				x		x	x	
<i>Lysidice ninetta</i>	x																	
Maldanid sp.													x		x			
<i>Mayella</i> sp.	x																	
<i>Methanoaricia dendrobranchiata</i>	x			x														
<i>Micronephtys</i> sp.					x	x								x				

Table 18. Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling (continued).

Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280	2,750	3,290
Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
		647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
<i>Nautilinellid</i> sp.						x								x				x
<i>Neoamphitrite</i> sp.	x																	
<i>Nephtys</i> sp.	x																	
<i>Nereis</i> sp.	x				x				x					x			x	x
<i>Nicomache</i> sp.	x				x	x				x			x	x	x	x	x	x
<i>Notomastus</i> sp.									x				x	x	x		x	
<i>Oligobrachia</i> sp.																	x	
Orbiniid sp.																		x
<i>Paraehesione</i> sp.																	x	
<i>Paranaitis polynoides</i>	x																	
<i>Pholoe</i> sp.	x															x		
<i>Phyllosyllis</i> sp.	x																	
Phyllocid sp.										x								
<i>Pista</i> sp.	x																	
Pogonophoran spp.													x	x		x	x	x
<i>Polynoella</i> sp.										x								
<i>Prionospio</i> sp.					x		x		x	x	x		x	x	x	x	x	
<i>Protomystides</i> sp.										x				x	x	x	x	x
<i>Proscoplos</i> sp.	x																	
<i>Pseudosyllides</i> sp.	x				x													
<i>Questa</i> sp.	x																	
<i>Sabellastarte</i> sp.	x																	
Sabellid sp.						x									x			
<i>Scotoplos</i> sp.	x																	x
<i>Seepiophila jonesi</i>	x	x		x														
Serpulid sp.	x															x		
Spintherid sp.	x																	
<i>Spiochaetopterus</i> sp.														x	x	x	x	

Table 18. Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling (continued).

Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280	2,750	3,290
Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
		647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
Spionid sp.														x				
<i>Sthenelanelia</i> sp.	x																	
<i>Subprotula</i> sp.															x			
<i>Syllides</i> sp.									x									
<i>Synelmis</i> sp.																		x
Terebellidae	x																	
<i>Terebellides</i> sp.						x				x								
<i>Tharyx</i> sp.	x																	
<i>Timarete</i> sp.						x				x								
unid polychaete spp	x			x	x				x					x				x
Mollusca																		
Aplacophora																		
Aplacophora sp.	x					x				x			x					x
Polyplacophora																		
<i>Ischnochiton</i> sp.					x		x			x								
<i>Leptochiton</i> spp.	x																	
Gastropoda																		
<i>Bathynnerita naticoidea</i>	x																	
<i>Cancellaria rosewateri</i>	x																	
<i>Cantrainea macleani</i>	x	x																
<i>Cataegis meroglypta</i>	x				x					x								
Cocculinidae gen nov															x			
<i>Cordesia</i> gen. sp. nov.																		x
<i>Diodora tanneri</i>	x																	
<i>Eosipho canetae</i>	x																	
<i>Fucaria</i> sp.																x		x
<i>Gymnobella</i> sp.nov.	x																	

Table 18. Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling (continued).

Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280	2,750	3,290
Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
		647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
<i>Nudibranch</i> sp.																		x
<i>Odostomia</i> sp.nov.	x																	
<i>Paraleptopsis</i> sp.				x	x				x	x			x	x	x		x	x
<i>Phymorhynchus</i> sp.													x	x		x	x	x
<i>Propilidium</i> sp.	x																	
<i>Provanna sculpta</i>	x			x														
<i>Puncturella</i> sp.										x				x				
<i>Pyropelta</i> sp.					x		x									x		
<i>Turbonilla</i> sp.nov.	x				x													
Bivalvia																		
<i>Acesta</i> sp. nov.	x																	
<i>Bathymodiolus brooksi</i>					x		x		x	x	x	x	x	x	x	x	x	x
<i>Bathymodiolus childressi</i>	x			x	x	x	x		x	x					x	x		
<i>Bathymodiolus heckerae</i>														x		x	x	x
<i>Calypptogena ponderosa</i>	x		x															
<i>Calypptogena</i> sp.					x	x							x	x	x		x	x
<i>Cuspidaria</i> sp.	x												x	x	x	x	x	x
Lucinid sp.														x	x			
<i>Pecten</i> sp.	x																	
<i>Tamu fisheri</i>	x					x				x								
<i>Vesicomya cordata</i>	x																	
indet. Bivalve	x																	
Arthropoda																		
Crustacea																		
<i>Alvinocaris muricola</i>						x	x		x	x	x	x	x	x	x	x	x	x
<i>Alvinocaris stactophila</i>	x																	
Amphipoda spp.	x					x	x		x	x			x	x	x	x	x	x

Table 18. Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling (continued).

Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280	2,750	3,290
Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
		647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
Atelecyclid sp.	x																	
<i>Bathynectes longispinus</i>	x																	
<i>Bathynomus giganteus</i>															x			
<i>Calaxius</i> sp.	x																	
<i>Chaceon</i> sp.								x										
Chirostylid sp.										x								
<i>Costatoverruca floridana</i>	x																	
Isopoda spp.										x	x		x	x	x	x	x	x
<i>Munidopsis</i> sp. nov. 1	x			x	x	x												
<i>Munidopsis</i> sp. nov. 2	x																	
<i>Munidopsis</i> spp.							x		x	x			x	x	x	x	x	x
<i>Nibilia</i> sp.	x																	
<i>Parapagurus pilosomanus</i>														x				
<i>Periclimenes</i> sp.	x					x								x				
<i>Plesionika</i> sp.	x																	
<i>Rochinia crassa</i>	x																	
<i>Rochinia tanneri</i>	x																	
<i>Stenopus</i> sp.	x																	
unid. barnacle		x								x								
unid. brachyuran													x					
unid. Galatheid						x				x								
unid. shrimp						x				x							x	
Chelicerata																		
Pycnogonida																		
<i>Anoplodactylus</i> sp.	x																	
<i>Collosendeis</i> sp.																		x
<i>Pentacolosendeis</i> sp.	x																	
Brachiopoda																		

Table 18. Species Sampled at All Sites Visited Using Both Quantitative and Non-Quantitative Sampling (continued).

	Depth (m)	550	950	950	1,020	1,080	1,180	1,260	1,280	1,400	1,410	1,650	1,890	1,910	2,190	2,200	2,280	2,750	3,290
	Site (shallowest-left to deepest-rt)	ULS	GB	MC	GB	MC	GC	GB	GB	MC	GC	KC	AT	WR	AT	AC	AC	AC	FE
			647	462	697	853	600	829	697	640	852	243	425	269	340	645	601	818	
	stalked brachiopod		x			x													
	Echinodermata																		
	Asteroidea																		
	unid. sea star																		x
	<i>Sclerasterias tanneri</i>	x																	
	Ophiuroidea																		
	<i>Amphioplus</i> sp.	x																	
	<i>Amphiura</i> sp.										x			x					
	<i>Asteroschema</i> sp. nov.	x																	
	<i>Ophienigma spinilimbatum</i>					x	x			x	x			x	x	x	x	x	x
	<i>Ophioctenella acies</i>						x			x	x	x	x	x	x	x	x	x	x
	<i>Ophiotreta vallencia rufescens</i>																		
	Echinoidea																		
	<i>Echinus</i> sp.		x																
	<i>Sarsiaster griegi</i>														x	x	x		
	Holothuroidea																		
	<i>Chirodota heheva</i>													x	x	x	x	x	x
	Chordata																		
	<i>Bellottia robustus</i>	x																	
	<i>Chauliodis sloani</i>	x																	
	<i>Diaphus dummerli</i>	x																	
	<i>Diplacanthapoma brachysoma</i>	x																	
	<i>Dysommia rugosa</i>	x																	
	<i>Ilyopis brunneus</i>	x																	
	<i>Lophius</i> sp.				x														
	<i>Ophichthus cruentifer</i>	x																	
	<i>Pachycara</i> sp.					x													
	unid fish														x				

The samples obtained in this study provide a relatively complete picture of the lower slope seep communities, however additional collections still contribute to the species list at a approximately one additional taxon per collection (**Figure 13a**). Tubeworm and mussel-associated communities follow similar patterns of species accumulation, and mussel beds are overall slightly more diverse than tubeworm aggregations (beta diversity). Of the primary sites investigated in this study, the 2,200-2,300 m depth range the best characterized, and AT340 was the most thoroughly characterized (**Figure 13b**). The AC818 site was also heavily sampled, with samples from each known substantial mussel bed and almost every tubeworm aggregation. Even with this intensive sampling effort, an average of 2.5 new taxa were added with each additional sample at AC818 suggesting that there are numerous, rare species present in these communities.

Overall, macrofauna communities that were sampled from similar depths were the most similar. There were clear divisions in community types between the upper (< 1,000 m) and lower (> 1,000 m) slope seeps and further among the tubeworm and mussel-associated communities within depth ranges (**Figure 14**). A few species known from the upper slope sites were present in samples from the shallower sites (GB647, GB697, MC853 GC415, and GC600) and rarely found in collections as deep as 2750 m (**Table 18**), but these species never dominated the communities sampled (**Table 19**). The species of seep-associated decapod shrimp (*Alvinocaris* spp.) and galatheid crabs (*Munidopsis* spp.) found on the lower slope were different from those on the upper slope. *Alvinocaris muricola* was in fact the dominant member of the lower slope mussel- and tubeworm-associated communities. A much higher phylogenetic-level change in fauna with depth is seen among the dominant seep-associated heterotrophs that feed on detritus or organic films. Gastropod molluscs (snails and limpets) are dominant in this category above 900 m, while below 1400 m echinoderms predominate, notably the ophiuroid (brittle star) *Ophiactenella acies*, the synallactid holothuroid (worm-like sea cucumber) *Chirodota heheva*, and the heart urchin *Sarsiaster greigi*. The cause for this phylum-level shift from Mollusca to Echinodermata remains elusive, but mirrors a similar shift in the non-seep fauna with depth (Carney, 2005) and suggests that similar depth related effects influence the composition of both the normal slope communities and the seep environments embedded in it.

Previously reported bathymetric trends of changing biomass and faunal density in background Gulf communities were not apparent in these collections when compared to similar collections from the upper slope of the northern Gulf. Density and biomass of fauna in the lower slope collections were within the range of those reported from the upper slope seeps, and biomass estimates higher in deep water than at the upper slope seeps (**Figure 15**). In general, density and biomass values were greater in mussel beds than tubeworm aggregations. A mid-slope diversity maximum, as reported in the background Gulf of Mexico communities and the deep-sea soft benthos world-wide, was not apparent

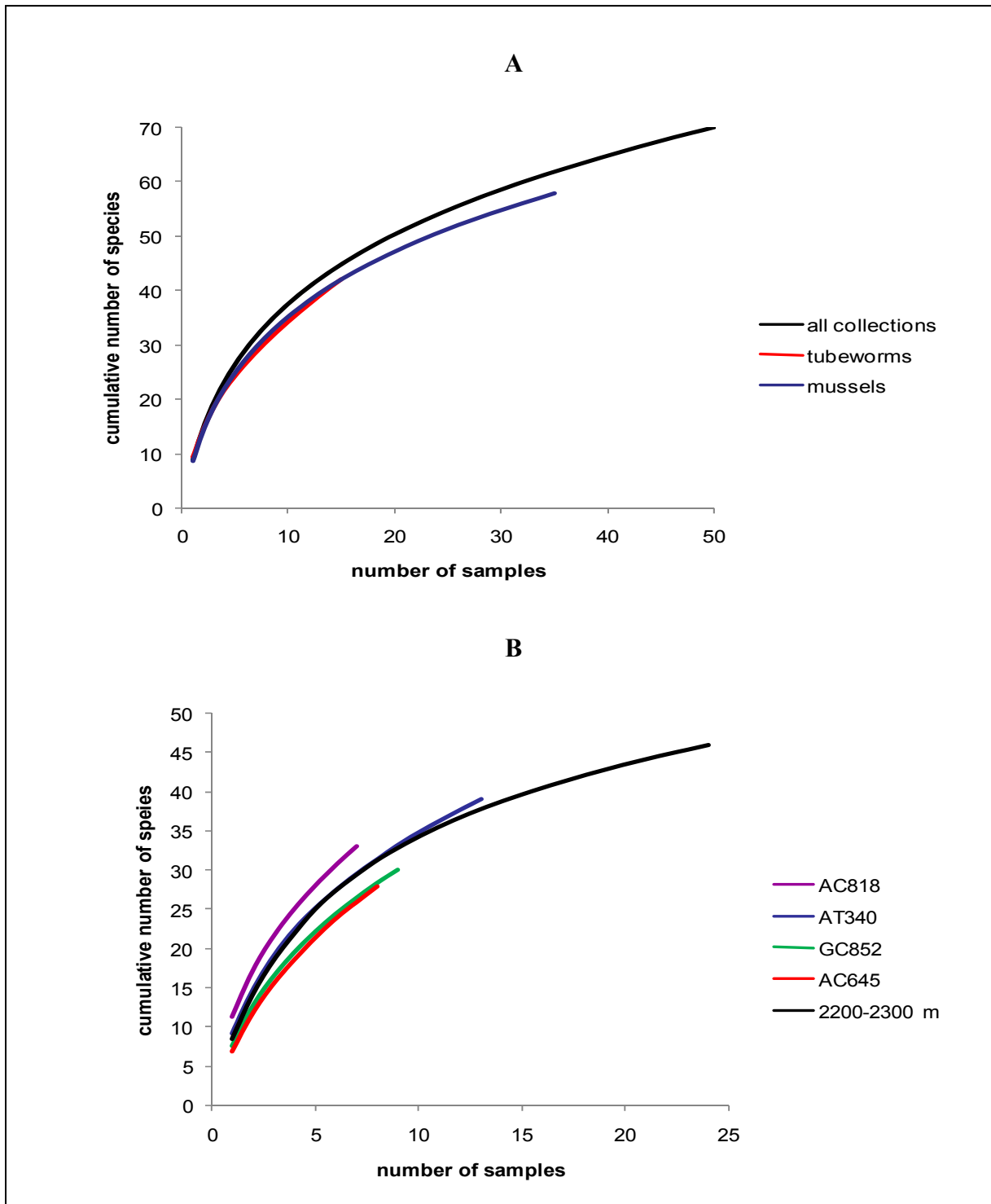


Figure 13. Sampling efficiency curves. (A) Mussel, tubeworm, and all community types at all sites combined. Mussel-associated taxa include both mussel pot and mussel scoop collection devices. (B) Curves for the four most-sampled sites and for the sites between 2,200 and 2,300 m depth combined.

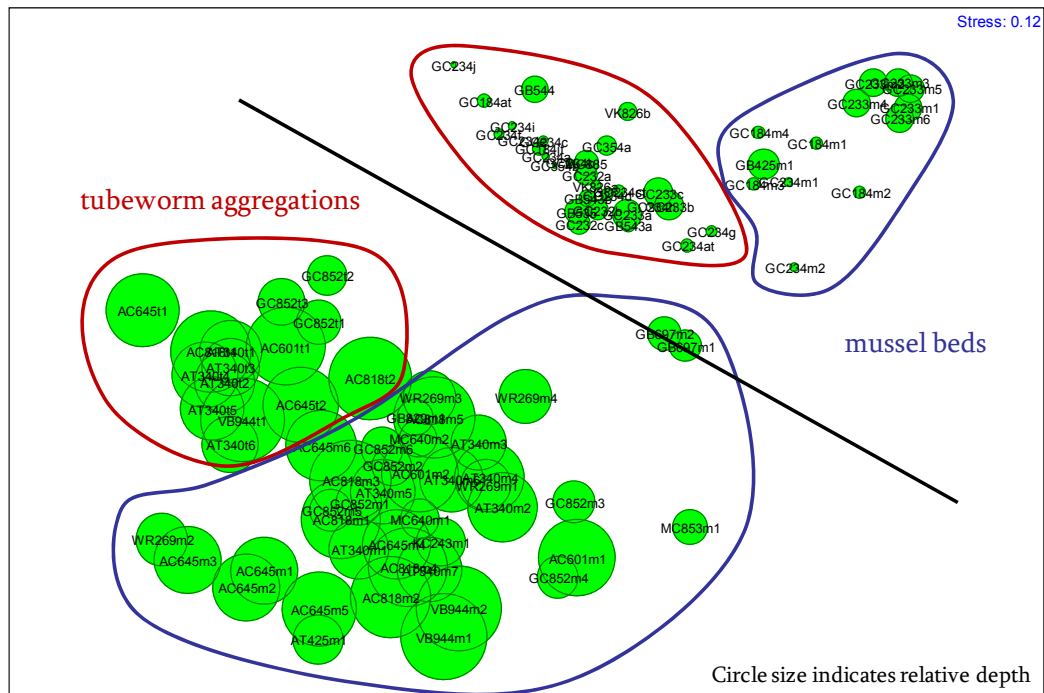


Figure 14. Nonmetric multidimensional scaling (MDS) ordination of mussel and tubeworm communities based on Bray-Curtis similarity of fourth-root transformed densities of fauna.

Previously reported bathymetric trends of changing biomass and faunal density in background Gulf communities were not apparent in these collections when compared to similar collections from the upper slope of the northern Gulf. Density and biomass of fauna in the lower slope collections were within the range of those reported from the upper slope seeps, and biomass estimates higher in deep water than at the upper slope seeps (**Figure 15**). In general, density and biomass values were greater in mussel beds than tubeworm aggregations. A mid-slope diversity maximum, as reported in the background Gulf of Mexico communities and the deep-sea soft benthos world-wide, was not apparent in these samples (**Figure 15**). This is likely due to the more significant influence of seep productivity and successional trends in regulating these characteristics of hydrocarbon seep communities.

In the quantitative samples collected, tubeworm aggregations and mussel beds hosted different associated communities (**Figure 16**). Mussel beds contained higher abundances of *Ophiotennella acies*, and tubeworms contained high abundances of two species of capitellid polychaetes, *Heteromystides* sp. and *Protomystides* sp. *Heteromystides* sp. was found occupying and occasionally filling the tubes of dead tubeworms. *Protomystides* sp. was found forming small “caps” on the tops of *E. laminata* and occasionally *Lamellibrachia* sp. and their coelomic

cavities were filled with blood, presumably from the tubeworms. Further investigations into the relationships of these two species to the tubeworms are underway.

Comparisons among mussel bed samples indicated that community similarity was most closely correlated to the depth of the collection ($r = 0.244$, $p < 0.001$) and the proportion of *B. brooksi* in the samples ($r = 0.350$, $p = 0.019$). Distance between collections was not significantly correlated to community similarity, suggesting that depth is a stronger determinant of community type than distance. This can be seen in the similarity among the communities at 2,200-2,300 m in Atwater Valley and Alaminos Canyon. In tubeworm aggregations, the best predictor of community similarity was the average length of the *E. laminata* found in the aggregation ($r = 0.335$, $p = 0.001$). The other variables tested were not significant, but again depth ($r = 0.174$, $p = 0.099$) was a slightly better predictor than distance between collections ($r = 0.136$, $p = 0.199$).

Some successional trends were detected in the communities associated with both tubeworms and mussels. Mussel beds and tubeworm aggregations composed of smaller individuals harbored communities comprised of a greater relative biomass of grazing species (**Figure 17**). In **Figure 17**, community samples (mussel pots shown in a and bushmaster collections in b) are arranged by increasing average length of mussels shells or tubeworm tubes measured. Symbiotic fauna include organisms known to harbor bacterial symbionts, but excludes the mussels and tubeworms acting as foundation species that account for over 97% of the total biomass in each collection. Commensal species include the polychaetes inhabiting the ends of the tubeworm tubes or living inside mussel shells. Grazer and deposit feeders primarily include species of polychaetes, gastropods, and ophiuroids as well as *Chirodota heheva*. The primary predator category included large polychaetes, but was largely composed of *Alvinocaris muricola*, which made up over 50% of the total biomass of associated fauna. Secondary predators included occasional individuals of large crustaceans or fishes. This group was mainly composed of *Chirodota heheva*, *Phascolosoma turnerae*, and *Ophioctenella acies*. Tubeworm communities contained lower total biomass of primary consumers than mussel bed communities, suggesting that they are a later stage of succession. Within tubeworm aggregations, the similarity of communities in aggregations of similarly sized *E. laminata* suggests a temporal trend in community structure as has been previously observed on the upper slope. However, nearly all tubeworm and mussel communities were dominated in terms of biomass by the shrimp *Alvinocaris muricola*, which made up an average of 37.8% of the biomass in mussel communities and 63.1% of the biomass in tubeworm communities. These results suggest that within a given site community structure changes as tubeworms and mussels grow over time, providing preliminary evidence for the successional progression of communities. A complete successional story will be developed with the addition of growth rate data and in situ water chemistry in the coming year.

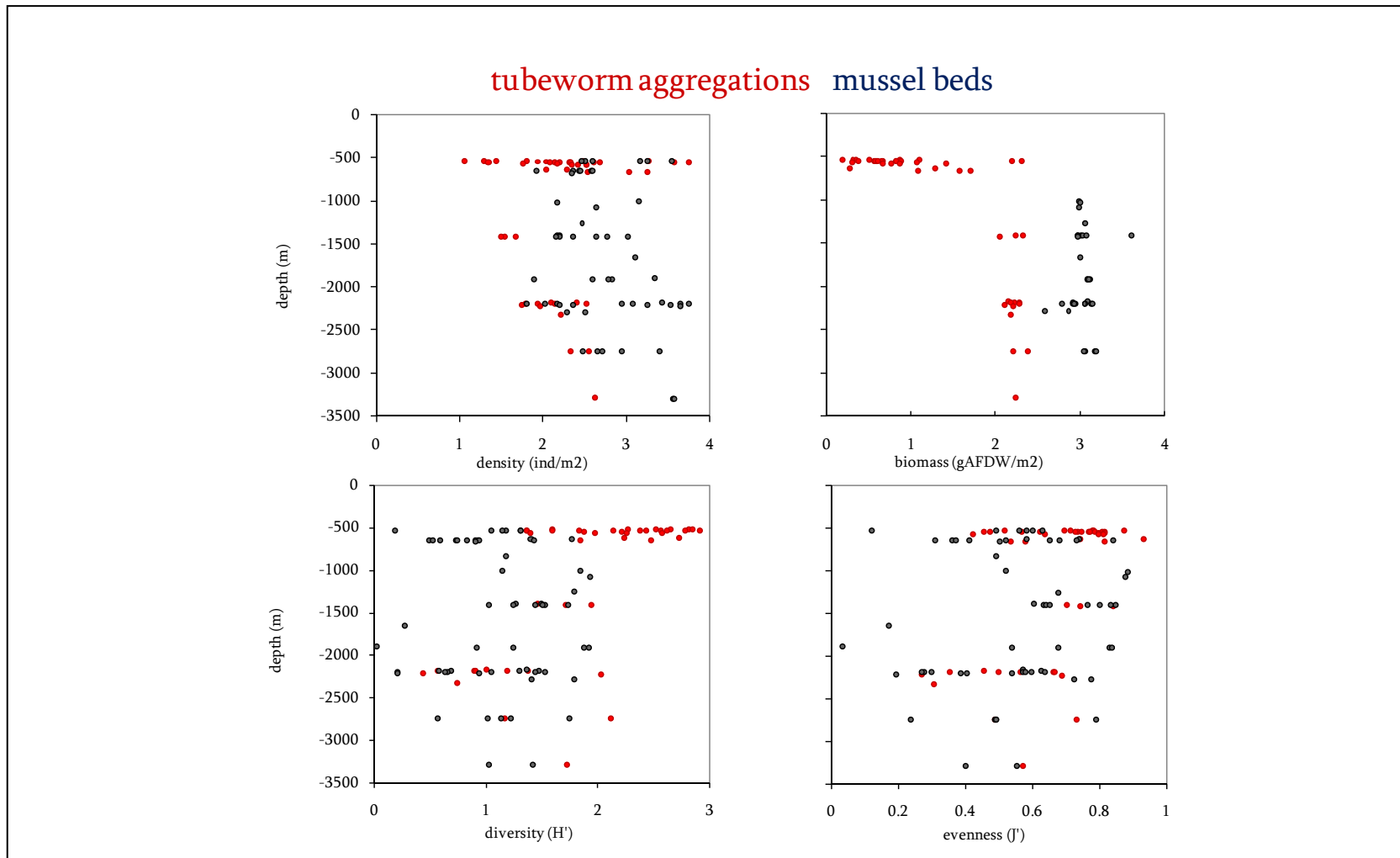


Figure 15. Density, biomass, diversity and evenness of the communities sampled using quantitative collections devices vs depth of the sites.

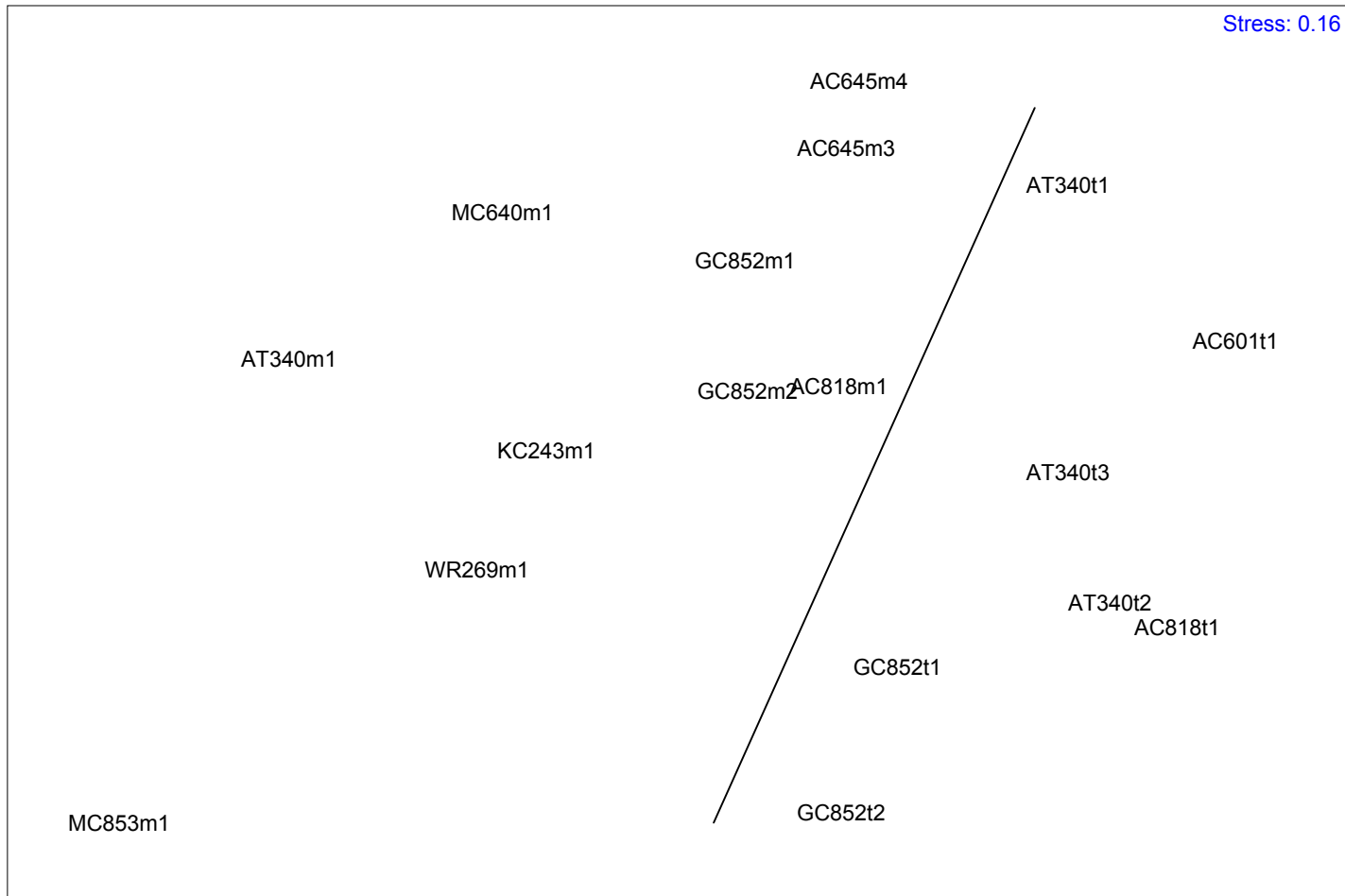


Figure 16. Nonmetric multidimensional scaling (MDS) ordination of mussel (m) and tubeworm (t) communities based on Bray-Curtis similarity of fourth-root transformed relative abundance data.

Table 19.

Abundances of Taxa Sampled in Tubeworm Aggregations.

Sample	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm
Dive	4179	4180	4183	4186	4187	4195	4196	J2-270	J2-276	J2-277	J2-278	J2-282	
Cnidaria													
Anemone spp.		61											7
Nemertea													
nemertean sp.													1
Sipunculida													
<i>Phascolosoma</i> sp.				1	2		5				3		
Annelida													
Polychaeta													
<i>Branchinotogluma</i> sp.											1	2	
<i>Capitella</i> sp.							2						5
<i>Eurythoe</i> sp.											1		
Flabelligerid sp.													7
<i>Glycera tessellata</i>							2			1			1
<i>Harmothoe</i> sp.	1			2	1						2	3	
<i>Heteromystides</i> sp.	2	10	9	24	14	117		49	5		13		
<i>Lumbinereis</i> sp.							1						
<i>Nicomache</i> sp.										1			
<i>Oligobrachia</i> sp.													2
<i>Prionospio</i> sp.													1
<i>Protomystides</i> sp.	99	83	235	5	1	188	311	60	56	38	7	73	
<i>Spiochaetopterus</i> sp.							1			4			

Table 19. Abundances of Taxa Sampled in Tubeworm Aggregations (continued)

Site	AT340	AT340	AT340	GC852	GC852	AC818	AC601	AT340	AT340	AT340	GC852	AC818
Sample	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm
Dive	4179	4180	4183	4186	4187	4195	4196	J2-270	J2-276	J2-277	J2-278	J2-282
unid polychaete spp			1									
Mollusca												
Polyplacophora												
<i>Ischnochiton</i> sp.											1	
Gastropoda												
<i>Paraleptopsis</i> sp.		1	2	2	1	1						
<i>Puncturella</i> sp.				2							5	
Bivalvia												
<i>Calypptogena</i> sp.										1		
<i>Cuspidaria</i> sp.												19
Lucinid sp.										2		
<i>Tamu fisheri</i>				1								
Arthropoda												
Crustacea												
<i>Alvinocaris muricola</i>	16	22	55	5		14	74	32	25	109	10	21
Amphipoda spp.		7	28	11	1	9	1	2	1			2
Isopoda spp.		3			2	8						38
<i>Munidopsis</i> sp.		1				1	4	1		6	2	2
<i>Munidopsis</i> sp. (fuzzy)												1
unid. shrimp						1						

Table 19. Abundances of Taxa Sampled in Tubeworm Aggregations (continued)

Site	AT340	AT340	AT340	GC852	GC852	AC818	AC601	AT340	AT340	AT340	GC852	AC818
Sample	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm
Dive	4179	4180	4183	4186	4187	4195	4196	J2-270	J2-276	J2-277	J2-278	J2-282
Echinodermata												
Asteroidea												
unid. sea star						4						
Ophiuroidea												
<i>Ophioctenella acies</i>				1	2				1	1		
<i>Ophienigma spinilimbatum</i>						2	1	1				27
Holothuroidea												
<i>Chirodota</i> sp.	1					2	1					8

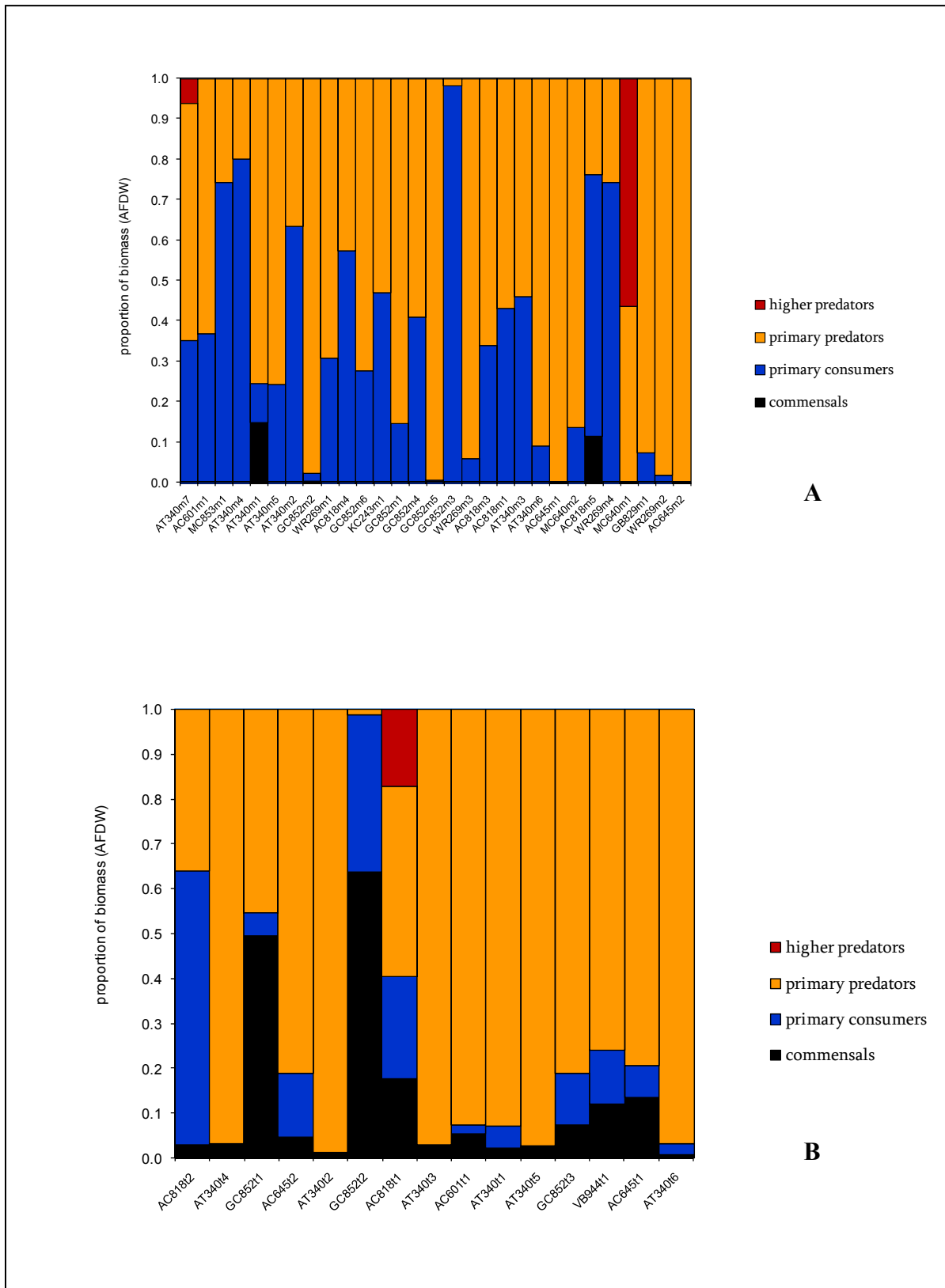


Figure 17. Proportion of biomass in each trophic level in quantitative samples from 2006 and 2007. (A) Mussel communities, (B) Tubeworm communities.

Other seep-related communities sampled in this study include small “fields” of pogonophorans at Walker Ridge (WR269, 1,950 m) and urchin beds in Atwater Valley (AT340, 2,220 m). The fields of undescribed pogonophorans were inhabited by the holothurian *Chirodota heheva* as well as a small amphipod and a small gastropod normally found at the ends of the pogonophoran tubes. The pogonophorans are being described by our collaborators from France and Austria (S. Hourdez and M. Bright). Moderate to high densities of heart urchins were imaged at several sites and some of the highest sediment sulfide levels measured during the cruise were associated with push cores taken in the urchin fields. The urchins appeared to be plowing through surface bacterial mats, exposing dark seep sediments below. Both of these community types are targeted for further interdisciplinary study during the 2007 JASON II operations.

Occasional small colonies of octocorals (“soft” corals) were present at most of the sites visited, and several large colonies of bamboo corals were seen at AC645. Only one site, Green Canyon 852 (1,410 m) contained hard-grounds extensively colonized by deep-water coral species. Two species of scleractinian corals were observed, along with many species of octocorals (Order Alcyonacea), including at least two species of bamboo corals (Family Isididae). The ‘Coral Garden’ area where these anthozoans were found covers an area approximately 30 m across on the shallowest southern end of a large, N-S trending mound that rises from 1,500 to 1,392 m characterized by large authigenic carbonate boulders and strong currents. *Enallopsammia rostrata* was collected from the base of a large carbonate boulder at 1,397 m using ALVIN. *E. rostrata* is a cosmopolitan species, but this finding extends its range in the Gulf of Mexico from the southeastern quadrant of the Gulf near the Straights of Florida. Data provided by our collaborator Cheryl Morrison at the USGS indicate that this Gulf *E. rostrata* individual differs from a sample from the Bishop Seamount in the Pacific by four substitutions (0.7 %) at the mitochondrial 16S gene, and a congener, *E. profunda*, by five substitutions (1.04 %). Given the generally slow evolutionary rate of mitochondrial genes in scleractinians, this level of differentiation of this gene within species (and often within genera) is uncommon, so this result suggests we may be dealing with a morphologically cryptic species. Another cosmopolitan scleractinian coral species, *Madrepora oculata*, was observed and photographed, but was not sampled. *M. oculata* is one of the primary deep reef constituents in the eastern Atlantic and occurs along the Southeastern U.S. coast, the Western Gulf of Mexico, and in the Indian and Pacific Oceans. Both of these cosmopolitan species were found close to their known depth limits (1,646 m for *E. rostrata* and 1,500 m for *M. oculata*). Only a few physical samples of the corals at this site were possible due to the extremely rugged topography of the site and the strong currents in the area at the time of the submersible dives. However, several samples of bamboo corals were also collected from this site, and although taxonomic identification is not complete, sequence data (C. Morrison, USGS) from the 5’ region of the *msh1* mitochondrial DNA gene allies these samples with the genus *Isidella*, with a 99% match to an undescribed *Isidella* species from Hawaii. The mosaic lines obtained over the main coral area at this site will guide our sampling efforts this year which should also be facilitated by JASON II’s station-holding capabilities.

One of the most challenging aspects of the community sampling in the first field season was the presence of extremely large (up to 25 cm in length) mussels that had a tendency to foul the opening of the mussel pots. To overcome this problem, a 63 μ m mesh nytex liner (similar to the liner of the Bushmaster) was fitted to the inside of a coarse-mesh net (the “scoop”) and used to

sample a number of mussel beds. The manipulator of the submersible dragged the scoop through the mussel bed then placed the entire scoop into a biobox and closed the lid. In planning for the second field season, the samples obtained by each method were compared to determine if the two methods sampled similar communities from the same habitats. There were 8 scoop samples taken at 6 sites and 12 mussel pots taken at 8 sites. Scoop samples contained an average of 9.0 species and 243 individuals per sample, while mussel pots contained an average of 7.2 species and 79 individuals per sample, and the scoop sampled species at a greater rate per sample (**Figure 14**). Species sampled in scoop samples but not mussel pots were a small cerianthid anemone, a nematode, the polychaetes *Hesionides* sp., *Lumbrineris* sp., *Syllides* sp., a pogonophoran, and a mussel-commensal nautilinellid, the gastropods *Fucaria* sp. and *Phymorhynchus* sp., the bivalves *Calyptogena* sp. and a species resembling *Tamu fisheri*. Species in the mussel pot samples but not the scoop samples were a platyhelminth, an ampharetid and maldanid polychaete, the polychaetes *Micronephtys* sp. and *Nereis* sp., the chiton *Ischnochiton* sp., the gastropod *Cataegis meroglypta*, the crustaceans *Bathynomous giganteus*, *Chaceon* sp., and multiple species of isopods, an unidentified urchin species, and an unidentified ophiuroid. The scoop appeared to sample gastropods and bivalves with greater efficiency including some species that have been previously reported as quite common in this depth range. Most of species sampled exclusively with the mussel pots are species found at the upper slope seeps (*C. meroglypta*, *B. giganteus*, *Chaceon* sp., *Ichnochiton* sp., and *Nereis* sp.), resulting from the shallower depth range of the mussel pot samples (1,050 m at MC853 vs. 1,400 m at GC852 for the scoop samples).

Statistical analyses were carried out on relative abundance data (proportion of individuals in each species) because not all scoop samples were lined with the finer mesh and not all mussel individuals were measured in all scoop samples. Even with these differences in methodology, the relative abundance of species was not significantly different between the two sampling devices (ANOSIM, Global R = 0.055, P = 0.237). A multidimensional scaling (MDS) ordination confirmed this result, where similarity among mussel communities was more highly governed by site than by collection method (**Figure 15**). These results indicate that the scoop samples are a sufficient, and possibly superior, sampling method for the mussel beds encountered, particularly for the mussel beds composed of large *B. brooksi* individuals. Both methods will be used in concert in 2007 and standardize collections to a measure of mussel shell surface area.

A total of 12 tubeworm aggregations were successfully stained during field operations in 2006. Most of these will be collected using the bushmaster collection device in 2007 and others will be collected using Jason's manipulator for determination of growth rates and ages of the deep-occurring tubeworm species.

MEIOFAUNA

Meiofauna were sampled from the more intensively studied dive sites. In this under-sampled group of very small animals (those passing through a 1-mm sieve but retained on a 32- μ m sieve), numerous undescribed species were discovered. Nematoda and Copepoda were the most common taxa, but members of the Tanaidacea, Isopoda, and Ostracoda were also found. Among them was one of the largest free-living members of the phylum Nematoda ever collected.

Meiofauna in 2 samples from bushmaster collections of tubeworm communities and 2 samples from mussel pot collections of bathymodiolin communities from GC852 have been analyzed. The collections were made during ALVIN dives 4186 and 4187 in 2006. The total numbers of meiofauna taxa (net size 32 μ m to 1mm) were determined (**Table 20**) and copepods were identified to species level. Analysis of mussel and tubeworm collections from AT340, mussel collections from AC645 and AC818, and collections from urchin beds are currently underway.

Abundances standardized to 10 cm² were extremely low (**Table 21**) and only two meiofauna phyla were found in the GC852 samples, Arthropoda (Copepoda, Ostracoda, Halacaria) and Nematoda. The copepod community was studied in detail and consisted of 14 families, 27 genera and 43 species (**Table 22**). Only 8 species have previously been described and the majority of these were previously only known from shallow waters. The remaining 35 species are new to science.

Table 20.

Total Meiofauna Per Sample from GC852

Taxa	BM 4186	MP 4186	BM 4187	MP 4187
Nematoda	1005	2	181	19
Copepoda	759	240	64	179
Ostracoda	3	0	0	11
Halacaria	7	0	0	9
Nauplii	55	0	10	92

Table 21.

Density of Meiofauna Per Sample from GC852 (Ind/10cm⁻²)

Taxa	BM 4186	MP 4186	BM 4187	MP 4187
Nematoda	3,56	0,04	0,64	0,36
Copepoda	2,81	4,52	0,23	3,37
Ostracoda	0,01	0	0	0,21
Halacaria	0,03	0	0	0,17
Nauplii	0,19	0	0,04	1,73

Table 22.

Species List and Total Abundance of Meiofauna from the GC852 Quantitative Collections

Taxon	BM 4186	MP 4186	BM 4187	MP 4187
Ord. Harpacticoida				
Fam. Ameiridae				
<i>Ameira parvula</i>	52	0	10	2
<i>Ameiropsis mixta</i>	36	0	0	0
<i>Ameiropsis</i> spec. 1	23	0	0	0
<i>Pseudameira</i> spec. 1	1	0	0	0
<i>Pseudameira</i> spec. 2	1	0	0	0
<i>Sarsameira</i> spec. 1	2	1	0	0
Fam. Ancorabolidae				
Ancorabolidae spec. 1	1	0	0	0
<i>Uptionyx</i> spec. 1	3	0	0	0
Fam. Argestidae				
Argestidae spec. 1	2	0	0	0
Argestidae spec. 2	2	0	0	0
<i>Argestes</i> spec. 1	0	0	10	0
Fam. Canthocamtidae				
<i>Heteropsyllus</i> spec. 1	4	0	0	0
<i>Mesochra</i> spec. 1	111	0	4	38
<i>Psammocamptus</i> spec. 1	0	0	0	1
Fam. Cletodidae				
<i>Cletodes longicaudatus</i>	0	0	2	0
<i>Strongylacron</i> spec. 1	2	0	0	0
Fam. Ectinosomatidae				
Ectinosomatidae spec. 1	0	0	1	0
<i>Halectinosoma</i> spec. 1	0	0	2	0
<i>Pseudobradya</i> spec. 1	0	1	2	11
<i>Pseudobradya</i> spec. 2	1	0	0	0
Fam. Laophontidae				
<i>Esola typhlops</i>	25	0	1	5
Fam. Miraciidae				
Miraciidae spec. 1	6	0	0	0
<i>Amphiascella neglecta</i>	58	0	4	0
<i>Amphiascus</i> spec. 1	8	0	1	0
<i>Amphiascus</i> spec. 2	89	0	0	0
<i>Amphiascus</i> spec. 3	101	0	0	0
<i>Delavalia gundulae</i>	2	0	0	1
<i>Delavalia</i> spec. 1	2	0	0	0
Fam. Pseudotachiidae				
<i>Pseudomesochra</i> spec. 1	1	0	0	0
<i>Pseudomesochra</i> spec. 2	0	0	0	1
<i>Pseudomesochra</i> spec. 3	0	0	0	1
<i>Xylora bathyalis</i>	0	0	2	3
Fam. Tegastidae				
<i>Smacigastes</i> sp. nov.	44	0	0	0

Table 22. Species List and Total Abundance of Meiofauna from the GC852 Quantitative Collections (continued).

Taxon	BM 4186	MP 4186	BM 4187	MP 4187
Fam. Tisbidae				
<i>Tisbe</i> spec. 1	0	9	0	65
<i>Tisbe</i> spec. 2	0	0	0	15
Ord. Cyclopoida				
Fam. Cyclopinidae				
Cyclopinidae spec. 1	3	0	0	0
<i>Cyclopina</i> spec. 1	0	2	0	9
<i>Pterinopsyllotus</i> spec. 1	0	0	1	0
<i>Oncaea</i> spec. 1	3	1	5	1
Fam. Poecilostomatoidae				
Poecilostomatoidae spec. 1	2	0	4	1
<i>Sapphirina</i> spec. 1	0	0	1	0
	0	0	0	0
unknown	7	0	2	5
Σ	592	14	55	159

Our preliminary analyses suggest that meiofauna species diversity measured as species richness and a variety of diversity indices is higher in tubeworm aggregations than in the mussel beds (**Table 23**). The copepod community of GC852 cold seep area shows no similarity in species composition to recent analyses of hydrothermal vent samples. Abundances of total meiofauna were also lower than those of tubeworm and mussel aggregations collected with similar equipment at hydrothermal vent sites on the East Pacific Rise.

Table 23.

Univariate Diversity Measures of Copepod Communities

	BM 4186	MP 4186	BM 4187	MP 4187
Species (S)	27	5	17	14
Individuals (N)	585	14	52	154
ES (55)	12,590	5,000	17,000	9,339
Margalef d	4,081	1,516	4,049	2,581
Pielou J'	0,725	0,701	0,877	0,656
Shannon H'(loge)	2,389	1,128	2,484	1,731
Simpson 1-λ'	0,881	0,593	0,908	0,746
Fisher α	5,850	2,782	8,792	3,742

Siboglinid Identification and Distribution

The two morphologically distinct “pogonophorans” collected during both cruises have now been sequenced and based on the mitochondrial 16s gene fall into two distinct clades of the

Siboglinidae (**Figure 18**, tree built by Neighbor joining of Kimura-2-Parameter distances. Bootstrap values have been calculated for 1,000 replicates. Values below 70% are not shown. "JSL" samples indicate samples collected by the Johnson Sea-Link subs, at depths ranging from 500 to 600 m. Other numbers indicate lease block and correspond to animals collected during the 2007 cruise.). The "Small Curly" one is a Monoliferan and most closely related to *Sclerolinum brattstromi* from the Norwegian margin. Monoliferans are a distinct clade from other pogonophorans and are basal to the vestimentiferan siboglinids. The larger straight one was identified as belonging in the described pogonophoran genus *Oligobrachia*. Both species are currently being described based on both molecular and morphological criteria by our French and Austrian collaborators.

One focus of the 2007 expedition was to identify the depth of transition of foundation species such as the vestimentiferan siboglinid ("tubeworms"). During the molecular confirmation of our identifications from the 2007 collections an additional cryptic species was discovered as was an unexpected overlap in the distribution of the *Lamellibrachia* species. Because of this we have begun to sequence additional individuals of each morphotype identified from each site. We have isolated DNA from over 70 vestimentiferan individuals from the deep-slope sites. Obtaining good sequences from the mitochondrial COI genes has proved problematic (about a 50% success rate) and we have moved our initial emphasis to the mitochondrial 16S gene. Based on the 16S sequences analyzed to date we can make the following generalizations. *Seepiophila jonesi*, a common and widespread species on the upper slope was confirmed in one of our collections on the lower slope, from GB647 at 1,000 m. *Escarpia laminata* was confirmed in collections as shallow as 1,250 m depth (in GB829) and in many of our other collections including our deepest site at 2,800 m depth (in AC818). A potential new species of *Escarpia* was found in the collections from GB697 at a depth of 1,270m. Additional escarpids collected from sites above 1250 m are currently being analyzed. *Lamellibrachia luymesii*, the dominant lamellibrachid on the upper slope was found in several of our collections between 1,000 and 2,000 m (from GB697 at both the 1,000 m and 1,270 m collection sites, GB829 at 1250 m and from WR269 at 1900 m). The common undescribed deeper water lamellibrachid, *Lamellibrachia* sp. nov. 1, was also found at these sites, as well as in the sites between 2,000 and 2,400 m depth (AC645, AC601, and AT340). An additional potential new species of *Lamellibrachia* (sp nov 2) was also present in some collections. No lamellibrachids were found in our relatively extensive collections from AC818 (2,800 m depth). DNA from additional individuals of *Lamellibrachia* from all sites is being extracted and in preparation for analysis of additional genes in all samples.

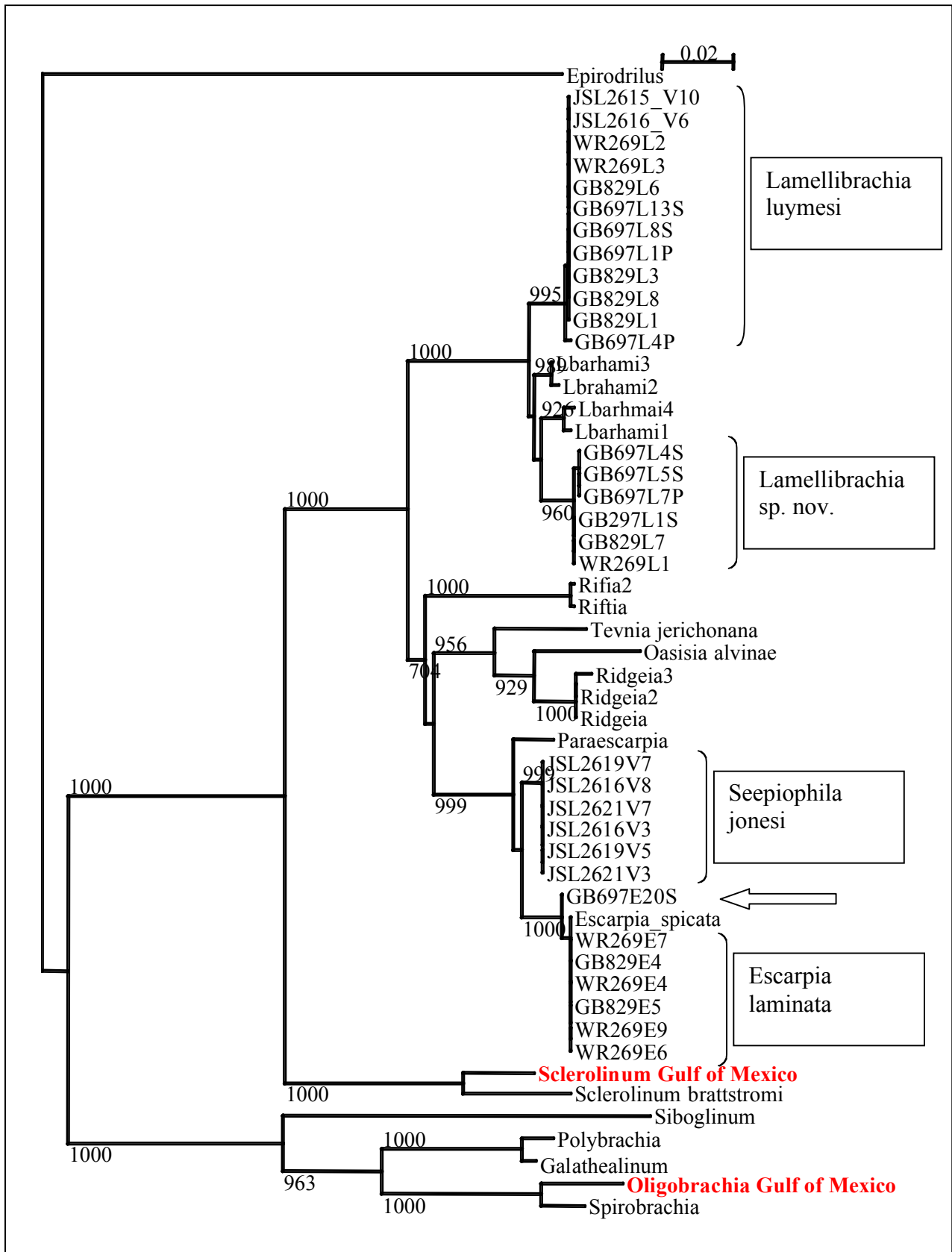


Figure 18. Phylogenetic tree of siboglinid species based on a 500-base pair alignment of the mitochondrial 16S gene.

Stable Isotope Analyses of Food Sources and Trophic Interactions

We collected 1682 samples using submersibles for potential stable isotope analysis from the two cruises to the deep slope of the Gulf of Mexico and stored them frozen at -80°C onboard the ship and at the laboratory at Penn State. Of these frozen samples, we have processed 628 samples to address specific questions about nutrition of deep slope animals.

All of the coral tissue and skeleton samples from the deep slope have been processed and analyzed for stable isotope composition. The tissue samples have been analyzed for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and the skeleton samples were for $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$. These data were included in a study that was part of the MMS-funded *Lophelia I* project and focused on cold-water corals, mostly *Lophelia pertusa*, collected from the Upper Louisiana Slope between 335 and 634 m. The aim of this study was to assess the extent of reliance of cold water coral communities upon local seep primary production, and data from the deeper corals collected between 960 and 1400 m were included to determine whether there is increased reliance upon seep production with depth due to the decrease in quantity and quality of surface-derived nutrition reaching the bottom. This manuscript is completed, have been approved by MMS, and will be submitted to Deep-Sea Research.

The main finding of this study was that the majority of the corals and other primary consumers on the Upper Louisiana Slope showed little, if any, reliance upon seep primary production, despite their proximity to old tubeworm aggregations (**Figure 19**, corals collected from deepwater sites (>900 m) as part of this project are indicated with yellow stars. All other organisms were collected on the upper slope as part of the *Lophelia I* project.). Hard and soft corals from deeper sites (between 960 and 1450 m) had similar tissue isotope values to the more shallow water species (**Figure 19**). There was also no notable difference in the skeleton stable isotope values between deep and shallow corals (**Figure 20**, the open triangles represent authigenic carbonates from the upper slope, the dashes represent *L. pertusa* skeleton from VK 826 and VK 862, and the open circles represent skeleton of scleractinian corals from deep sites collected as part of this project).

Exceptions to the lack of input of local production were found in the solitary coral *Caryophyllia polygona* from the Upper Louisiana Slope that had an unusually low tissue $\delta^{15}\text{N}$ value of 0.8‰ (from the GC234 study site at 501 m), and the related *Caryophyllia* sp. from the MC462 study site at 960 m that also had an unusually low $\delta^{15}\text{N}$ value of 0.2‰ (Figure 10). The unusually depleted $\delta^{15}\text{N}$ values indicate that these solitary corals specialize upon $\delta^{15}\text{N}$ -depleted food sources. Low $\delta^{15}\text{N}$ values indicate that the source of nitrogen is local rather than PON from the surface and has undergone little biological processing (i.e. trophic level enrichment). High concentrations of ammonium in seep pore waters have been documented and can favor relatively high fractionation rates during ammonium assimilation by nitrifying bacteria (Lee and Childress, 1994).

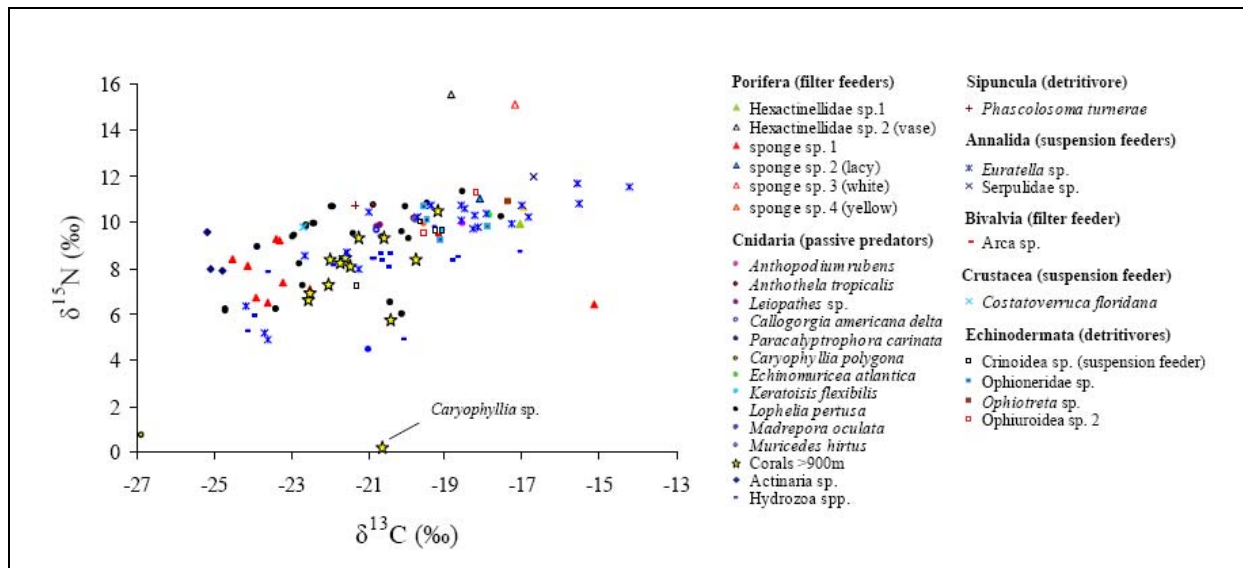


Figure 19. $\delta^{15}\text{N}$ vs. $\delta^{13}\text{C}$ for corals and suspension feeding organisms on the Louisiana Slope of the Gulf of Mexico.

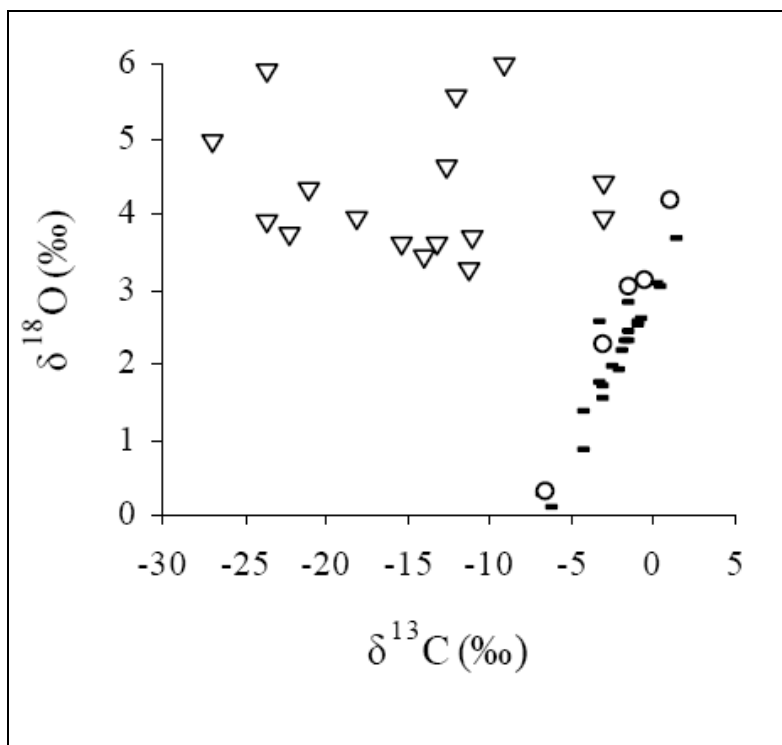


Figure 20. $\delta^{18}\text{O}$ vs. $\delta^{13}\text{C}$ in scleractinian corals skeleton and authigenic carbonates from the Louisiana Slope.

We are also focusing upon nutritional sources and trophic structure in deep Gulf of Mexico communities associated with chemosynthetic fauna (tubeworms, mussels, clams, and pogonophorans). To date we have prepared and sent over 600 samples to analytical labs (UC Davis and U. Virginia) for $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, and $\delta^{34}\text{S}$ analysis. $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ data have been returned for 411 samples representing 12 tubeworm and 24 mussel collections from 11 sites. Preliminary analysis of the vestimentiferan tubeworms and mussels shows that isotope values can vary considerably within species. For both mussels and tubeworms, samples tended to cluster together within a collection, but collections are sometimes significantly different within sites (**Figure 21**).

One notable trend was that mussel tissue $\delta^{15}\text{N}$ values was lower at Mississippi Canyon sites relative to the same species collected from other sites but were similar for both species within these sites (MC640: *B. brooksi* $\delta^{15}\text{N}$ was -11.7 to -11.1‰ and *B. childressi* -12.5 to -10.9‰; MC853: *B. brooksi* was -14.8 to -11.3‰ and *B. childressi* -15.5 to -12.0‰) (Figure 12). This suggests geochemical differences in the nitrogen sources at these sites compared to the sites outside of MC. Vestimentiferan tissue $\delta^{15}\text{N}$ values tended to be lower at Walker Ridge 269 relative to the same species collected from other sites and these values differed between the two species collected from this site (*E. laminata* tissue $\delta^{15}\text{N}$ was 0.2 to 2.3‰ and *Lamellibrachia* sp. was -3.5 to -2.5 ‰) (**Figure 21**). These two tubeworm species were collected together within the same aggregation; thus, the difference in their tissue $\delta^{15}\text{N}$ values reflects an interspecific difference in nitrogen sources (source partitioning) or different mechanisms of nitrogen assimilation (fractionation effect).

The lowest tissue $\delta^{13}\text{C}$ values tubeworms collected in this study (ca. -65‰) were from *E. laminata* collected from Atwater Valley 340 and are the lowest $\delta^{13}\text{C}$ values found thus far for any vestimentiferans. The highest tissue $\delta^{13}\text{C}$ (-26.7 and -25.2‰) values for tubeworms came from two small solitary *E. laminata* individuals that were collected in mussel pots from AT340 (denoted as open diamonds with black dots in Figure 12). This may at first seem paradoxical because larger *E. laminata* individuals from this site had more negative values that indicate methane as an ultimate carbon source and yet the small individuals were collected in an area where methane is abundant enough to support a high biomass of mussels. Also, tissue $\delta^{13}\text{C}$ for heterotrophic fauna in these collections ranged from -76 to -36‰. The most plausible explanation is that adult and juvenile *E. laminata* are utilizing different source pools of dissolved inorganic carbon. The tissue $\delta^{13}\text{C}$ values around -26‰ for the small *E. laminata* are consistent with fixation of seawater DIC ($\delta^{13}\text{C}$ ca. 0‰) by sulfur-oxidizing endosymbionts via the Calvin-Benson Cycle. The more negative values of the adult *E. laminata* are consistent with use of pore water bicarbonate derived from microbial oxidation of isotopically light methane.

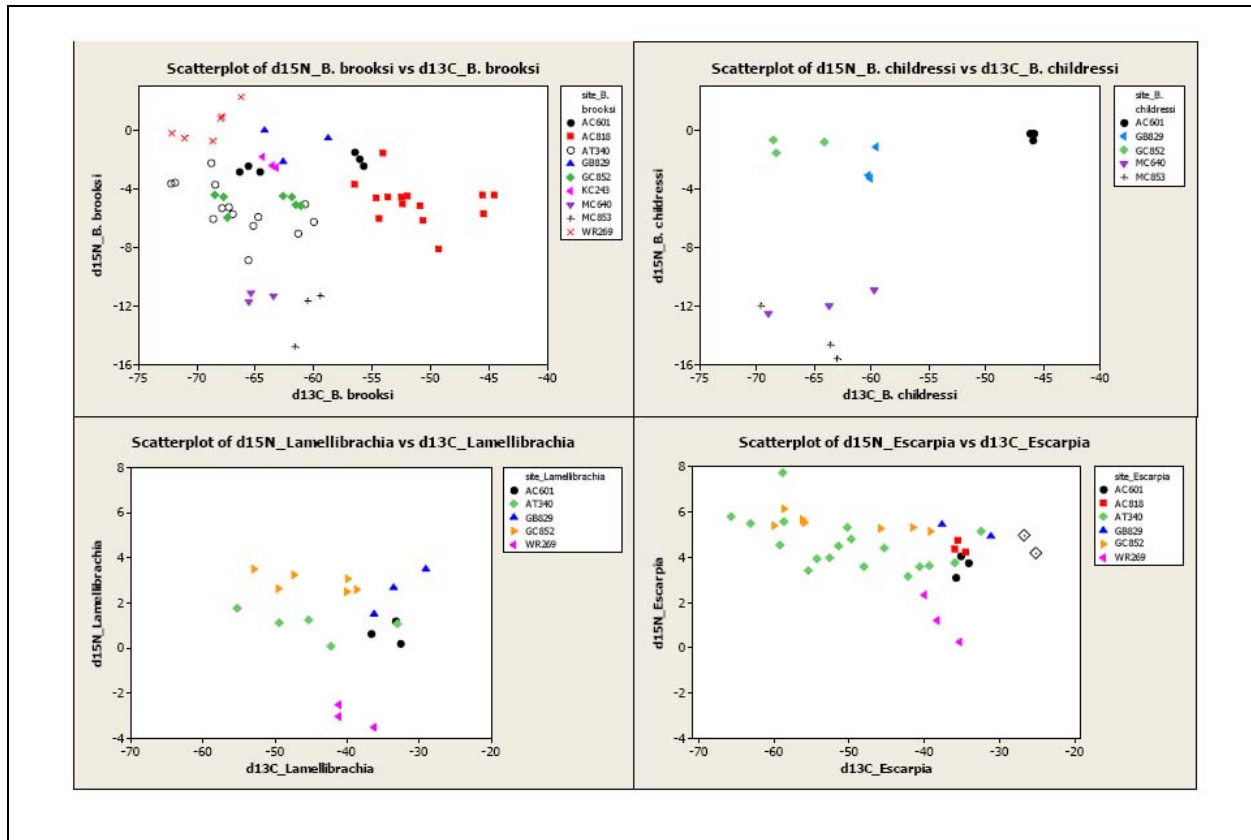


Figure 21. $\delta^{15}\text{N}$ vs. $\delta^{13}\text{C}$ for mussels (top panels) and vestimentiferan tubeworms (bottom panels) collected between 1,300 and 2,800 m on the continental slope of the Gulf of Mexico.

As juveniles, the primary site of gas exchange with the surrounding environment is across the plume. As they age, the worms extend the posterior end of their body into the sediment, and this “root” becomes the primary site of hydrogen sulfide uptake (Freytag et al., 2001). Seep tubeworms also release sulfate through the root via anion exchange, and it has been suggested that bicarbonate is the anion taken up by the tubeworms in exchange for sulfate (Dattagupta et al., 2006). Our data support this hypothesis and further suggests that this DIC is then fixed into organic carbon compounds by their symbionts.

We are awaiting the data from more of the samples of associated fauna before beginning a more comprehensive analysis of trophic relations among the fauna associated with tubeworms and mussels from the deep-slope sites. The very large differences in the stable isotope values in the foundation species among many of the sites will provide powerful tools for the analyses of trophic relations among the fauna common to many of the sites.

Vestimentiferan Growth Studies

A total of 12 tubeworm aggregations were successfully stained at 3 sites (GC852, AT340, and AC818) during field operations in 2006 and samples from all of these aggregations were collected in 2007, 5 by Bushmaster and 7 by manipulator grabs. These samples have yielded growth data on a total of 392 tubeworm individuals. Complete analysis of these data awaits the final determination of tubeworm species from ongoing morphological and phylogenetic examination, but some general trends can be described. The stained escarpids showed no growth in 51% of the individuals and grew a maximum of 4.5 cm between 2006 and 2007. In the lamellibrachids, 36% showed no growth and the maximum growth was 0.9 cm. These data suggest that vestimentiferan tubeworms on the lower slope grow at comparable rates to those on the upper slope, and that *Lamellibrachia* sp. nov. may grow even slower than *L. luymesii*.

In addition to the stained tubeworms, a number of previously banded tubeworms were spotted on the last dive of the 2006 field season. In 1992, thirteen tubeworms were successfully banded using a hydraulically powered tubeworm bander at AC645. Video and still images of these tubeworms show the position of the bands at that point in time. Using markers left on the seafloor and the previous images, seven of these worms were located using the JASON II during the June 2007 cruise. Five of the worms were confirmed to be alive in 2007 and two of the banded worms appeared to be dead. The banded tubeworms were imaged using a digital camera held perpendicular to the banded worms. These images were compared to the video and still images from 1992 to determine the amount of growth by these worms. Growth of the five living worms over that last 15 years ranged from 1 to 4 cm. Although growth was only recorded in a small number of animals, the fact that the banded animals were approximately the same length as nearby animals in 1992 and 2007 (**Figure 22**) suggests their growth was typical of tubeworms in these aggregations. This data is also consistent with the growth models we have published for related tubeworm species on the upper slope and suggest these deep-living species also grow very slowly and can live a long time.



Figure 22. (A) A video capture from 1992 video showing a tubeworm immediately after being banded. (B) The same tubeworm imaged in 2007 with a digital camera.

Coral Communities

Occasional small colonies of octocorals (‘soft’ corals) were present at most of the sites visited, but only two of the sites had scleractinian growth. These sites were mostly in the 900 – 1400 m range, with coral species becoming more scarce with depth. At GB647 (950 m), two species of gorgonians (*Villogorgia* sp. and *Placogorgia* sp.) were recovered from asphalt substrates. There was a small area of gorgonian colonization at GB697 (1,000 m) where *Crysoyorgia fewkesii* was collected. At MC462 (950 m), there was a more extensive area of coral growth where the scleractinians *Madrepora oculata* and *Caryophyllia* sp. along with the gorgonians *Acanthogorgia armata* and a paramuriceid species were collected. Several large colonies of bamboo corals were also seen at AC645 (2,200 m), but physical samples were not obtained.

Only one site, Green Canyon 852 (1,410 m) contained hard-grounds extensively colonized by deep-water coral species. Three species of scleractinian corals were observed, along with many species of octocorals (Order Alcyonacea), including at least two species of bamboo corals (Family Isididae). The ‘Coral Garden’ area where these anthozoans were found covers an area approximately 30 m across on the shallowest southern end of a large, N-S trending mound that rises from 1500 to 1392 m characterized by large authigenic carbonate boulders and strong currents. *Enallopsammia rostrata* was collected from the base of a large carbonate boulder at 1397 m using ALVIN. *E. rostrata* is a cosmopolitan species, but this finding extends its range in the Gulf of Mexico from the southeastern quadrant of the Gulf near the Straits of Florida. Data provided by our collaborator Cheryl Morrison at the USGS indicate that this Gulf *E. rostrata* individual differs from a sample from the Bishop Seamount in the Pacific by four substitutions (0.7%) at the mitochondrial 16S gene, and a congener, *E. profunda*, by five substitutions (1.04%). Given the generally slow evolutionary rate of mitochondrial genes in scleractinians, this level of differentiation of this gene within species (and often within genera) is uncommon, so this result suggests we may be dealing with a morphologically cryptic species. Two other cosmopolitan scleractinian coral species, *Madrepora oculata* and *Solenosmilia variabilis*, were observed and photographed in 2006 and collected in 2007. *M. oculata* is one of the primary deep reef constituents in the eastern Atlantic and occurs along the Southeastern U.S. coast, the

Western Gulf of Mexico, and in the Indian and Pacific Oceans. Two of these cosmopolitan species were found close to their known depth limits (1,646 m for *E. rostrata*, and 1500 m for *M. oculata*) while *S. variabilis* is known to over 3,300 m.

Only a few physical samples of the corals at this site were possible due to the extremely rugged topography of the site and the strong currents in the area at the time of the submersible dives. However, several samples of gorgonians were also collected from this site. Although taxonomic identification of the bamboo corals is not complete, sequence data (C. Morrison, USGS) from the 5' region of the *msh1* mitochondrial DNA gene allies these samples with the genus *Isidella*, with a 99% match to an undescribed *Isidella* species from Hawaii. Another bamboo coral, *Keratoisis* sp., a specimen of the precious coral *Corallium medea* and a paramuriceid (different from the species at MC642) were also collected in 2007. One other significant collection was made at this site, a specimen of *Iridogorgia pourtalesii* (**Figure 23**) that, to quote Dr. Sephen Cairns, "...was quite a find since this species has only been collected a handful of times and usually in very poor condition."



Figure 23. *Iridogorgia pourtalesii* from GC852.

Heart Urchin Communities

A new hydrocarbon seep community type dominated by large and dense aggregations of heart urchins was discovered in 2006 in sediments with very high sulfate reduction rates and sulfide levels. The urchins have been identified as *Sarsiaster griegi*, which have also been observed at seeps on Blake Ridge off the southeastern US. In order to better understand the relation between this species, seepage, and associated meiofaunal communities we made a series of push core collections in association with these communities, conducted a manipulative experiment, and collected images for a short time series study during the 2007 JASON II cruise.

Three different sea urchin communities were studied, two in AT340 where the urchins were apparently quite mobile and leaving visible trails, and another in AC818 where the urchins were apparently relatively immobile. Sediment cores from mobile urchin trails, in front of urchins, and underneath urchins were obtained at one of the AT340 communities, and also from underneath and beside still urchins and at AC818. These cores will provide information on the natural abundance of meiofauna in these seep sediments (for comparison to other seep meiofaunal communities) and the urchins effect on the communities. Preliminary results (from a single pair of cores) indicate that there is high abundance of meiofauna outside the urchin trails at AT340, with approximately a 10:1 nematode to copepod ratio, as well as representation by more rare taxa (including kinorhynchs and tanaids) than are found in the urchin trails. Overall abundance appears to be much lower in the urchin trails, and the community is primarily nematodes, with few copepods or other taxa. To separate the effects of bioturbation and predation by the urchins on the meiofauna communities we also conducted a manipulative experiment at the other community in AT340. An “artificial urchin” was dragged through the sediment on the periphery of the urchin field at AT340, and cores were obtained 10 days later inside and outside the artificial trail. Finally to better understand the extent of the urchins’ impact on the meiofaunal communities and their bioturbation rates, images for a photomosaic were collected from an undisturbed sea urchin community and repeated after 10 days and again after 2 additional days. Preliminary results from a small area of this mosaic (**Figure 24**) indicate that urchins move an average of 1.5 meters over the course of 10 days, which is faster than reported estimates of heart urchin movements (which average approximately 3 cm per day).

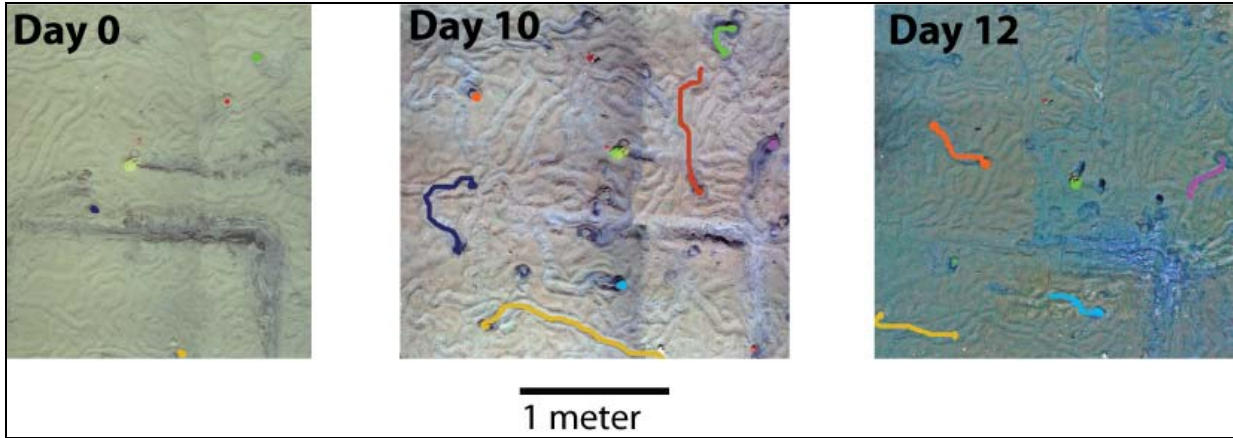


Figure 24. Three mosaics analyzed to determine the potential for tracking individual urchins.

MICROBIOLOGY/BIOGEOCHEMISTRY

Water Column Biogeochemistry

Results and Discussion

Oxygen and methane concentrations were quantified on board ship. Nutrient concentrations were determined within 10 days of returning from the cruise. Other analyses are on-going. All sites were characterized by a pronounced oxygen minimum (concentrations $<4 \text{ mg L}^{-1} \text{ O}_2$) in the midwater, between about 500 and 1,400 m water depth. This oxygen minimum did not appear to correspond to temperature or salinity anomalies, suggesting it resulted from elevated rates of biological respiration. Within the oxygen minimum zone, nitrate concentrations peaked, suggesting active nitrification in this depth interval. Water column methane concentrations were elevated significantly (between 10 nM and 100 μM) compared to the concentration expected from equilibrium with atmospheric methane ($\sim 2 \text{ nM}$). Highest methane concentrations were always observed in the deepest samples and the concentrations at depth at AC601 exceeded those at GC852 and AT340 by an order of magnitude. At the AC601 site, methane was supersaturated throughout the 2,300 m water column, even at the surface, suggesting that this site is a source of methane to the atmosphere.

Methods of *sample collection and analysis* were presented in the previous report so are not repeated here. The water column at all sites examined was thermally stratified and a pronounced oxygen minimum zone was observed. At GC852, the oxygen minimum zone was present between about 300 and 800m (**Figure 25**, left panel). In this same zone, nitrate concentrations increased, suggesting active water column nitrification (middle panel). Methane concentrations were about 100 nM near the bottom, similar to concentrations observed at other sites in the Gulf of Mexico, and methane oxidation rates accounted for a turnover of up to 1% of the methane pool per day, which is quite high for the oceanic water column (right panel).

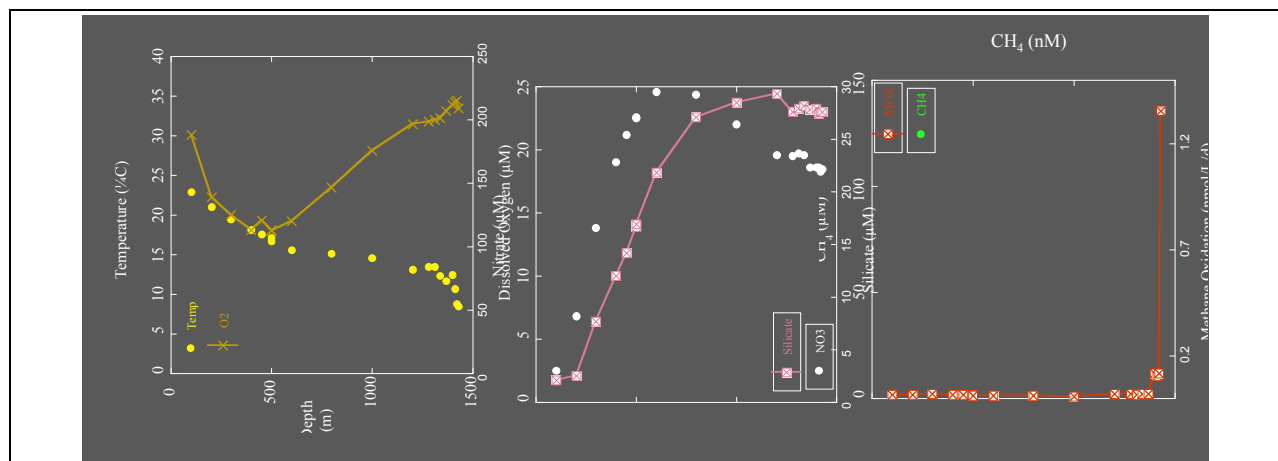


Figure 25. Water column biogeochemistry at GC852.

Similar profiles of oxygen, nitrate and methane were found at the other sites sampled (AT340, AC601) but methane concentration and oxidation rates were highest at AC601. There, bottom water methane concentrations were about 35 μM (as opposed to nM at other sites) and methane concentrations were extremely supersaturated throughout the water column.

Sediment Biogeochemistry

Results and Discussion

Most of the geochemical and rate analyses are on-going, but the pH, salinity and C₁-C₅ concentration data sets are complete as these analyses were conducted on board the ship.

Salinity and pH

Cores were categorized as normal to low salinity (35-40 ‰), intermediate salinity (40 to 75 ‰) and high salinity (>75‰). Most of the cores collected fell into the normal to low salinity range. Three cores (4178-R4 [75 ‰, MC853], 4182-R2 [75‰, MC640] and 4193-R2 [62 ‰, AC601]) were categorized as intermediate salinity and six cores were categorized high salinity (4173-Y1 [122 ‰, AT340], 4178-Y2 [115 ‰, MC853], 4182-Y4 [88 ‰, MC640], 4193-Y1 [90 ‰, AC601], 4196-Y5 [90‰, AC601], and 4196-R5 [76‰, AC601]).

Most of these sediments were extremely sulfidic and exhibited peculiar pH profiles. Core to core variability in pH distribution was significant but generally speaking three types of profiles were noted. The lowest pH values (down to 6.5) were observed in the high salinity sediments from AC601. In intermediate salinity sediments, pH tended to increase with depth, possibly because of increased sulfide concentration at depth. In low salinity sediments, a pH maximum was observed in the upper 2-4 cm and the pH decreased below that depth.

Methane Concentrations

On dive 4173 to AT340, cores were collected near tubeworm bushes and from near a mussel bed. Methane concentrations in the pore water near the tubeworm bush were low (< 20 μM), while concentrations near the mussel bed were extremely high, up to 3 mM. Most of the cores from dive 4174 to GC600 were oil stained. Both sets of cores were collected from white bacterial mats but the red set was taken near mussel beds and the yellow set was taken near tubeworms. Methane – as well as concentrations of higher alkanes up to C₅ – were extremely high (up to 7 mM CH₄) in the yellow cores; concentrations in the red cores were over an order of magnitude lower (max ~300 μM). Concentrations of methane in the sediment core collected from mussel beds at GC852 (dive 4177) were extremely low (< 20 μM).

Methane concentrations in the cores from MC853 (dive 4178) were extremely elevated (up to 7.5 mM). Ethane (but no alkanes >C₃) was also detected in these cores. These cores were collected from areas of dense white bacterial mats. The first set of cores retrieved from AT340 (dive 4181) were from alongside a tubeworm and methane concentrations ranged from 50 μM to 1.2 mM. Dive 4182 to site MC640 retrieved two sets of cores from bacterial mats alongside brine flows. Concentrations of methane in these cores was quite high (up to 6 mM). On dive 4183 to AT340, control cores were collected from areas having no oil staining or chemo fauna. The methane concentration in these cores was < 8 μM . Another set of cores was collected from an urchin field. Methane concentrations here were also low (12 to 40 μM). On dive 4184 to GC600, two sets of

cores were collected, one from a dead clam bed and one from an area of live clams. Neither set of cores had elevated methane concentrations. In fact, in the upper ~10 cm, methane was below detection and below there concentrations reached only 10 μM .

Site GC852 was home to deep water corals. Two sets of cores were collected here on dive 4189, red cores over 'gray' mats with mussel shell debris in area and yellow cores from an area of patchy white mat. Methane concentrations in both sets of cores were $> 1 \text{ mM}$ over the entire depth of the core. Dive 4191 was to WR269/270 and cores were retrieved from a Pogonophoran field. Methane concentrations increased over depth, reaching 1.5 mM at 6 cm and having a maximum concentration of 2.6 mM at 12 cm. Dive 4192 at AC818 retrieved a set of cores from an urchin field and a set of cores from a mussel bed. Methane concentrations were low ($< 50 \mu\text{M}$) in the upper 10 to 14 cm but reached concentrations of 1.3 to 1.7 mM at depths $> 18 \text{ cm}$. On dive 4193 to AC601, three sets of cores were taken. Four control cores were taken at the edge of the site. Methane concentration in the control cores was $< 5 \mu\text{M}$. Cores collected from the bottom and edge of the brine lake were extremely supersaturated with methane (concentrations $> 1.5 \text{ mM}$) even though continual degassing was observed during return of the submersible to the surface. Methane concentrations in the brine (determined in sub-samples obtained using small Niskin bottles) were $> 1.5 \text{ mM}$.

Dive 4194 retrieved one set of cores from AC645. Methane concentrations were $< 30 \mu\text{M}$ at all depths in this core. Dive 4196 returned to AC601. One set of cores was collected from the 'floc' zone at the edge of the brine lake. Methane concentration in these cores was high, but did not exceed 1 mM. The other set of cores was collected from beneath the brine, about 2 m out into the lake. These cores had much higher methane concentrations (up to 3 mM). All cores degassed significantly during ascent to the surface.

All geochemical analyses and rate measurements (for sulfate reduction, anaerobic methane oxidation and methanogenesis) have been completed. Not all of the twenty seven sets (a 'set' is used here to denote 4 to 6 replicate cores) of sediment cores collected (AT340: 5 sets of cores; GC600: 4 sets of cores; GC852: 4 sets of cores; MC853: 2 sets of cores; MC640: 3 sets of cores; WR269/270: 1 set of cores; AC818: 2 sets of cores; AC645: 2 set of cores and, AC601: 6 sets of cores) can be discussed here. Instead, results highlighting differences between sites are presented. Both between and within (as a function of habitat) site variability in geochemical signatures and microbial activity was observed. At site MC853 (1,070 m water depth), the sediments were oily, white microbial mats were common on the sediment surface, and the pore water salinity was substantially elevated (to 115‰) and the pH dropped sharply with depth (**Figure 26**). Methane concentrations were around saturation ($\sim 1 \text{ mM}$ at 1 atm) but were much higher at one depth. Sulfate was rapidly depleted from the pore water, likely because of both high rates of sulfate reduction and upward advection of sulfate-free brine. Concentrations of hydrogen sulfide were almost 20 mM at the depth where sulfate concentrations reached zero.

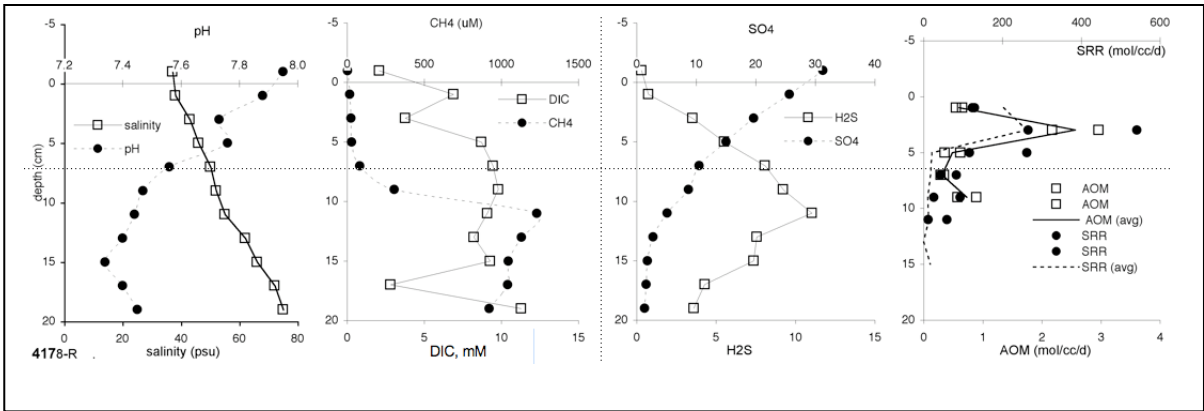


Figure 26. Sediment biogeochemistry from MC853 (1st microbial mat).

The depth distribution of sulfate reduction (SR) and anaerobic methane oxidation (AOM) were similar but SR rates were about 6 times higher than AOM rates. The AOM rates observed at this site were among the highest measured on the cruise.

A second set of cores from MC853, also from a microbial mat, revealed similar geochemical signatures and rates of microbial activity (**Figure 27**). In this core, lower pore water salinities were accompanied by a deeper sulfate penetration depth and deeper penetration of the SR zone. AOM rates in this core, however, were much lower.

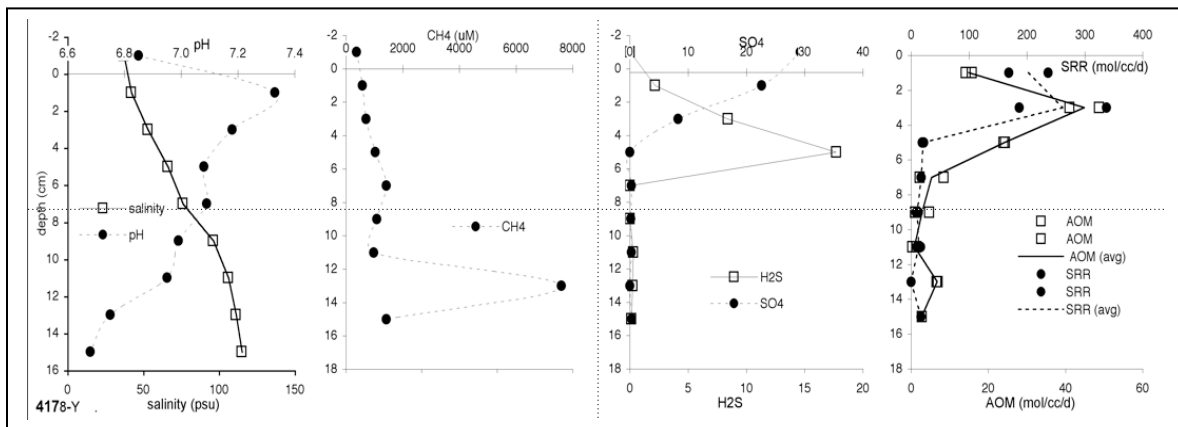


Figure 27. Sediment biogeochemistry from MC853 (2nd microbial mat).

The GC600 site (1250m water depth) was also characterized by oil-stained sediments and hypersaline pore waters (**Figure 28**). Sulfate was rapidly depleted, which resulted in very low activity rates for sulfate reducing bacteria. Rates of AOM were also low despite high methane availability; AOM was likely limited by sulfate.

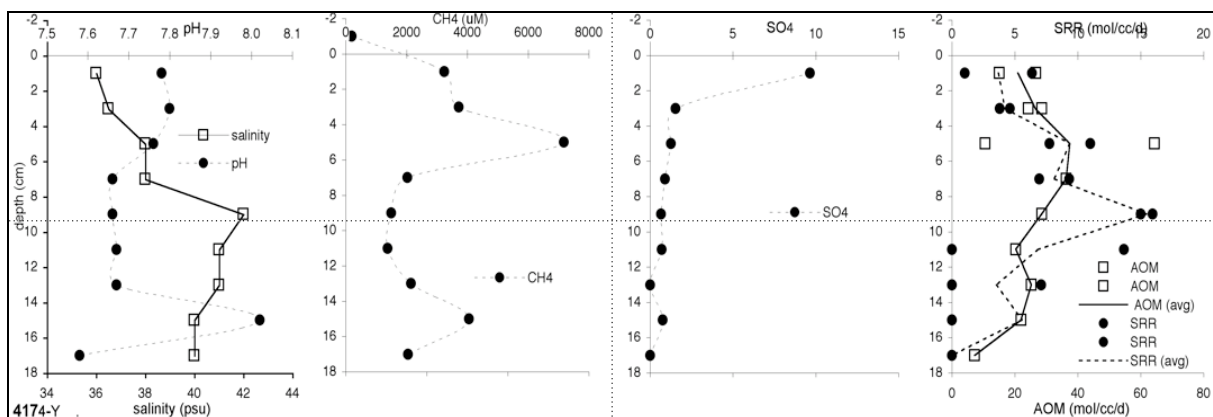


Figure 28. Sediment biogeochemistry from GC600 (oily sediment).

Other cores from GC600 (e.g., clam beds) showed different patterns of geochemical distributions and microbial activity (**Figure 29**). Sulfate depletion was very gradual and methane concentrations and AOM rates were much lower.

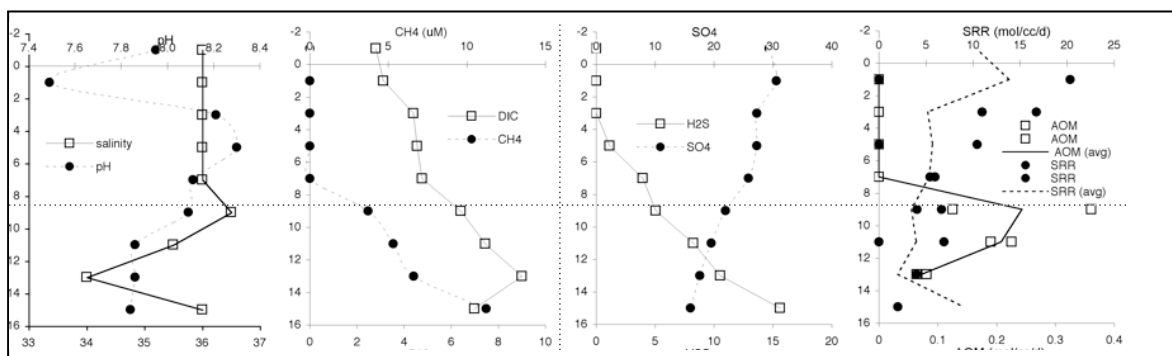


Figure 29. Sediment biogeochemistry from GC600 (clam bed).

High rates of AOM were observed in a pogonophoran core from WR269/270 (1,953 m water depth) (**Figure 30**). In this core, the pH increased substantially (from 7.4 to 8.2) with depth. Sulfate was rapidly depleted with depth and as sulfate was consumed, hydrogen sulfide accumulated. Methane concentrations were quite high in the zone sulfate-free zone. Sulfate reduction rates were high but were restricted to the upper few cm where sulfate was available. Surprising, AOM rates peaked below this zone where little to no sulfate was available. AOM rates in this core represented the highest rates measured on the 2006 cruise. However, because this zone was sulfate free, the electron acceptor for AOM must be something other than sulfate; we intend to follow up on this on the 2007 cruise.

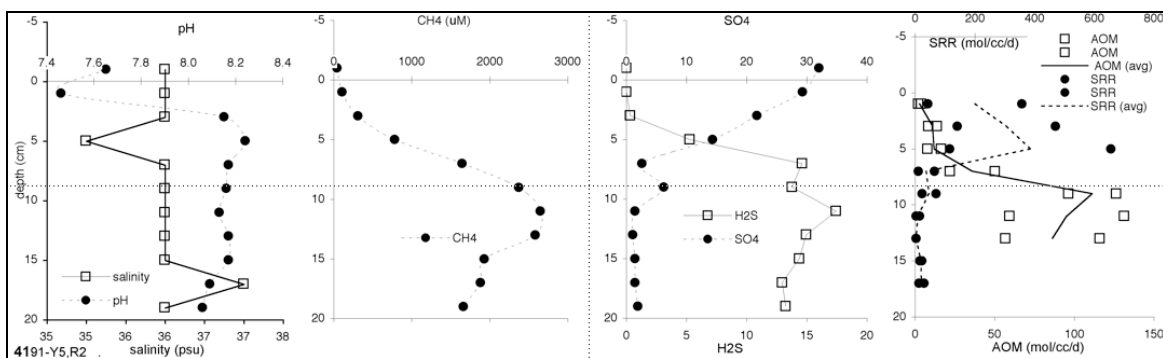


Figure 30. Sediment biogeochemistry from WR269/270 (pogonophoran meadow).

Site AT340 (2,180 m water depth) exhibited a variety of sub-habitats, ranging from brine flows, to microbial mats to tube work meadows. In sediments adjacent to tube worm bushes, sulfate reduction rates were generally high ($> 50 \text{ nmol SO}_4^{2-} \text{ reduced cm}^{-3} \text{ d}^{-1}$) but varied a lot with depth; AOM rates were extremely low (as were methane concentrations). No sulfate depletion was observed despite high rates of SR in the upper sediments, suggesting rapid reoxidation of hydrogen sulfide to sulfate (data not shown). At a brine seep, sulfate reduction rates were extremely high ($>200 \text{ nmol SO}_4^{2-} \text{ reduced cm}^{-3} \text{ d}^{-1}$) but rates were limited by sulfate concentrations. Pore water salinities of up to 120 ‰ suggested active upward brine advection which limited SR and consequently AOM rates. Methane concentrations were much higher at brine sites (data not shown).

At AC645 (2,210m water depth), another pogonophoran meadow was sampled (**Figure 31**). In contrast to the WR269/370 pogonophoran cores, methane concentrations in these cores were very low. A pH minimum was observed in the upper few cm of the sediment, likely reflecting sulfide oxidation. Gradual sulfate depletion and accumulation of hydrogen sulfide was observed. Rates of SR and AOM in these cores were much lower than those observed at WR269/2770.

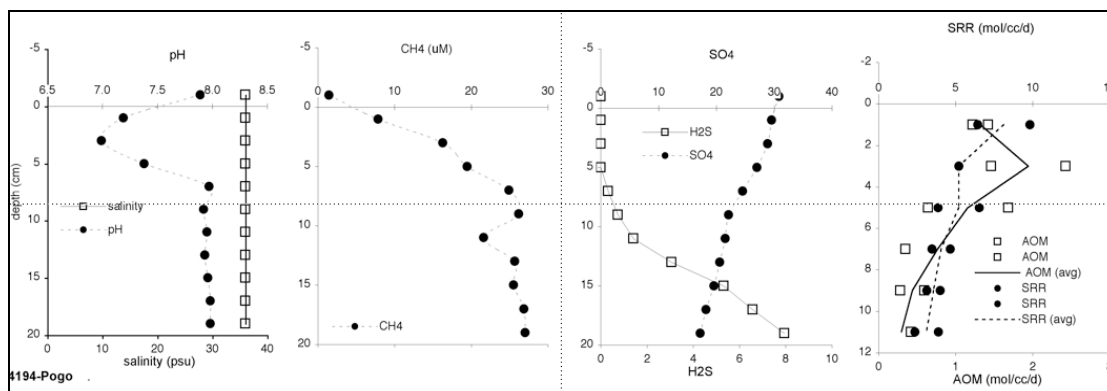


Figure 31. Sediment biogeochemistry from AC645 (pogonophoran meadow).

Perhaps the most interesting site sampled was the AC601 “Brine Lake”. A series of sediment cores was collected away from the brine (“control”), from the bottom of the lake, from the outside edge in an urchin meadow, and from the inner edge of the lake. Not surprisingly, different patterns of biogeochemical signatures and rates of microbial activity were observed at these different sites.

The control site was far removed from the brine lake (**Figure 32**). The salinity of the pore water was slightly elevated above seawater (36 versus 34 ‰). The elevated pH and methane concentration in the upper portion of the cores is related to a sampling artifact—these cores were collected prior to sampling in the brine lake and as a result of immersion on the brine, the geochemistry in the upper couple of cm is altered. The pH increased slightly with depth and methane concentrations were below detection below 5 cm depth. No sulfate depletion was observed; rates of SR and AOM were extremely low.

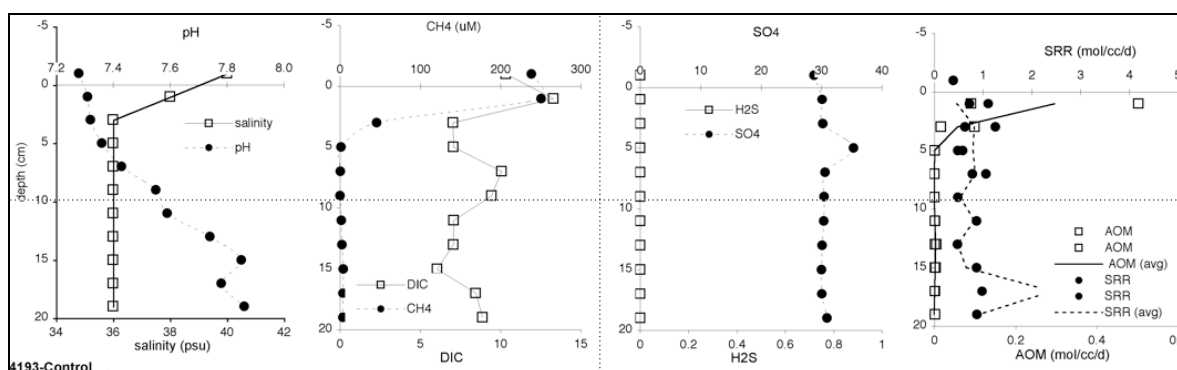


Figure 32. Sediment biogeochemistry from AC601 (control site).

The brine in the brine lake was about 90‰ and it was methane charged (**Figure 33**), concentrations of up to 1.5 mM were observed despite substantial degassing during return to the surface. The pH was about 6.8 and showed little variation over depth. Sulfate was rapidly depleted from about 6 mM concentration in the overlying brine to <1 mM at the remaining depths. Hydrogen sulfide concentrations were less than 1 mM throughout the core. Sulfate reduction rates were from 10 to 80 nmol SO_4^{2-} reduced $\text{cm}^{-3} \text{d}^{-1}$ but AOM rates were extremely low (< 1 nmol CH_4 oxidized $\text{cm}^{-3} \text{d}^{-1}$). Low rates of AOM have been observed at other GOM brine sites (Joye et al. in review).

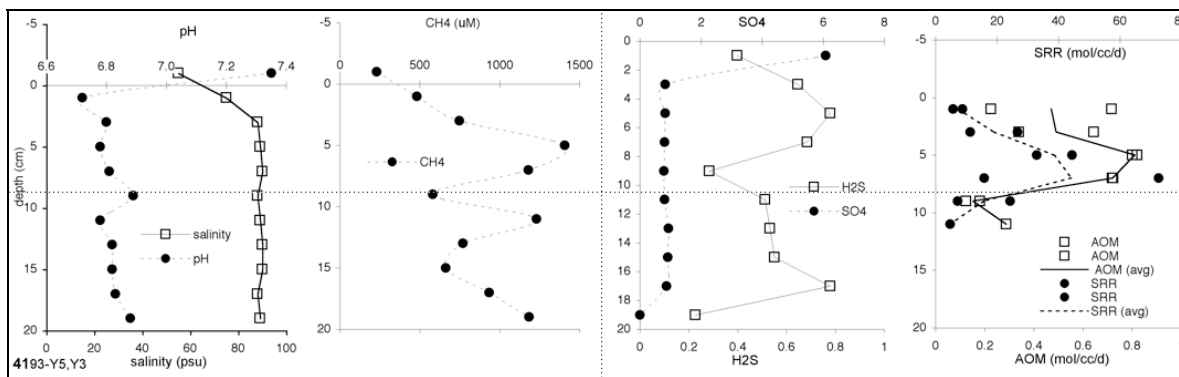


Figure 33. Sediment biogeochemistry from AC601 (brine lake bottom).

A third set of cores was collected from the outer edge of the brine lake in a field of heart urchins (**Figure 34**). At this site, the pore water salinity was about 40‰, less than half that observed in sediments from the bottom of the lake. The pH increased with depth. Methane concentrations were high (~ 1 mM) towards the bottom of the core. Sulfate concentration decreased steadily with depth, probably as a function of both sulfate reduction and upward advection of sulfate-free brine. Sulfate reduction rates were fairly low (about 10 to 20 nmol SO_4^{2-} reduced $\text{cm}^{-3} \text{d}^{-1}$). AOM rates were higher in these sediments, though 1:1 coupling between AOM and SR was only observed in the deepest sediments (ca. 20 cm depth).

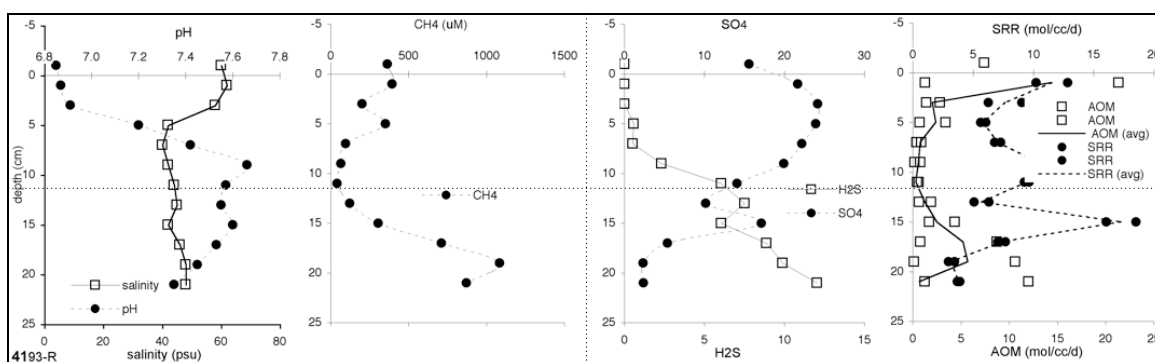


Figure 34. Sediment biogeochemistry from AC601 (lake outer edge; urchins).

The final set of cores from this site was collected from the inner edge of the brine lake in a field of white precipitate that turned out to be authigenic barite (**Figure 35**). Here, the pore water salinity was about 90‰, similar to that observed in sediments from the bottom of the lake. The pH increased with depth from 6.6 at the surface to 6.8 at depth. Methane concentrations were high (~ 1 mM) and DIC concentrations were up to 10 mM. Sulfate concentration decreased steadily with depth but sulfate remained above the detection limits at most depths. Concentrations of hydrogen sulfide were highest between 10 and 20 cm. Sulfate reduction rates were extremely high in surface sediments ($>1500 \text{ nmol } \text{SO}_4^{2-} \text{ reduced } \text{cm}^{-3} \text{d}^{-1}$); these were the highest SR rates measured during the 2006 cruise. AOM rates were low in these sediments, despite the high CH_4 concentrations.

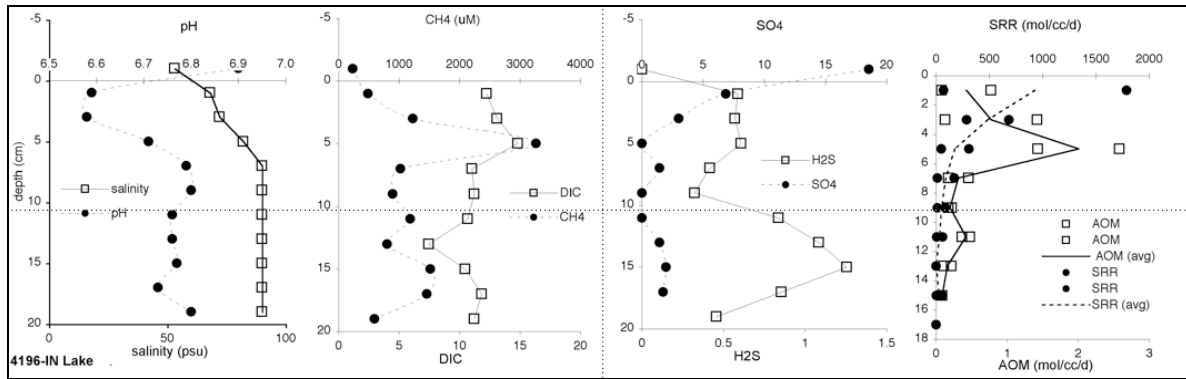


Figure 35. Sediment biogeochemistry from AC601 (lake inner edge; barite).

Microbiology and Molecular Biology

Molecular analyses, including CARD-FISH and development of clone libraries, are currently under way. Laboratory experiments using ‘live mud’ collected on the cruise are also underway.

PHOTO SURVEYS

Table 24 is a summation of the photo survey results. The last two columns show Sites (rows) totaled by numbers of photographs showing the targeted organisms (Sum) and ranking by numbers of photographs showing tubeworms, mussels, and corals (TW, M, C). This table and ranking will likely change with additional photo-analysis. The last row of the table contains the sum of photos of targeted organisms over the cruise duration. The total number of survey photos captured with the bottom in view (BIV) is 10,922. **Table 25** lists the 24 sites that drift photo surveys and trawls/box cores were taken from the complete list given in **Table 26**. **Table 27** provides the sequence of operations during Legs 1 & 2 of the cruise. The positions of the sites were precisely determined by Harry Roberts in consultation with MMS personnel. In the table they are designated by lease block number (site). A map of the cruise track is reproduced as **Figure 36**.

Table 24.

Photo Survey Summary (BIV – Bottom In View)

Name	Depth (m)	BIV photos	Brine	Bacteria	Shells	Mussels	Tube worms	Coral	Sum	TW, M, C
GC852	1,448	1054	122	227	84	28	90	37	551	155
MC640	1,404	976	546	548	48	48	1	0	1191	49
KC243	1,610	747	132	80	98	25	6	0	341	31
AT340	2242	502	153	130	23	13	12	0	331	25
KC216	1,754	802	221	128	8	0	16	0	373	16
GC600	1,249	694	69	350	164	8	4	1	595	13
KC333	1,685	333	20	21	27	3	3	0	74	6
AT342	2375	516	267	27	15	2	3	0	314	5
KC129	1,691	271	60	27	4	3	0	0	94	3
KC514	1,656	579	99	135	4	1	0	0	239	1
MC462	983	622	0	0	0	0	0	1	0	1
WR268	1,862	523	21	68	0	0	27*	0	89	0
MC981	1,300	825	369	407	12	0	0	0	788	0
GC296	994	766	456	288	0	0	0	0	744	0
WR269/ WR270	1,952	467	120	174	1	0	0	0	295	0
GC817	1,423	515	18	56	5	0	0	0	79	0
GC767	1,586	269	1	69	0	0	0	0	70	0
GC812	1,802	225	7	44	0	0	0	0	51	0
GC868	1,360- 1,460	236	11	0	0	0	0	0	11	0
	SUM	10922	2692	2779	493	131	135	39	6230	305

Table 25.**Stations Occupied during Legs 1 and 2 of the Reconnaissance Cruise**

Leg	Date	Site	Depth (m)	Latitude (N)	Longitude-(W)	Activity
1	3/12/2006	KC243	1,610	26.750278	92.829167	DCS
1	3/13/2006	KC333	1,685	26.633881	92.687776	DCS
1	3/13/2006	KC514	1,656	26.474008	92.462472	DCS
1	3/14/2006	KC216	1,754	26.771944	92.000333	DCS
1	3/14/2006	KC129	1,691	26.854722	92.913056	DCS
1	3/15/2006	GC852	1,448	27.112500	91.164167	DCS
1	3/15/2006	GC767	1,586	27.204444	91.008333	DCS
1	3/15/2006	GC812	1,802	27.144722	90.967500	DCS
1	3/16/2006	GC817	1,423	27.149294	90.722628	DCS
1	3/16/2006	GC600	1,249	27.366389	90.564167	DCS
1	3/17/2006	GC296	994	27.671389	90.361111	DCS
1	3/17/2006	MC981	1,300	27.973889	89.295000	DCS
2	3/19/2006	MC462	983	28.496667	88.883833	DCS
2	3/19/2006	MC548	1,,000	28.404987	88.967487	Trawl
2	3/19/2006	MC685	1,500	28.287575	88.739185	Trawl
2	3/20/2006	MC640	1,404	28.355833	88.793056	DCS
2	3/20/2006	AT340	2242	27.646389	88.365833	DCS
2	3/20/2006	MC908	2000	28.065796	88.582635	Trawl
2	3/21/2006	AT342	2375	27.666667	88.269722	DCS
2	3/21/2006	AT209	2500	27.778787	88.321719	Trawl
2	3/22/2006	GC868	1,360 - 1,460	27.090000	90.374444	DCS
2	3/23/2006	WR269/ 270	1,952	26.684440	91.671389	DCS
2	3/23/2006	WR265	1,820	26.682572	91.885683	Boxcore
2	3/23/2006	WR268	1,862	26.680278	91.755833	DCS

Table 26.**Sites Selected for Photo Survey by Harry Roberts**

Lease Block	Depth (m)	Latitude (N)	Longitude (S)	Comments
SE21	2,891.94	25.948889	-92.9177778	Mound on scarp, good migration pathway
KC129	1,691.64	26.854722	-91.9130556	Bright positive amplitude, subsurface wipeout between two salt masses
KC216	1,753.82	26.771944	-92.0033333	Mound, but with not much amplitude
KC243	1,609.95	26.750278	-92.8291667	Mound with a phase reversal
KC295	1,814.17	26.704444	-92.4033333	Not much amplitude expression, but slick and good migration route
KC524	1,771.80	26.476667	-91.9758333	Large feature, no positive amplitude, but mound with slicks
WR268	2,055.57	26.680278	-91.7558333	Flow site at edge of salt
WR269	1,925.42	26.684444	-91.6713889	Mound #2 (excellent site)
WR270	1,924.51	26.697222	-91.6475	Mud vent (phase reversal)
MC36	935.74	28.934167	-88.2047222	Edge of "Mickey Ear", bright amplitude
MC462	982.68	28.496667	-88.8838889	Very positive amplitude (good site)
MC640	1,414.88	28.355833	-88.7930556	Positive and negative amplitudes, flows
MC981	1,300.28	27.973889	-89.295	High amplitude, good site
GC296	994.87	27.671389	-90.3611111	Shell's man-made anomaly
GC600	1,248.77	27.366389	-90.5641667	High amplitude, flat, fault-controlled
GC767	1,585.87	27.204444	-91.0083333	Small positive and negative amplitudes (slicks)
GC768	1,619.10	27.193611	-90.9688889	Big complex crest of NE amplitudes
GC812	1,801.98	27.144722	-90.9675	Broad mound, flows, in topo. low, but great migration paths
GC852	1,448.41	27.1125	-91.1641667	Positive amplitude on top of mound, great migration route
GC868	1,811.12	27.09	-90.3744444	Gas hydrate outcrop where BSR is exposed (slicks)
AT340	2,242.11	27.646389	-88.3658333	Center of many small amplitudes
AT342	2,405.18	27.666667	-88.2697222	NW high amplitude on flank of circular salt structure

Table 27a.

Operational Sequence – Leg I

Site	Date	Start Time	End Time	Activity	Depth (m)	Comments
	3/10/2006	800	2,200	Mobilize		Freeport TX
	3/10/2006	2230	0	Transit		In route to Keathly Canyon
	3/11/2006	0	2400	Transit		Slow speed in heavy seas
	3/12/2006	0	430	Transit		Arrival at KC243 station
KC243	3/12/2006	430	1600	Preparation		Trouble shooting camera strobe interface
KC243A	3/12/2006	1602	1929	Photo-transect	1,650	Successful photo-survey of KC243A
	3/12/2006	1940	2400	Transit		Transit to KC333
KC333	3/13/2006	0		Photo-transect		
KC514	3/13/2006			Photo-transect		
KC216	3/14/2006	0	545	Photo-survey		KC216 Knoll with flow channels, anomaly on basin flank ENE
	3/14/2006	600	900	Underway		Transit to KC129
KC129	3/14/2006	1025	1338	Photo-survey		KC129 Anomalies on E flank of low mound
	3/14/2006	1500	1600	Meeting		Science planning meeting
	3/14/2006	1600	2100	Underway		Transit to GC852
GC852	3/14/2006	2,200	0	Survey	1,448	Photo survey GC852
GC852	3/15/2006	0	200	Survey		GC852-Camera turned off on launch. No data
GC852	3/15/2006	300	800	Survey	1,448	Completed photosurvey of GC852
	3/15/2006	830	1130	Underway		Transit to GC767
GC767	3/15/2006	1200	1400	Survey	1,586	Completed survey of GC767
	3/15/2006	1430	1600	Underway		Transit to GC812
GC812	3/15/2006	1700	2000	Survey	1,802	Completed survey of GC812
	3/15/2006	2000	0	Underway		Transit to GC817
	3/16/2006	0	30	Underway		Transit to GC817
GC817	3/16/2006	120	730	Survey	1,449	Completed survey of GC817
	3/16/2006	800	930	Underway		Transit to GC600
GC600	3/16/2006	930	1700	Standby		Standby while drift camera battery recharges
GC600	3/16/2006	1715	2115	Survey	1,187	Completed survey of GC600
	3/16/2006	2215	0	Underway		Transit to GC296
	3/17/2006	0	230	Underway		Transit to GC296
GC296	3/17/2006	300	700	Survey	980	Completed survey of GC296
	3/17/2006	730	1400	Underway		Transit to MC981
MC981	3/17/2006	1400	715	Survey	1,300	Completed survey of MC981
	3/17/2006	1730	0	Underway		Transit to Venice LA
	3/18/2006	0	700	Underway		Transit to Venice LA arrive 0700

Table 27b.

Operational Sequence – Leg II

Site	Date	Start Time	End Time	Activity	Depth (m)	Comments
Venice	3/18/2006	700	1630	Crew change		Crew change & reprovision
	3/18/2006	1630	0	Underway		Transit to MC462
	3/19/2006	0	130	Underway		Transit to MC462
MC462	3/19/2006	200	600	Survey	960	Completed survey of MC462
	3/19/2006	700	900	Underway		Transit to MC548
MC548	3/19/2006	900	1300	Standby		Rigging trawl, trawling at wrong depth, fixing A-frame
MC548	3/19/2006	1330	1600	Trawling	1,000	Completed trawl station 1 at MC548
	3/19/2006	1700	1800	Underway		Transit to MC685
MC685	3/19/2006	1815	2145	Trawling	1,500	Attempting trawl at MC685
	3/19/2006	2,200	0	Underway		Transit to MC640
MC640	3/20/2006	15	445	Survey	1,404	Completed survey of MC640
	3/20/2006	500	1,000	Underway		Underway to MC908 trawl site
	3/20/2006	1,000	1200	Underway		Transit to AT340 photosurvey site. Wait on weather/battery charge
AT340	3/20/2006	1330	1740	Survey	2,242	Completed survey of AT340 site
MC908	3/20/2006	1800	2,200	Box core	2,000	Attempt box core at MC908
AT342	3/21/2006	45	430	Survey	1,404	Completed survey of AT342
	3/21/2006	500	1,000	Underway		Transit to trawl station
AT209	3/21/2006	1030	1400	Trawling	2,500	Completed trawl of AT209
	3/21/2006	1400	0	Underway		Transit to GC868 photo station ETA 3/22 10:00
	3/22/2006	0	1,000	Underway		Transit to GC868
GC868	3/22/2006	1115	1514	Survey	1360-1460	Photosurvey GC868-camera malfunction, no images, repair and repeat
GC868	3/22/2006	1800	2115	Survey	1360-1460	Completed photosurvey of GC868
	3/22/2006	2130	0	Underway		Transit to WR269
	3/23/2006	0	900	Underway		Transit to WR269
WR269 WR270	3/23/2006	1,000	1400	Survey	1,925	Completed survey of WR269/270 combined site
	3/23/2006	1400		Underway		
	3/23/2006	1445	Underway	Underway		Transit to WR265 box core site
WR265	3/23/2006	1500	2100	Sampling	1,820	Took two box cores
	3/23/2006	2100	2130	Underway		Transit to WR268
WR268	3/23/2006	2,200	0	Survey	1,860	Photosurvey of WR268
WR268	3/24/2006	0	150	Survey	1,860	Completed survey of WR268
	3/24/2006	230	0	Underway		Return to Freeport TX

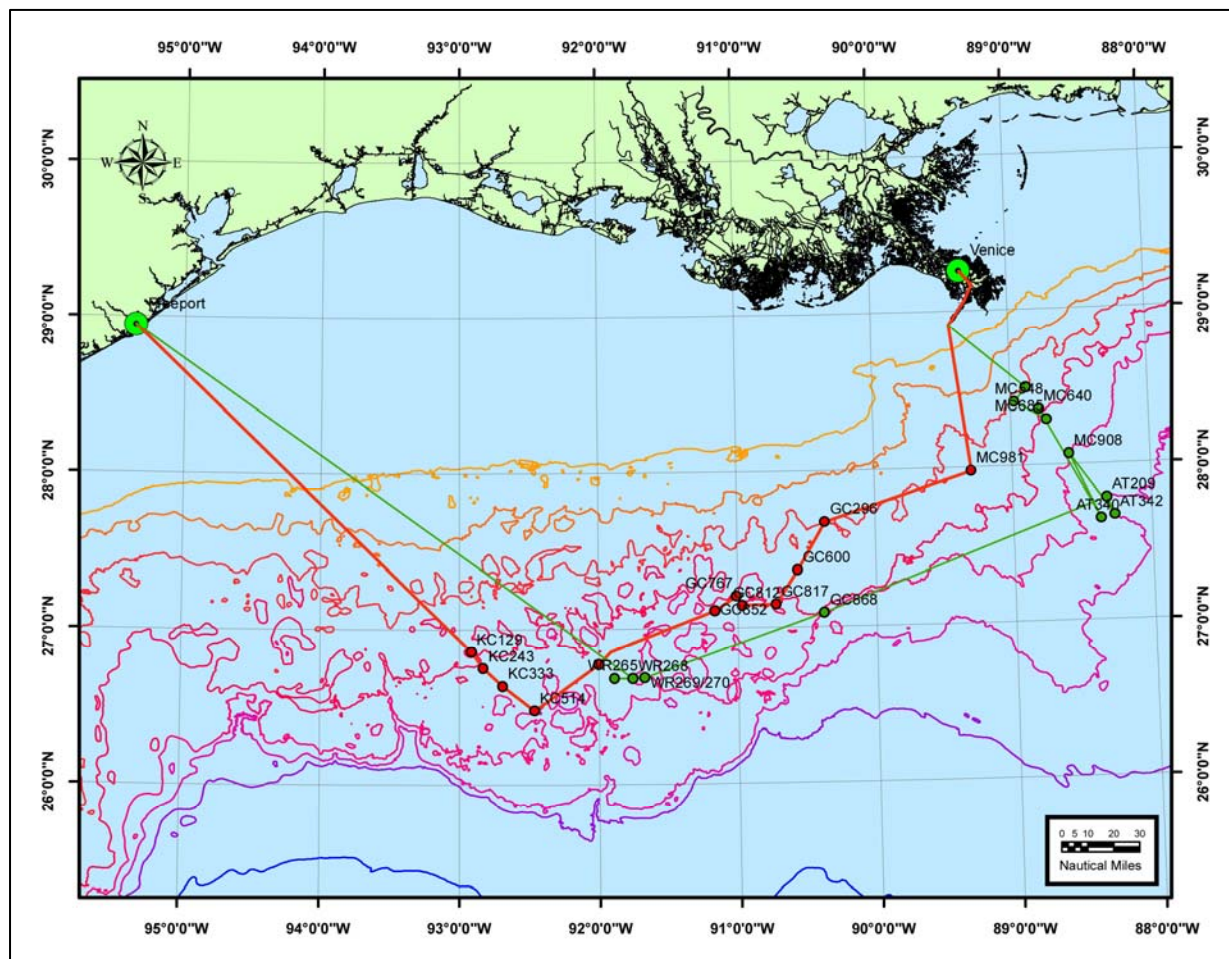


Figure 36. Route map for Legs 1 (—) and 2 (—) of the Reconnaissance cruise.

Image Analysis Progress

Down-looking Camera

Approximately 15,000 images were collected during the May 2006 ALVIN cruise. A large fraction of these were taken with a vertically oriented camera (D-cam) and strobe system mounted below the work basket of ALVIN. The logistic details of image collections were detailed the cruise report. Briefly stated, the camera was triggered by an interval-circuit, taking pictures every 10 seconds. Each digital image was recorded with a time stamp, which in turn can be correlated with the navigation information recorded by the submarine. Because the camera was oriented vertically, the area covered in each photograph is a regular geometric function of the altitude of the camera when the photograph was taken. Given that most of the photographs were taken close to the bottom with clear visibility and adequate lighting, the major biological and geological features of the seafloor can be reliably distinguished. So the photographic records are way to examine the distribution and abundance of these features. However, there are issues that need to be addressed concerning possible bias in how the images were collected.

Also, because reviewing and analyzing the images is potentially quite time-consuming, the optimal level of effort that should be allocated to this task needs to be decided. The images have been under review in MacDonald's lab at Texas A&M University - Corpus Christi. Results in progress are summarized in the following paragraphs.

Complete Counts

In this approach, all fauna and significant bottom features were counted and measured, using a standardized set of descriptors. Taxonomic identification was to nearest practical taxon for the running measurements, but individual species were noted. Depending on the category of feature, three different quantifications were used. Presence-absence, the simplest quantification simply denoted that a particular species or feature was noted in a given photograph. Counts attempted to count individuals of a given species in each photograph. For area measurement, the analyst outlined the area of a given fauna and measured the number of image pixels in the outlined area. In all cases, care had to be taken when photographs overlapped so as to avoid double measurements. Image analysis was carried using Image-J, a publicly available image-processing suite maintained by the National Institutes of Health. **Figure 37** shows how all three measurement types were compiled for a given image. The upper panel shows a photograph taken when the submarine was fairly high off the bottom. The large section of the bottom marked off had been analyzed in the previous image and was excluded from further counts. The lower panel show the next photograph in the sequence taken when submarine approach more closely to the bottom. In this image, the portion that had been scored in the previous image is again marked off and only the new bottom are is counted or measured.

The area covered by the major chemosynthetic fauna—tube worms, mussels, or clams—was outlined in Image-J and the pixel counts from each outline were noted. All counts and areas were compiled in a spreadsheet where each image was assigned to a row and the categories were compiled in columns. Areas were estimated based on the altitude of the submarine when the photo was taken, given the acceptance angles of the camera used. **Table 28** summarizes results from the complete counts at three sites (AT340, AC601, and AC645).

Table 29 shows the progress toward completion of the ALVIN images. In practice, the complete count method proved very time-consuming and is probably not practical for the entire image data set. Additionally, review of the image collection has revealed issues of navigation and questions regarding sampling bias. The methodology will prove useful when unbiased photographic samples are collected with Jason.

In order to complete the review of all the ALVIN images, the less time-consuming approach of simply noting presence-absence of fauna with qualitative designations for abundance will probably have to be adopted.

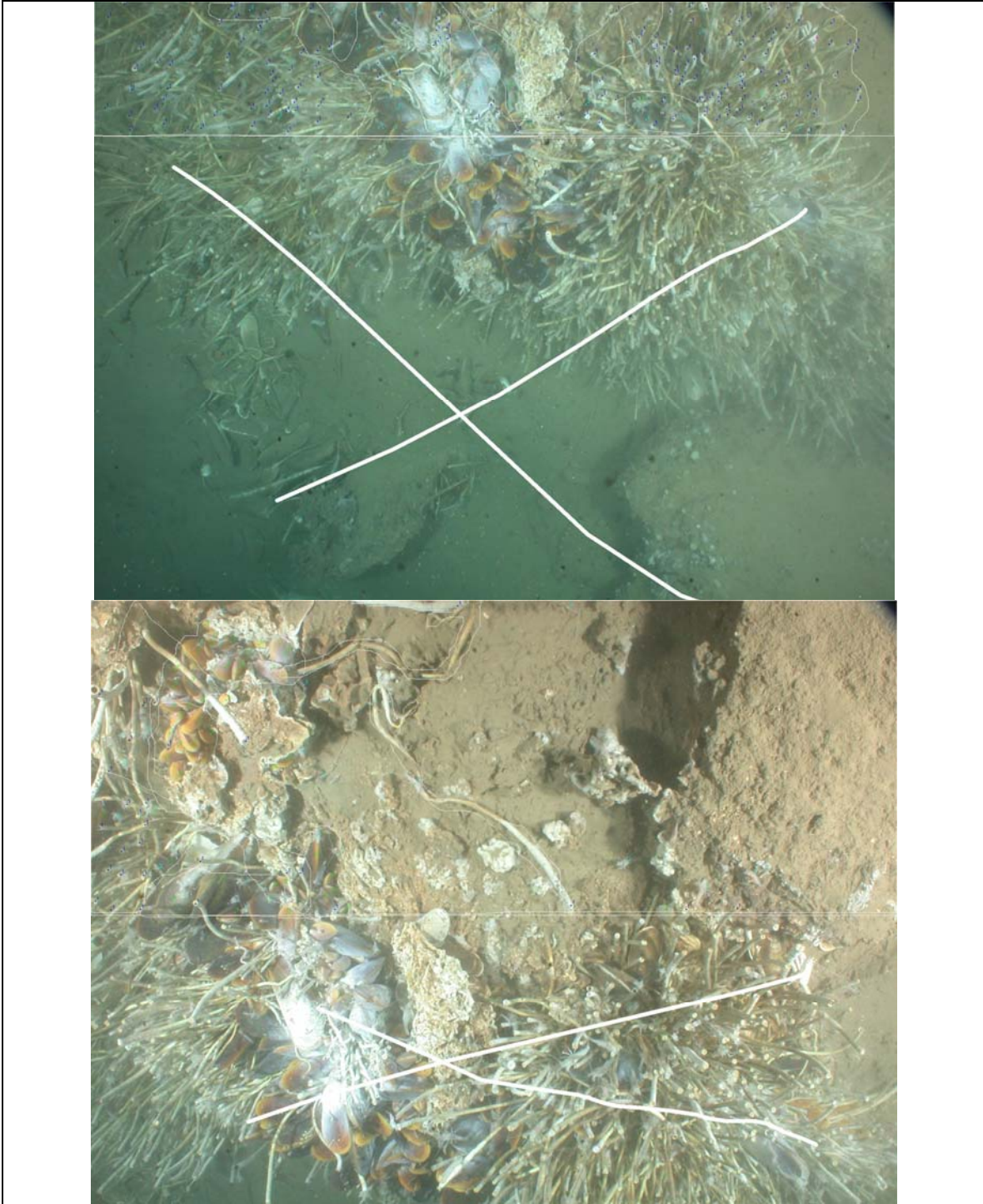


Figure 37. Example images analyzed for complete coverage.

Table 28.

Summary Results for Exhaustive Image Analysis

		D4181 (AT340)		D4193 (AC601)		D4194 (AC645)	
		<i>Total images</i>	<i>Total area m2</i>	<i>Total images</i>	<i>Total area m2</i>	<i>Total images</i>	<i>Total area m2</i>
		582	2,842.56	640	4406.38	900	8,704.84
Category	type	Per Image	Dive total	Per Image	Dive total	Per Image	Dive total
brinepool;	MSR		0.00	2.96	405.43		0.00
brinechannel;	MSR		0.00	0.83	0.83	0.00	0.00
brinespot	P/A	4.47%	26	0.03	18	5.00%	45
brinepoolmass	P/A	0.00%	0	0.00	1		
pooledge;	MSR	0.89	4.47	6.37	720.07		0.00
mudpool;	MSR		0.00	3.06	3.06		0.00
shellmslsingle	P/A	10.14%	59	5.00%	32	8.33%	75
shellmslcluster	P/A	28.52%	166	0.00%	0	11.67%	105
carb_rubble	MSR	1.78	28.42		0.00		0.00
carb_low_relief	MSR	1.49	392.59	0.63	3.79	3.49	815.79
carb_high_relief	MSR	3.00	6.01		0.00	9.75	204.72
bac_mat_TOTAL	MSR	0.03	0.53	0.35	2.78	0.26	6.23
tbw_single	MSR	0.02	2	0.01	0	0.04	4.70
tbw_cluster	MSR	1.04	101.67	1.16	8.14	3.48	821.07
tbw_cluster or single	CNT	27.99	5962	11.13	334	82.41	28433
Pogos	MSR	0.43	5	0.19	3	1.28	36.80
Alcyonacea	CNT		0	2.20	22	1.12	47
Zoantharia	CNT	1.00	1		0		0
Actinaria	CNT	1.08	14	2.55	28	7.89	71
Vesicomylidae	MSR		0.00		0.00		0.00
Bathymodiolus_single	P/A	0.17%	1	3.60	18	1.50	3
Bathymodiolus_cluster	CNT	52.09	1198		0	104.05	6243
Bathymodiolus	MSR	3.41	78.04	0.00	0.03	1.71	104.45
Holothurian	CNT	1.30	13	1.13	53	1.19	62
Echinoidea	CNT	1.83	11	5.53	177	2.00	2
Gastropoda	CNT	2.11	19	1.00	14	1.00	10
Asteroidea	CNT	1.00	5	1.00	1	1.00	3
Ophiuroidea	CNT	1.00	2		0	1.00	1
Caridea	CNT	10.71	1489	1.39	53	11.66	1702
Brachyura	CNT	1.00	1		0	1.00	1
Anomura	CNT	1.00	1		0		0
Galatheid	CNT	3.56	637	1.10	11	2.65	381
Ostracoda	CNT		0		0		0
Amphipods	CNT		0	217.62	2829		0
Cnidarian	CNT		0		0		0
Fish	CNT	1	4	1.00	6	1.00	8
trash	P/A	1.37%	8	2.97%	19	1.78%	16

Table 29.

**Progress Toward Completion of Image Analysis of the Down-Looking Camera Images
Collected with ALVIN in the May 2006 Cruise**

Site	Dive	Total Images	Images Completed	Staff hours	Average Min/Image
AC601	D4193	640	640	49.9	4.7
AC645	D4194	1,005	1005	137.6	8.2
AC818	D4192	475			
	D4195	1,775			
AT340	D4173	412			
	D4179	954			
	D4180	620			
	D4181	932	423	40.2	5.7
	D4183	514	81	12.6	9.3
GC600	D4174	755			
	D4184	785			
GC852	D4177	300			
	D4185	949			
	D4186	688			
	D4187	1,077			
	D4189	472			
	D4190	248			
KC243	D4186	1,265			
	D4176	115			
MC640	D4182	932	174	25	8.6
WR269	D4175	184	184	35	11.4
	D4191	559	367	55	9.0

RECONNAISSANCE CRUISE – SITE CHARACTERIZATION AND EVALUATION

Keathley Canyon 243

This station is situated on a level area on a southwest oriented slope at approximately 1,610 m depths. The DSC reached the bottom and at 16:10 hrs on 12 March and collected images with a 12 second repeat rate until 19:13 hrs. A total of 747 images were collected with the bottom in view and acceptable navigation. The site showed good evidence for development of chemosynthetic communities including extensive bacteria mats, scattered and concentrated dead shells, and small patches of living mussels. Tube worms were observed as solitary individuals or small clusters in six photographs. Geological indications of seepage included extensive brine-staining and patches of carbonate. This site should be considered as a good candidate for additional study (**Figures 38 and 39**).

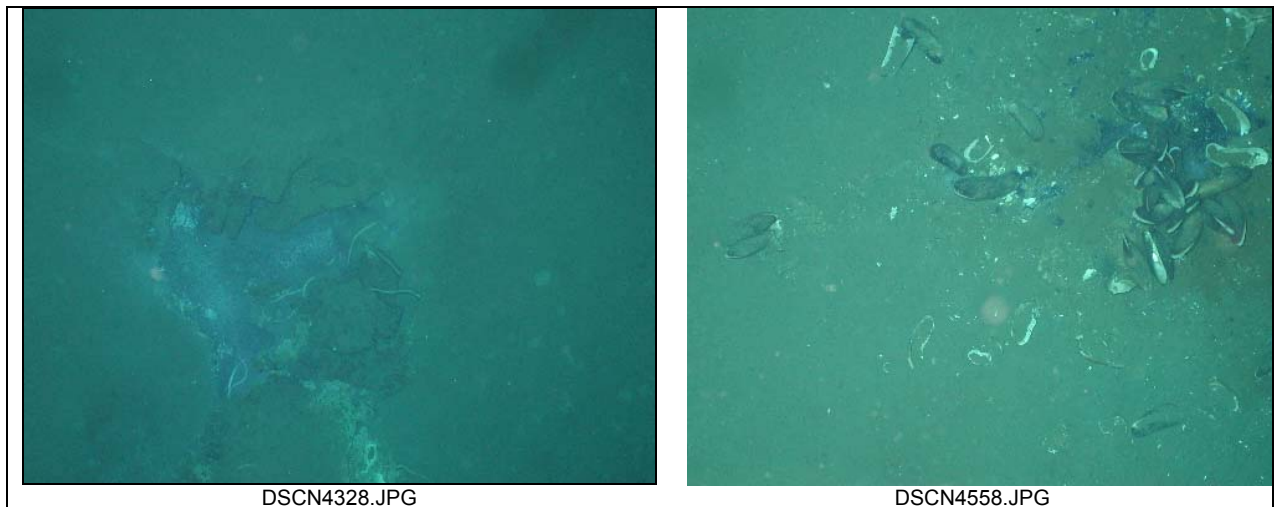


Figure 38. Representative photography from KC243.

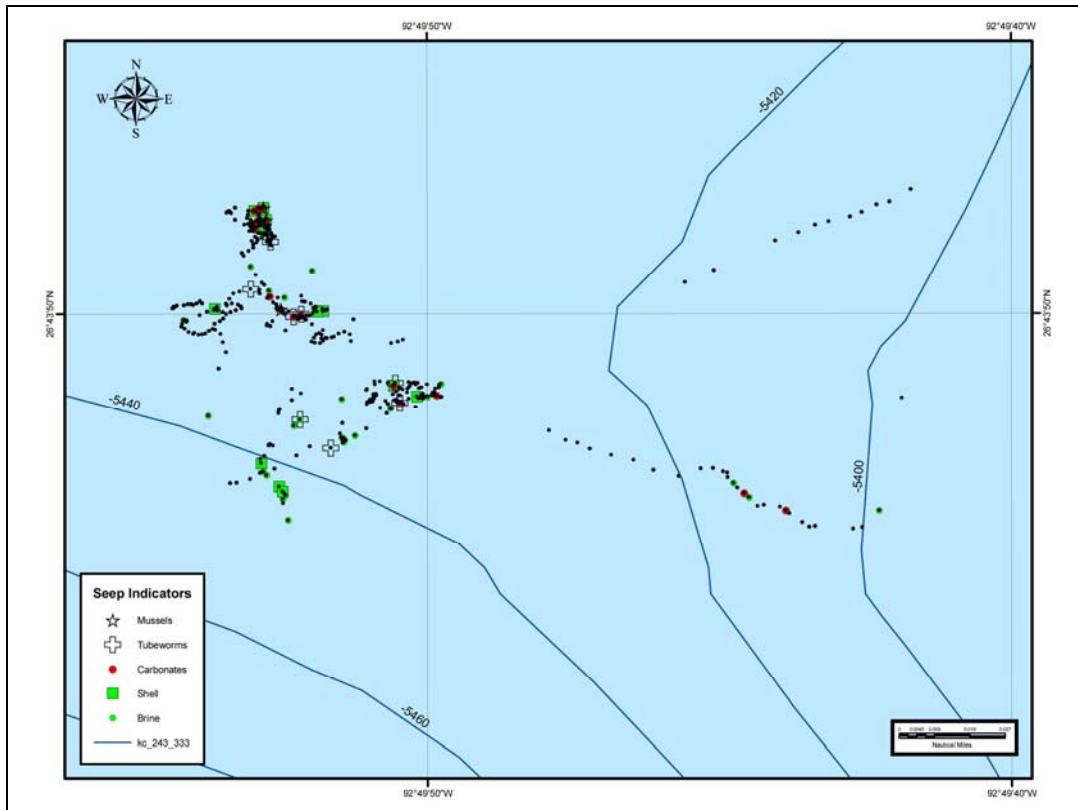


Figure 39. Survey results from KC243 station.

Keathley Canyon 333

This station is situated on the crest and eastern flank of a low mound a depths from 1,650 to 1,720 m. The DCS reached bottom at 03:03 hrs on 13 March and collected images with a 12 second repeat rate until 04:33 hrs. A total of 267 images were collected with the bottom in view and acceptable navigation. The site showed some evidence for development of chemosynthetic communities including occasional bacteria mats, scattered and scattered dead shells, and a few solitary mussels. Tube worms were observed as a solitary individuals in three (3) photographs. Geological indications of seepage included extensive brine-staining and of carbonate boulders. This site should be considered as a marginal candidate for additional study (**Figures 40 and 41**).

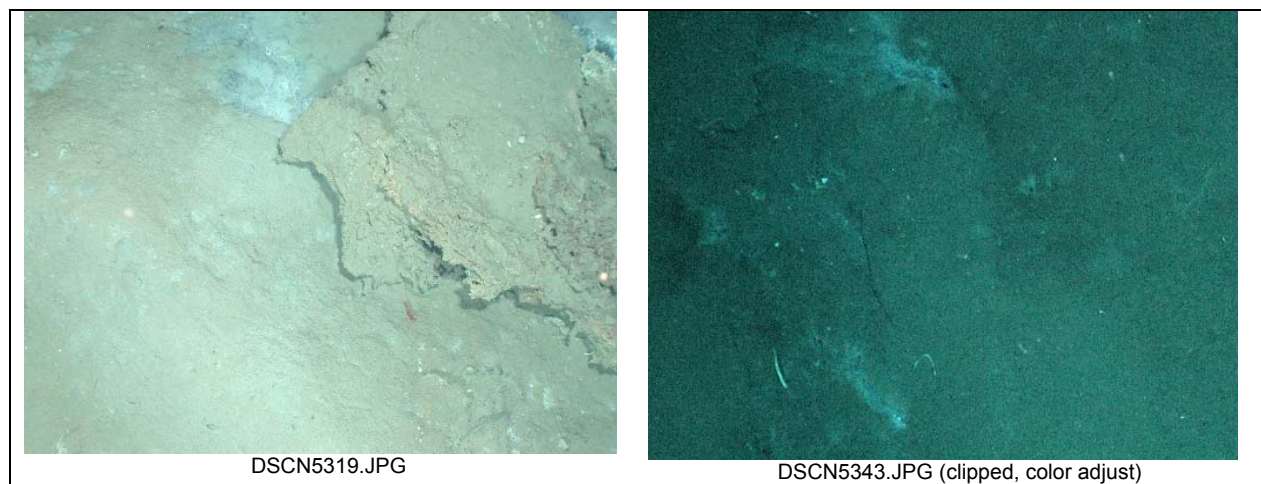


Figure 40. Representative photography from KC333.

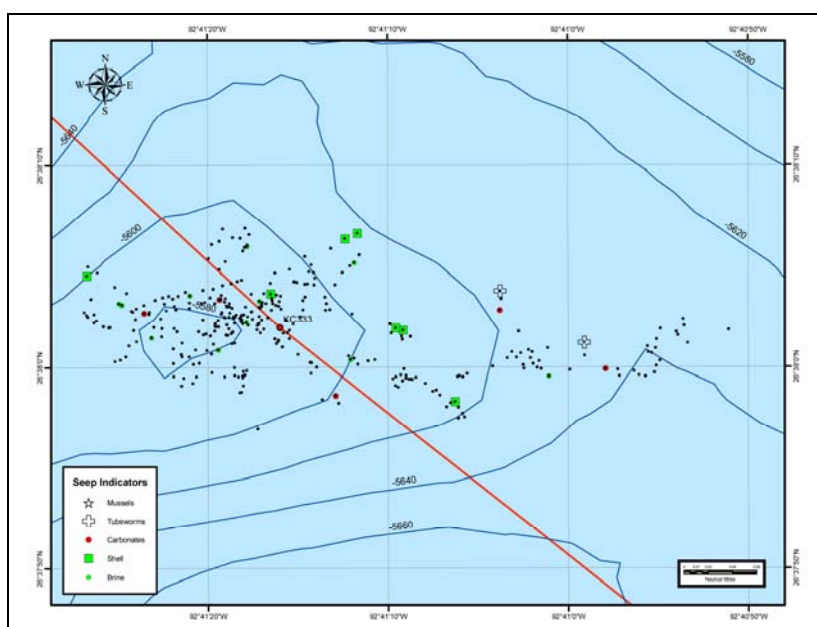


Figure 41. Survey results from KC333.

Keathley Canyon 216

This station is situated on the crest and the steeply sloping eastern flank of a mound at 1,750 m. The DCS reached bottom at 00:42 hrs on 14 March and collected images with a 10 second repeat rate until 05:47 hrs. A total of 802 images were collected with the bottom in view and acceptable navigation. The site appears to be an active mud volcano. It showed some scant evidence for development of chemosynthetic communities, with fauna limited to bacteria, dead shells, and a few solitary mussels. Tube worms were photographed as solitary individuals associated with

carbonate outcrops in the eastern portion of the site. Geological indications of active fluid flow included extensive brine-staining, large mud flows, and disturbed sediments. The eastern portion of the site featured more extensive brine and bacteria covered sediments and numerous solitary shells. This site should be considered as a marginal candidate for additional study (**Figures 42 and 43**).

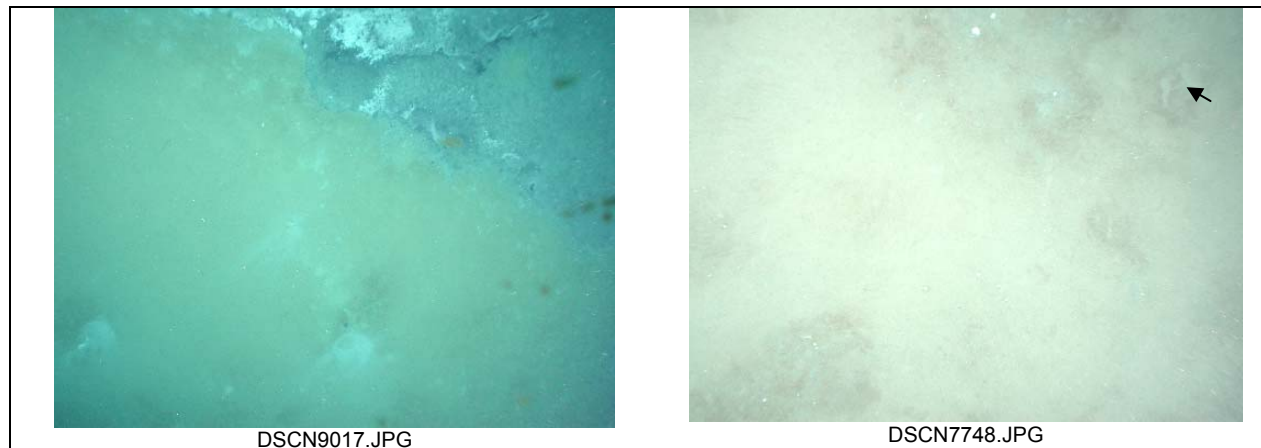


Figure 42. Representative photography from KC216.

Keathley Canyon 129

This station is situated on the crest and the gradual sloping eastern and southern flanks of a mound at 1,675 m. The DCS reached bottom at 12:39 hrs on 14 March and collected images with a 12 second repeat rate until 03:14 hrs. Survey operations were hampered by heavy seas. A total of 271 images were collected with the bottom in view and acceptable navigation. The site appears to be an active mud volcano. It showed moderate evidence for development of chemosynthetic communities, with abundant bacteria, dead shells, and a small mussel clusters. A solitary tube worm was possibly photographed associated with carbonate outcrops. Geological indications of active fluid flow included extensive brine-staining, large mud flows, and disturbed sediments. Carbonates were developed as large jointed pavements in one area. This site should be considered as a marginal candidate for additional study (**Figures 44 and 45**).

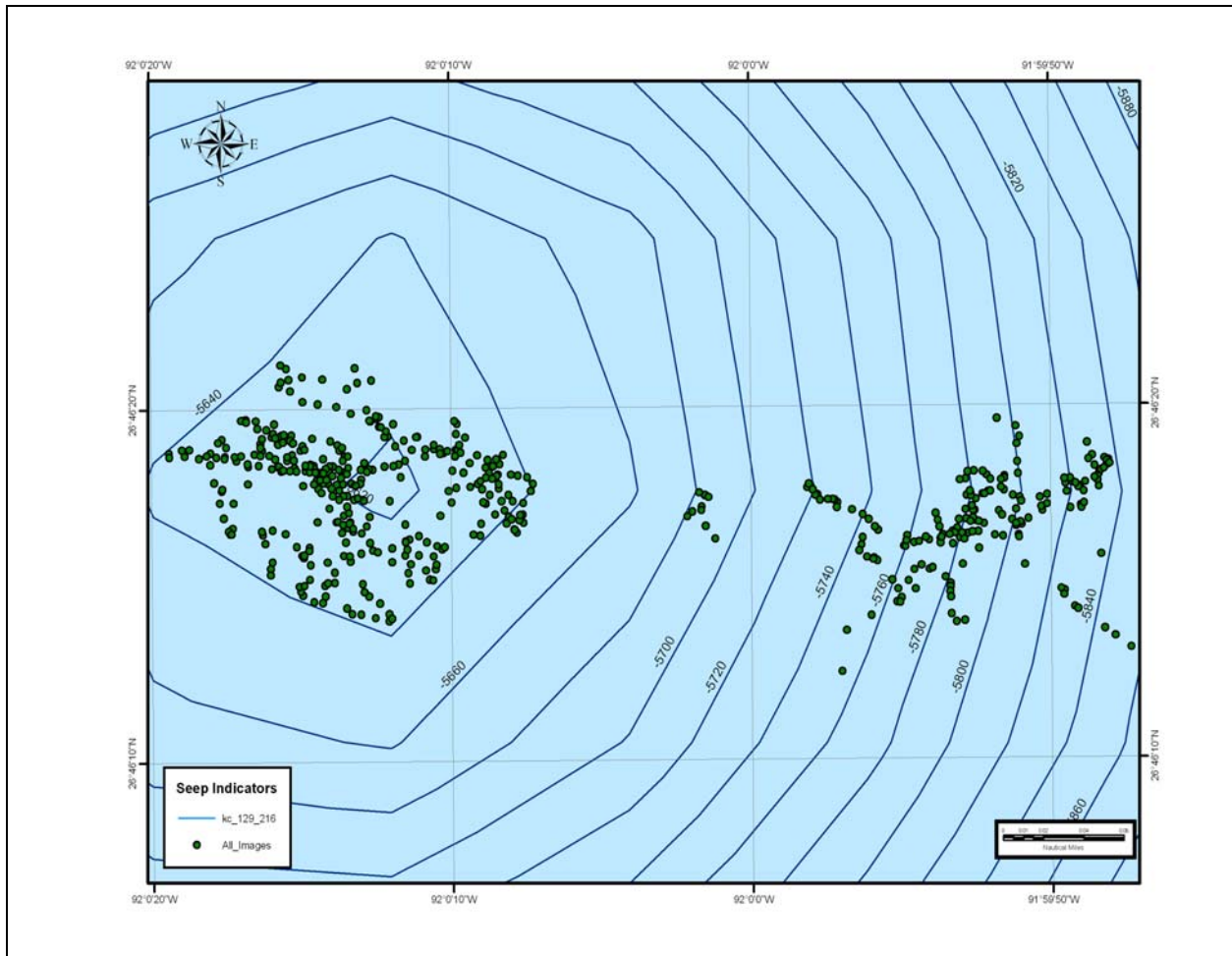


Figure 43. Survey results from the KC216 station.

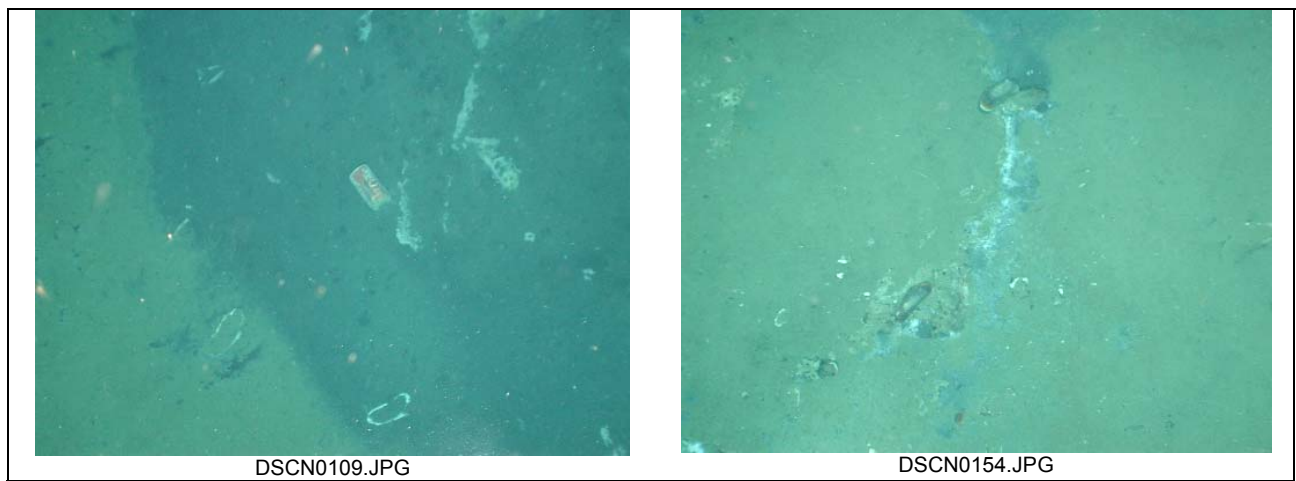


Figure 44. Representative photography from KC129.

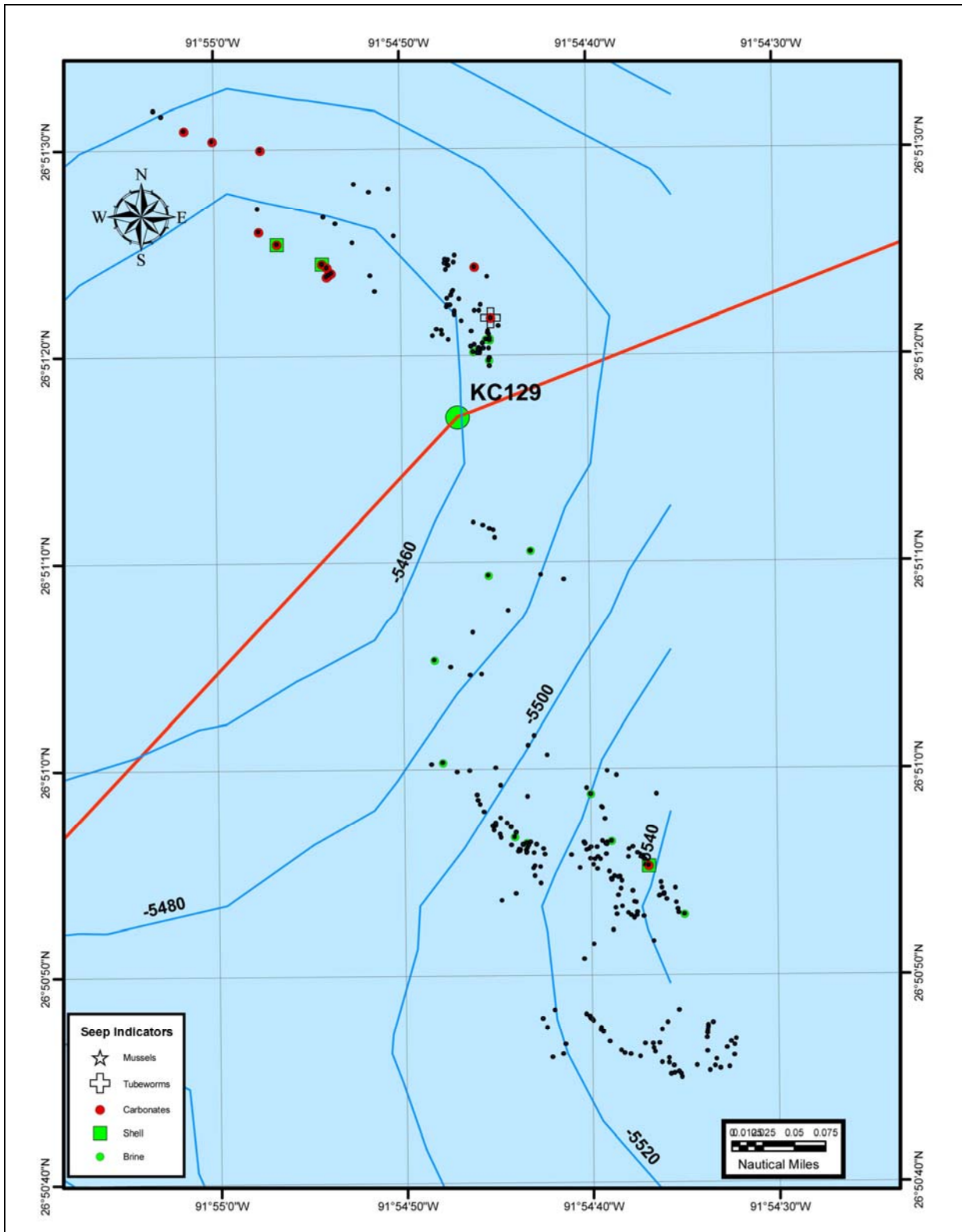


Figure 45. Survey results from KC129 station.

Green Canyon 852

This station is arrayed along a steep-sided, north-south oriented ridge at 1,450 m. The DCS reached bottom at 04:04 hrs on 15 March and collected images with a 12 second repeat rate until 07:58 hrs. Survey coverage was focused along ridge-crest with relatively favorable sea conditions. A total of 1,054 images were collected with the bottom in view and acceptable navigation. The site contained probably the most prolific chemosynthetic community seen during the cruise and included a comparatively diverse array of chemosynthetic and heterotrophic fauna. Tube worms were widespread, mostly associated with large carbonates. Mussels were locally dense at several points. Development of carbonates was impressive and clearly indicates prolonged seepage at this site. The combination of hard substrata and topographic relief favored the colonies of deepwater coral. Gorgonians of several species were widespread. Live bamboo coral was seen at several points and pieces of another species of branching coral could be seen on the bottom around the boulders. This site should be considered as a high-priority candidate for additional study (**Figures 46 and 47**).

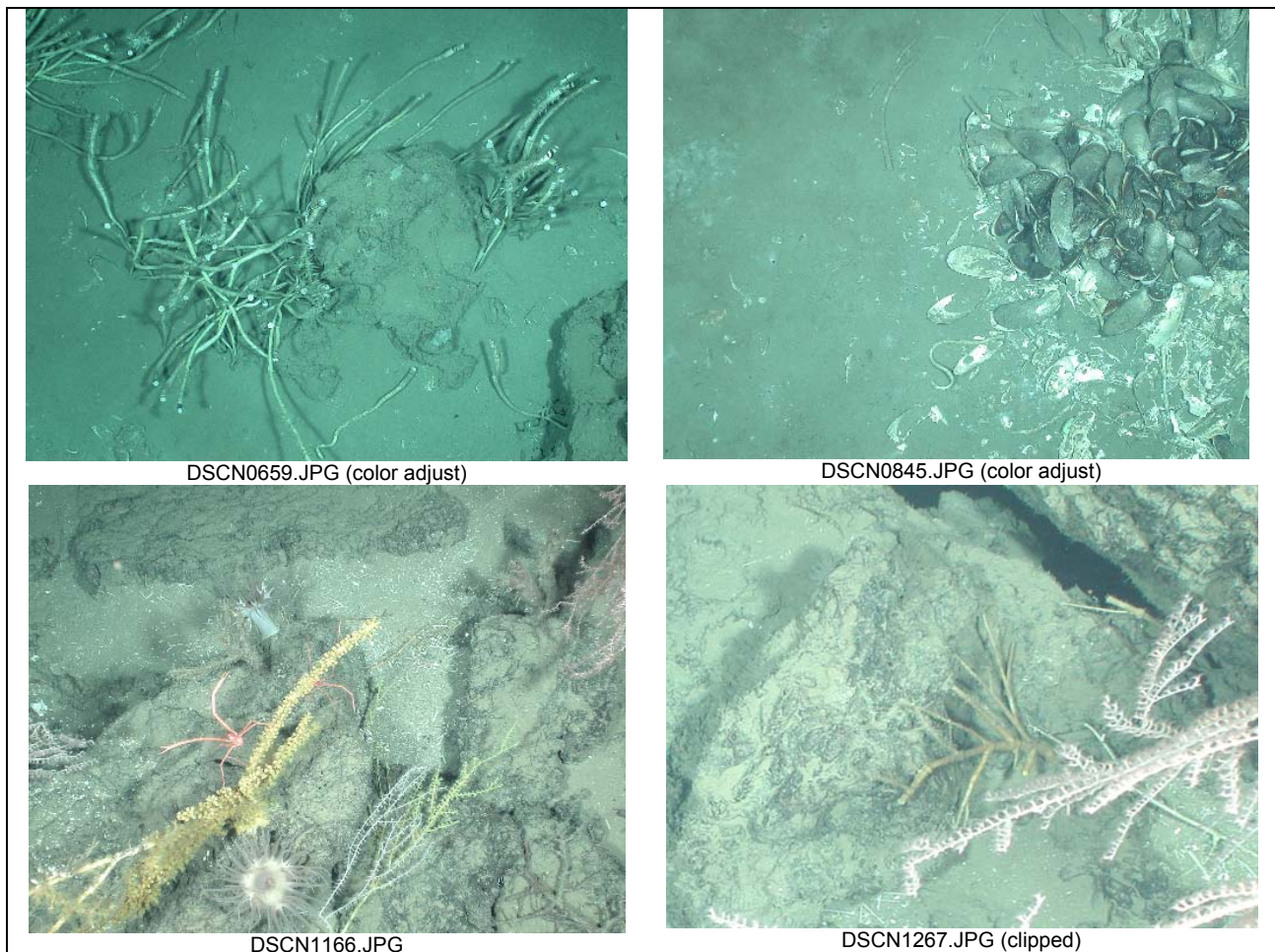


Figure 46. Representative photography from GC852.

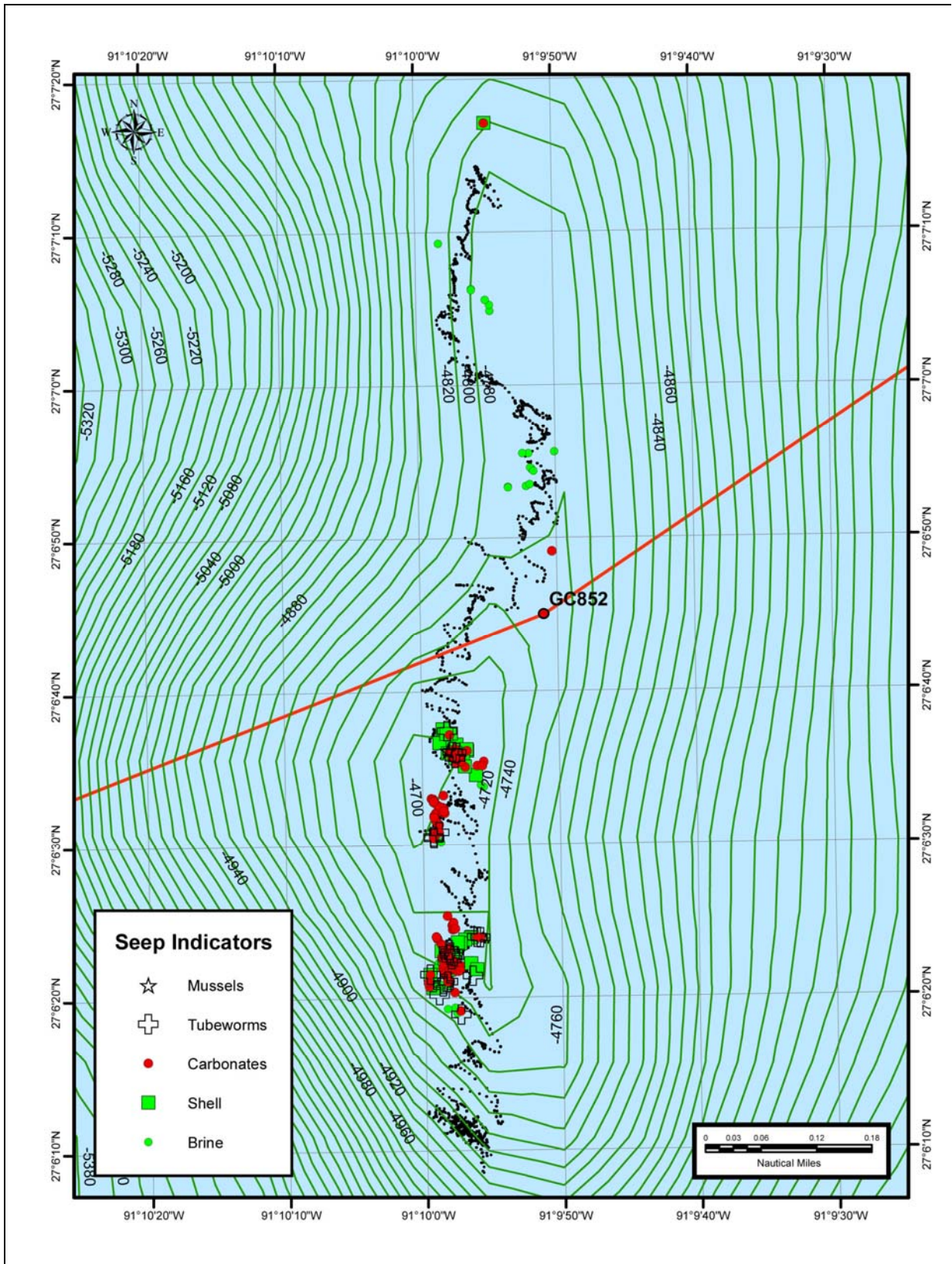


Figure 47. Survey results from GC852 station.

Green Canyon 767

This station is a series of anomalies on a steep slope between 1,480 and 1,590 m. The DCS reached bottom at 12:01 hrs on 15 March and collected images with a 10 second repeat rate until 13:58 hrs. A total of 269 images were collected with the bottom in view. The navigation data file for this site was lost and it is not possible to navigate the individual bottom images. The site appears to be a series of fluid flows on steep slope. It showed extensive bacteria mats and several brine-channels. This site should be considered as a poor candidate for additional study (**Figures 48 and 49**).

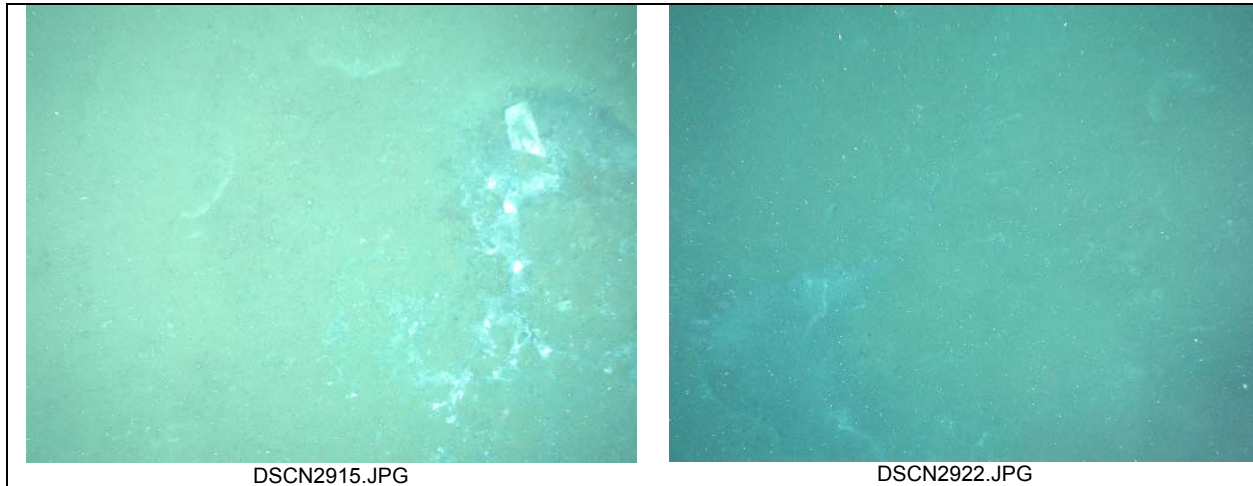


Figure 48. Representative photography from GC767.

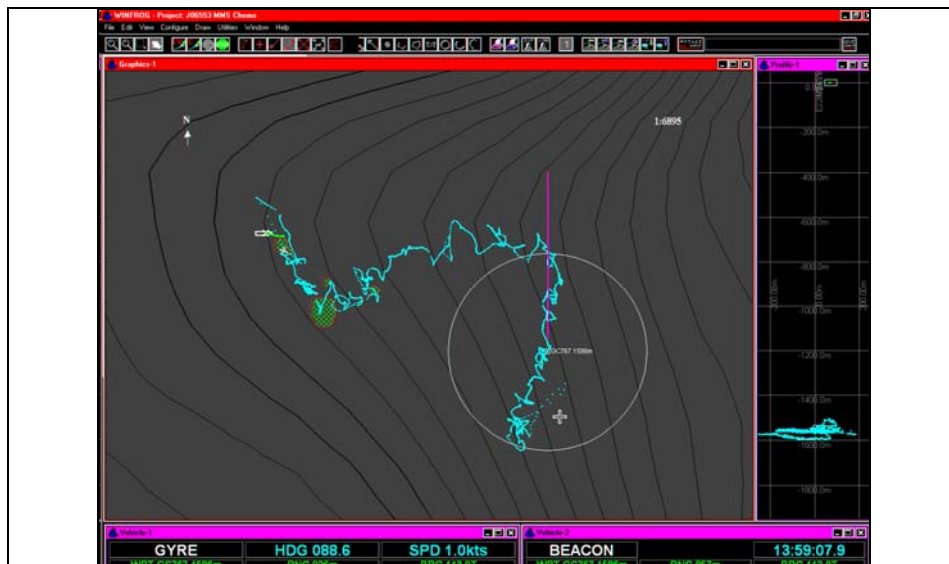


Figure 49. Survey results from GC767 station.

Green Canyon 812

This station is situated on a low-relief topographic high at a depth of about 1,800 m. The DCS reached bottom at 18:14 hrs on 15 March and collected images with an 11 second repeat rate until 19:24 hrs. A total of 225 images were collected with the bottom in view and acceptable navigation. The site showed extensive brine flows and frequent bacterial mats. Fresh mud flows suggest ongoing fluid venting. No chemosynthetic megafauna were seen. This site should be considered as a poor candidate for additional study (**Figures 50 and 51**).

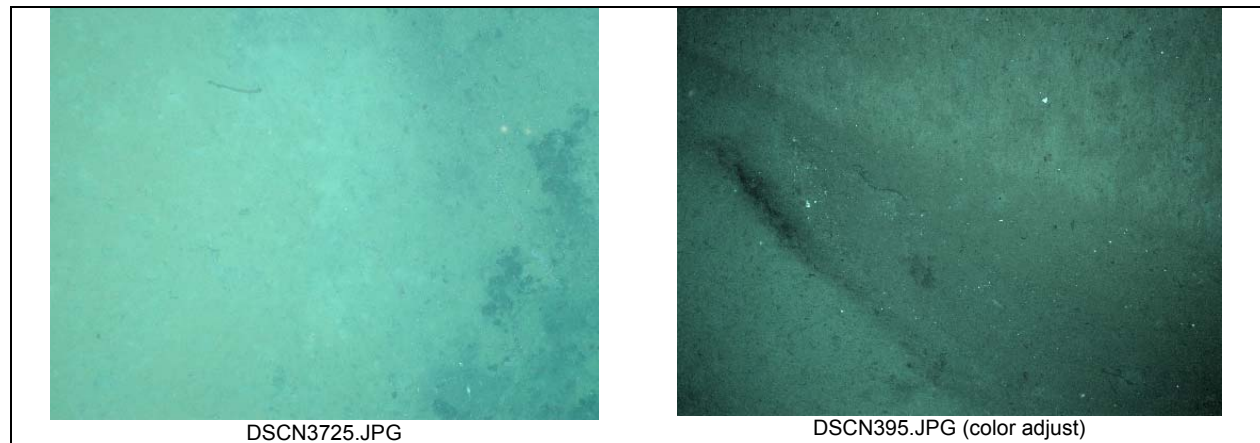


Figure 50. Representative photography from GC812.

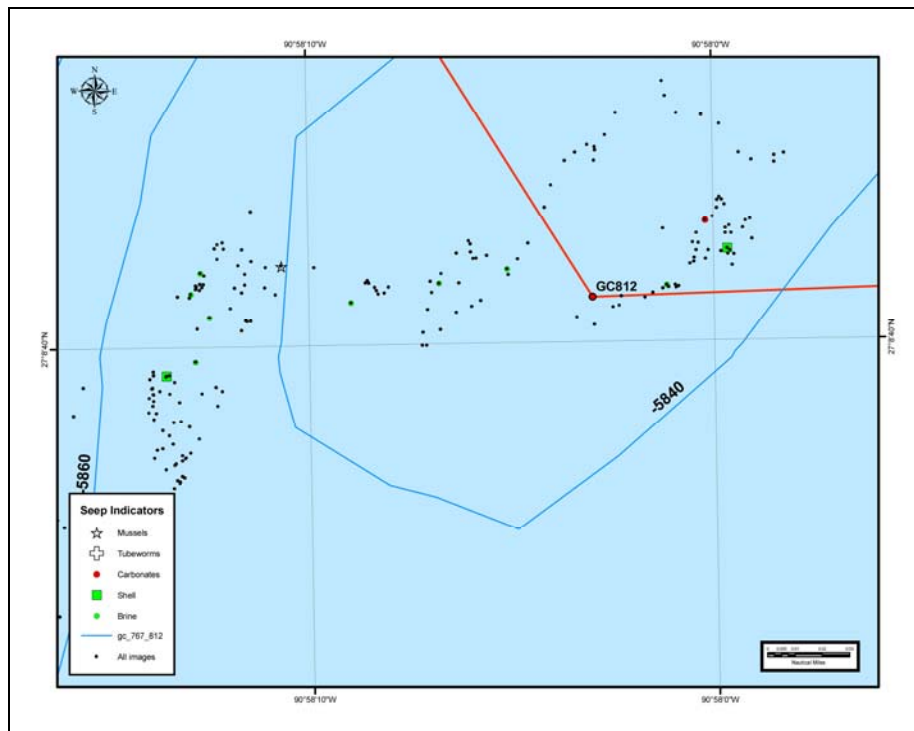


Figure 51. Survey results from GC812 station.

Green Canyon 817

This station is situated on a low-relief topographic high at a depth of about 1,800 m. The DCS reached bottom at 02:53 hrs on 16 March and collected images with an 11 second repeat rate until 07:02 hrs. A total of 515 images were collected with the bottom in view and acceptable navigation. Image quality was poor due to aperture setting at $f 2.5$. The site showed occasional bacterial mats. There was a single aggregation of mussels and dead shell with carbonate pavement. This site should be considered as a marginal candidate for additional study (**Figures 52 and 53**).

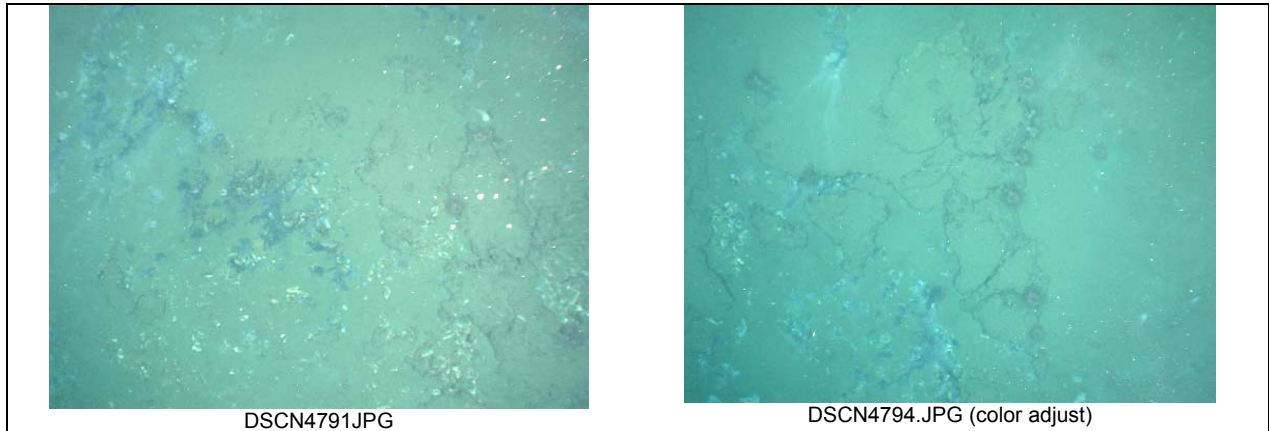


Figure 52. Representative photography from GC817.

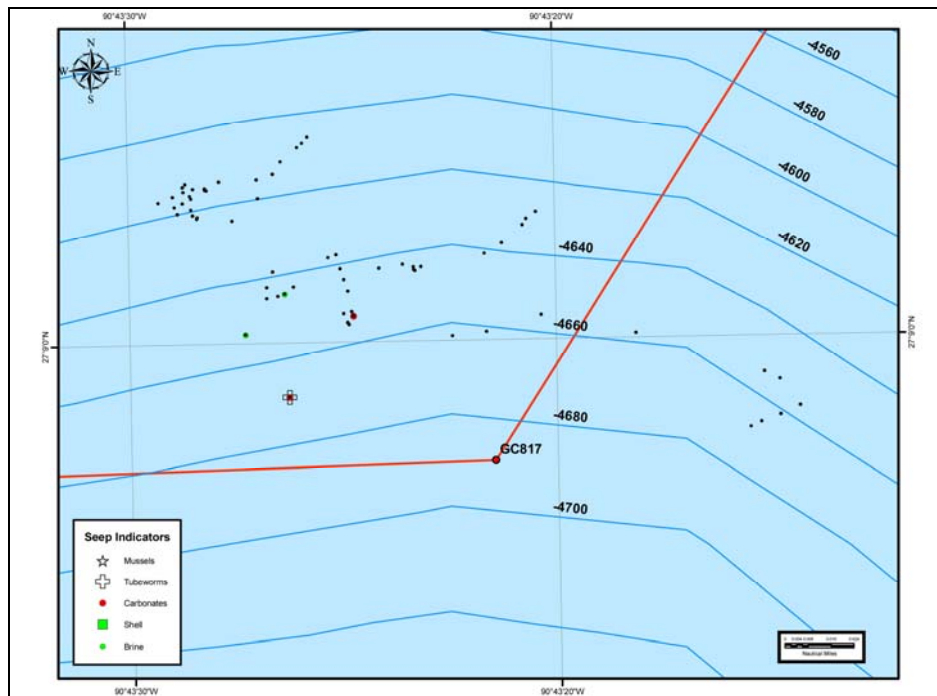


Figure 53. Survey results from GC817 station.

Green Canyon 600

This station is situated on a low-relief ridge at a depth of about 1,250 m. The DCS reached bottom at 17:40 hrs on 16 March and collected images with an 11 second repeat rate until 20:44 hrs. A total of 694 images were collected with the bottom in view and acceptable navigation. The site showed extensive hard ground and carbonate boulders. There were several sparse aggregations of tube worms growing under the carbonates. Scattered living mussels and extensive dead shells were also seen. Despite the extensive hard ground, no coral colonies were observed. This site should be considered as a possible candidate for additional biological study. The degree of lithification may have geological significance (**Figures 54 and 55**).

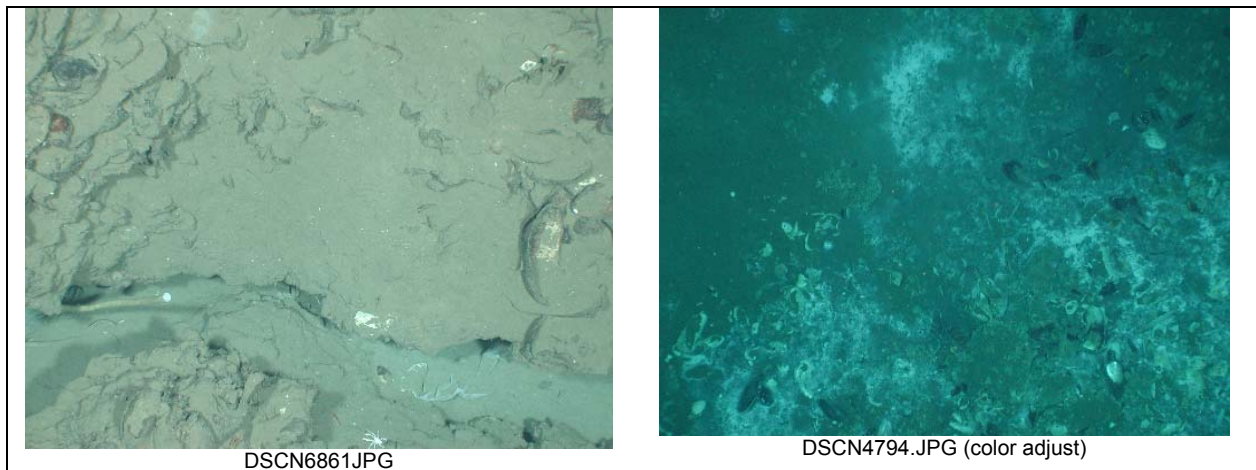


Figure 54. Representative photography from GC600.

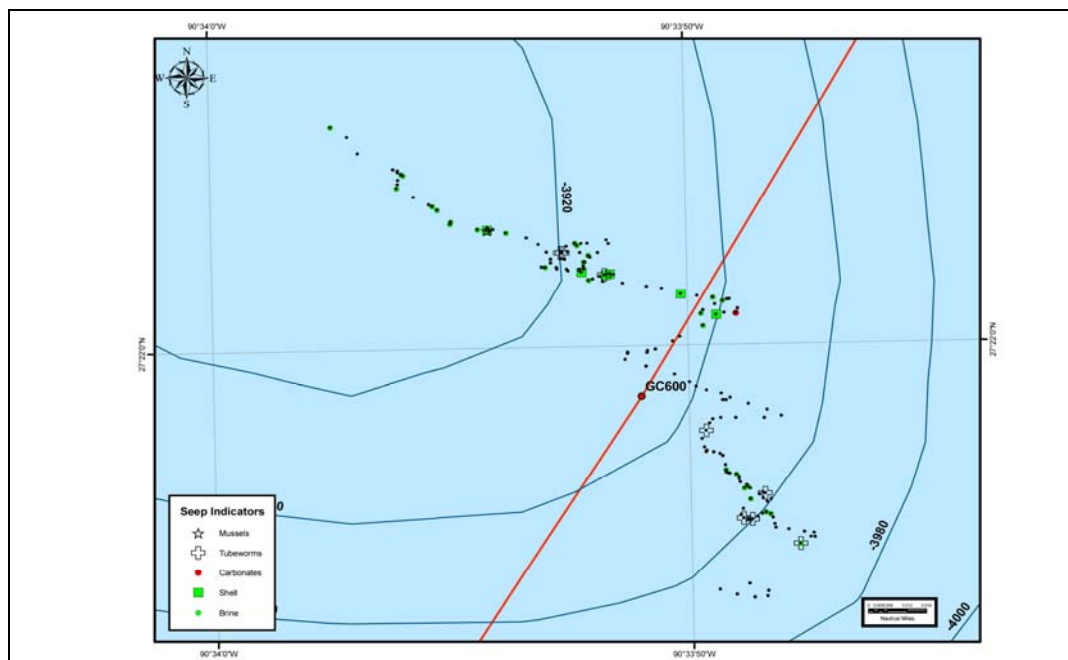


Figure 55. Survey results from GC600 station.

Green Canyon 296

This station was previously the site of an exploratory well that was shut in due to fluid flow. The DCS reached bottom at 03:29 hrs on 17 March and collected images with a 12 second repeat rate until 06:30 hrs. A total of 766 images were collected with the bottom in view and acceptable navigation. Calmer seas and level bottom contributed to quality survey collections. The site showed extensive areas of mottled-green depressions suggesting brine saturated sediments. The well site was characterized by completely featureless bottom, suggesting fluidized mud. Occasional bacteria mats were also seen, as was a solitary mussel shell. Notably there were abundant fish—many more than seen at previous stations—often two or three individuals in a single photograph. This site should be considered as a possible candidate for additional biological study to understand what is attracting the fish. However the complete lack of chemosynthetic megafauna argues against immediate submersible dives at this site (**Figures 56 and 57**).

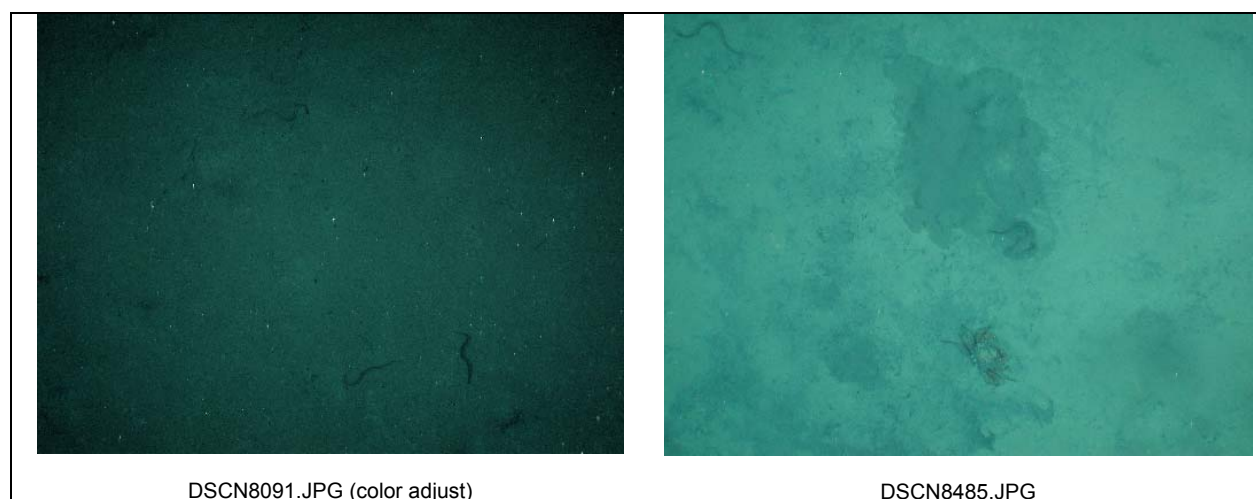


Figure 56. Representative photography from GC296.

Mississippi Canyon 981

This was a series of anomalies on west to east slope. The DCS reached bottom at 14:47 hrs on 17 March and collected images with an 12 second repeat rate until 17:44 hrs. A total of 825 images were collected with the bottom in view and acceptable navigation. Calmer seas again contributed to quality survey collections. The site featured a large mud-filled pool with extensive mud and brine flows. Development of bacterial mats was quite impressive over much of the site. However, apart from occasional shells and possible solitary tube worms, there was no development of a chemosynthetic community. This site is a poor candidate for further study (**Figures 58 and 59**).

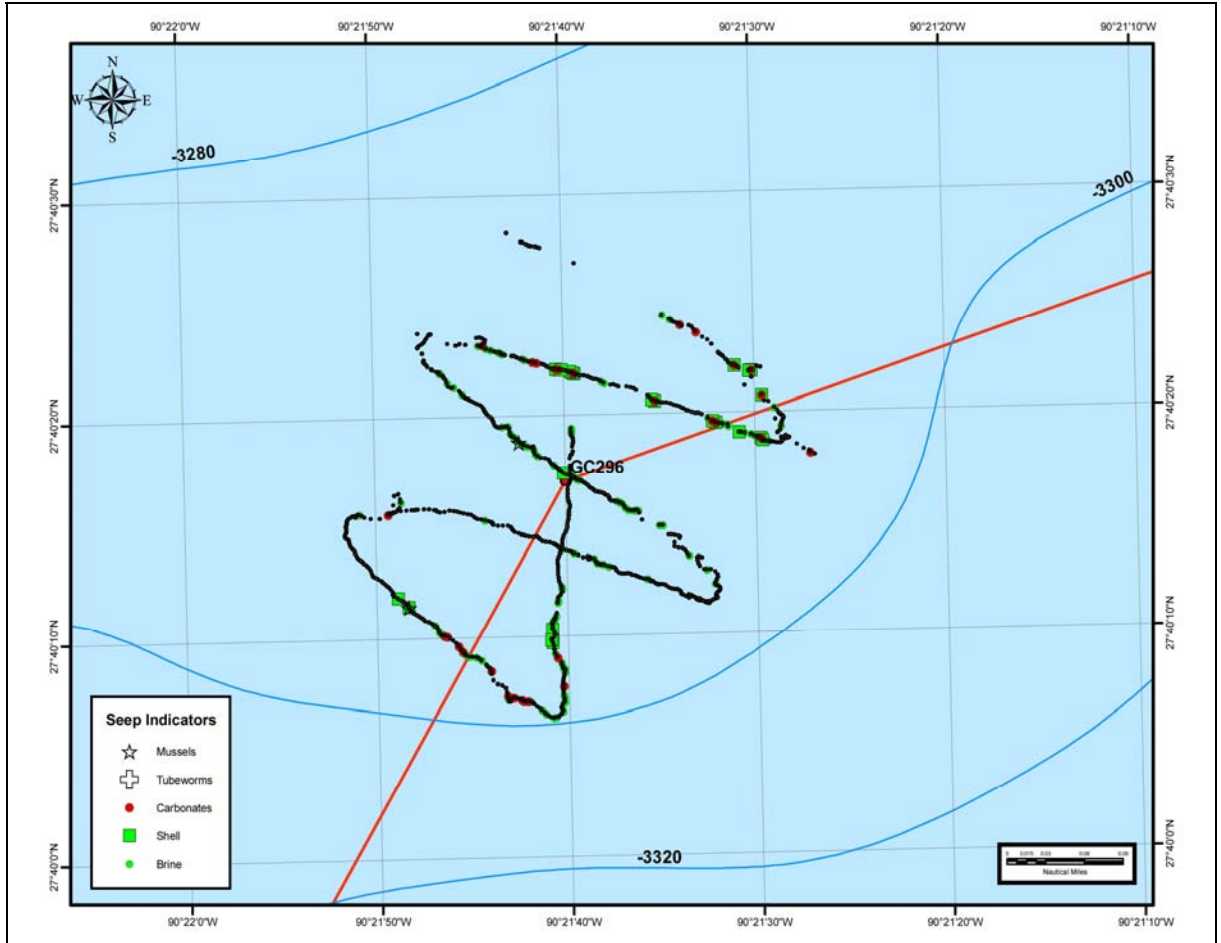


Figure 57. Survey results from GC296 station.

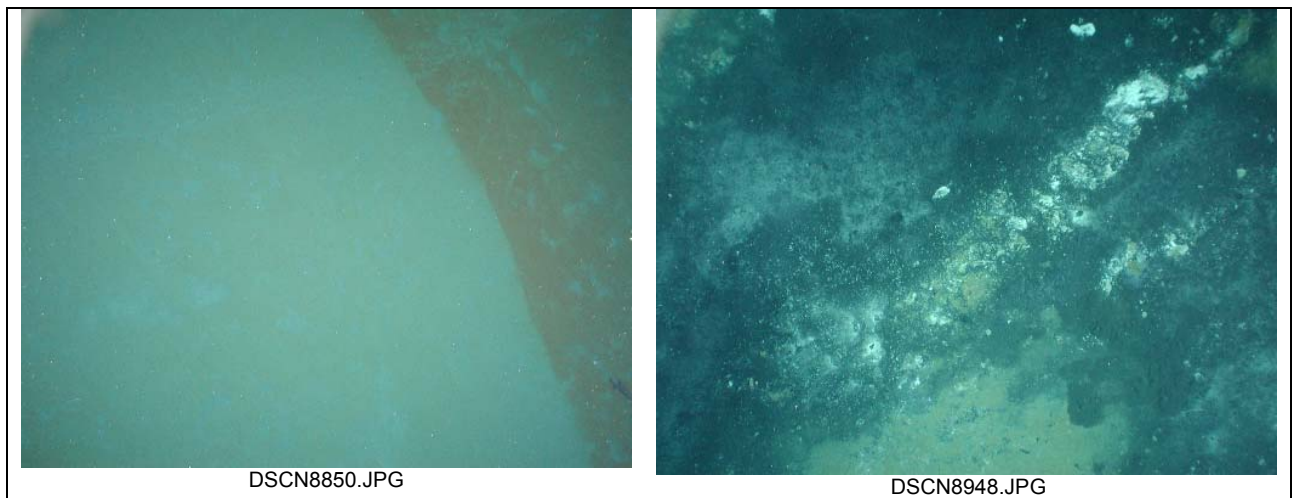


Figure 58. Representative photography from MC981.

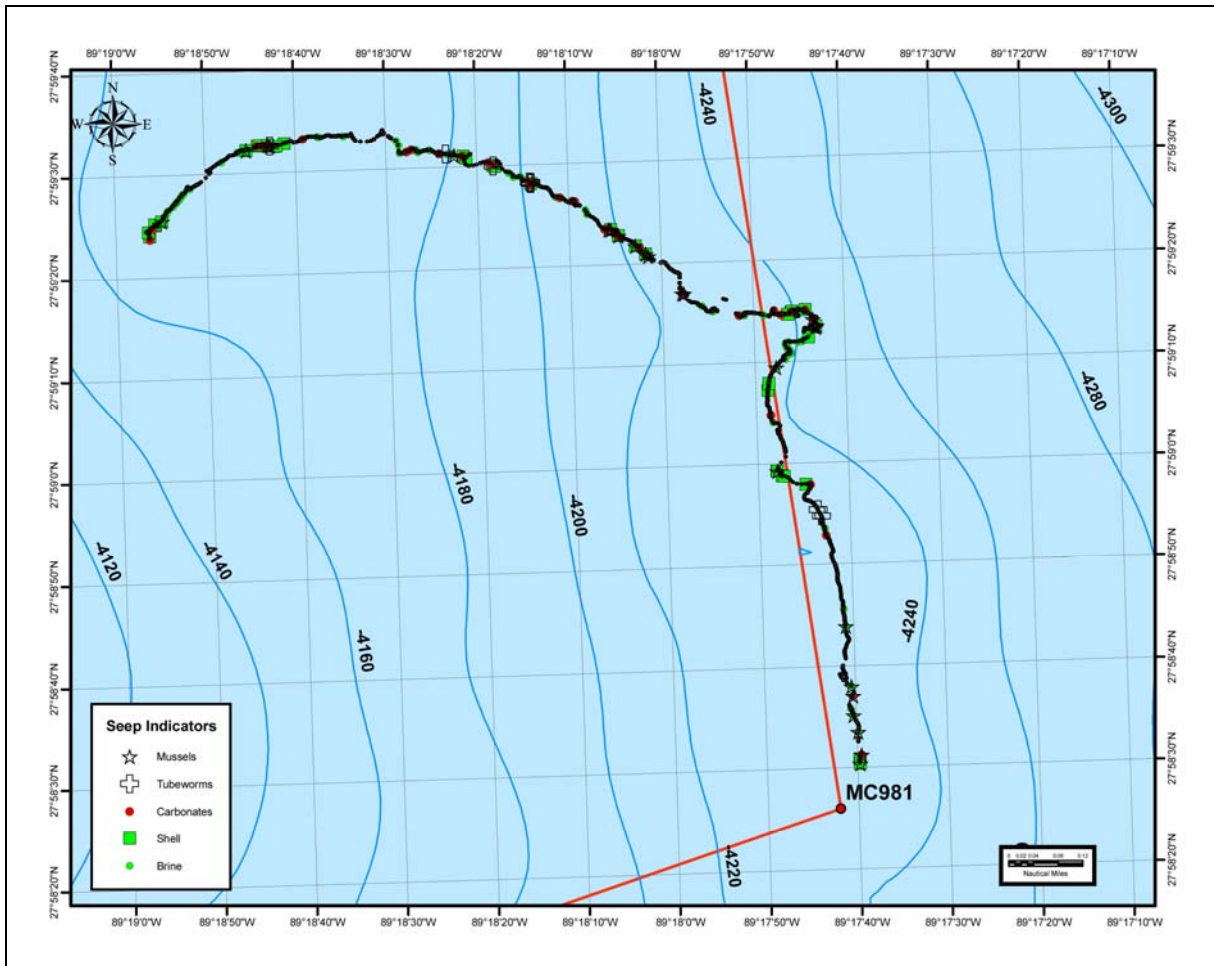


Figure 59. Survey results from MC981 station.

Mississippi Canyon 462

There were two targets at this site: a low mound and a terrace separated by 1.2 km at a depth of about 985 m. The DCS reached bottom at 02:25 hrs on 19 March and collected images with a 12 second repeat rate until 05:59 hrs. A total of 825 images were collected with the bottom in view and acceptable navigation. This site showed only isolated indications of seepage. Several carbonate outcroppings appeared to have bacteria or precipitate coatings with a few shells. Bacteria were also seen on sediment associated with brine staining. This site is a poor candidate for further study; however a gorgonian colony on a large carbonate boulder should be noted (**Figures 60 and 61**).

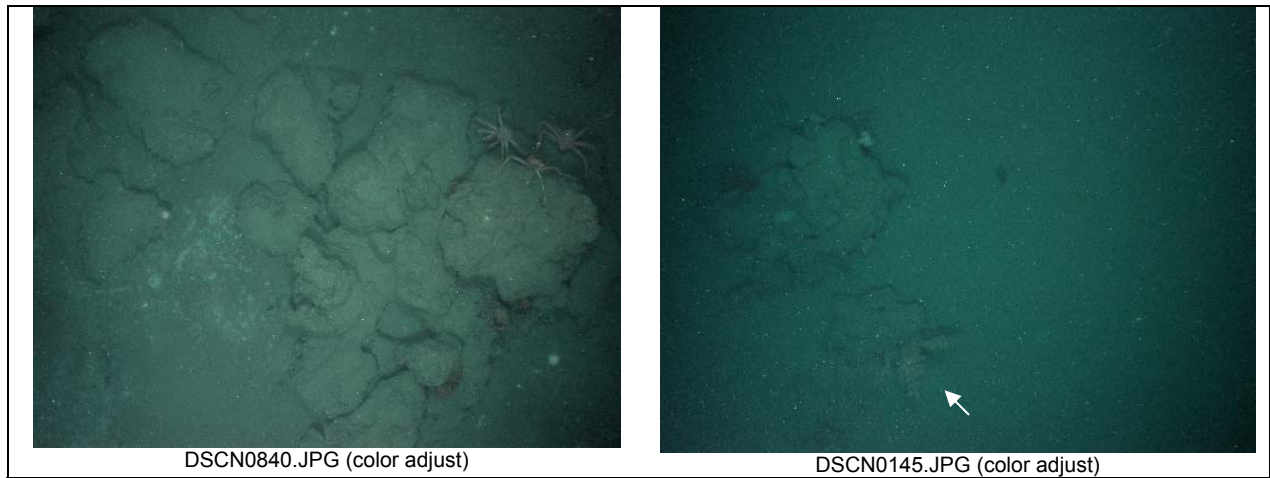


Figure 60. Representative photography from MC462.

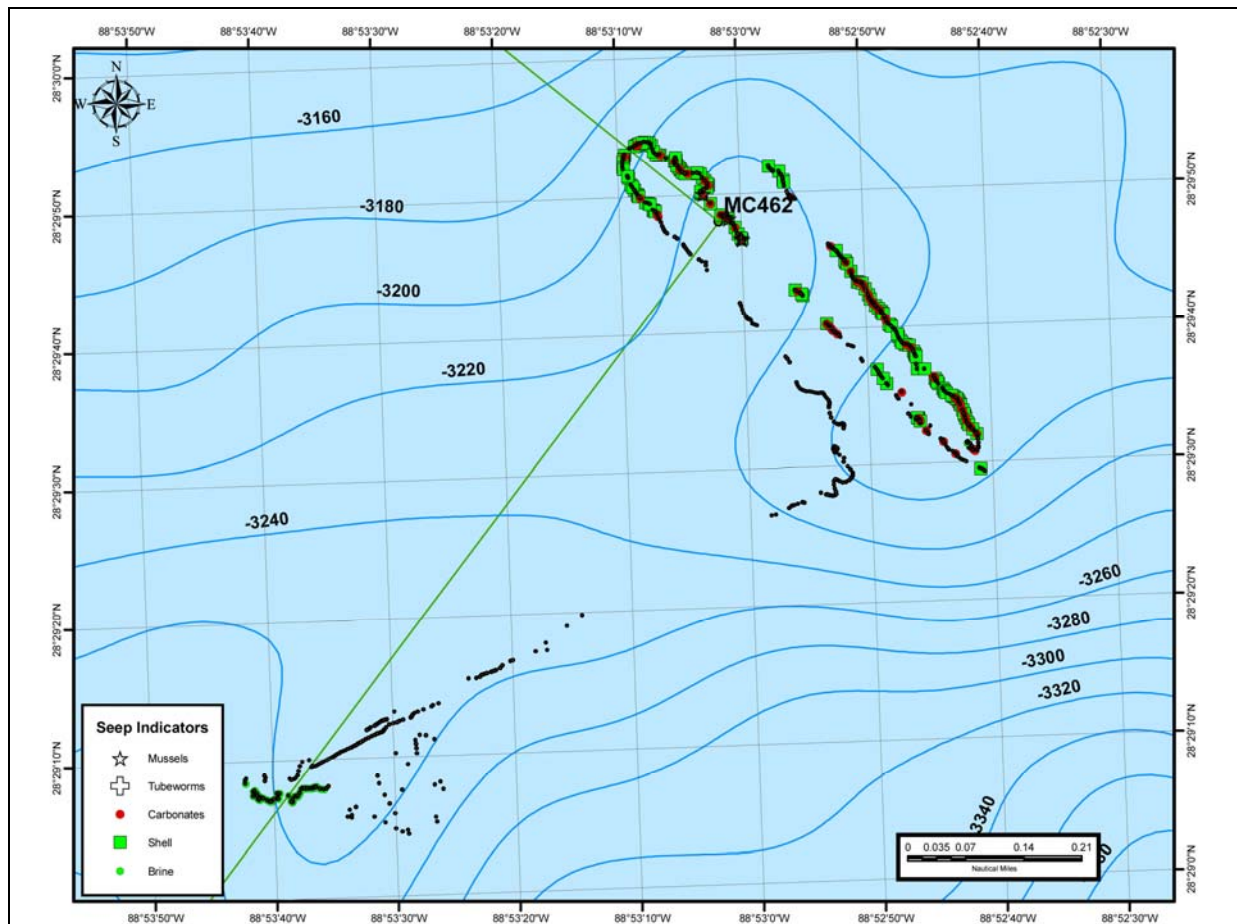


Figure 61. Survey results from MC462 station.

Mississippi Canyon 640

This site was a large, low-relief mound with numerous geophysical targets distributed across its crest. The DCS reached bottom at 00:50 on 20 March and collected images with a 12 second repeat rate until 04:11 hrs. Calmer seas and favorable winds provided good survey conditions. A total of 976 images were collected with the bottom in view and acceptable navigation. Many of these images occur in sequences that can be mosaicked to cover larger areas. This site showed only abundant chemosynthetic fauna—predominantly mussels. Carbonates were low, jointed pavements or solitary pieces. Bacteria were also seen associated with brine channels and near what appeared to be brine pools. Only one solitary cluster of tube worms was observed and this specimen was of an unusual growth form. Large areas of bottom were covered with very numerous, small tubes on open sediment. This site is a good candidate for further study (**Figures 62 and 63**).

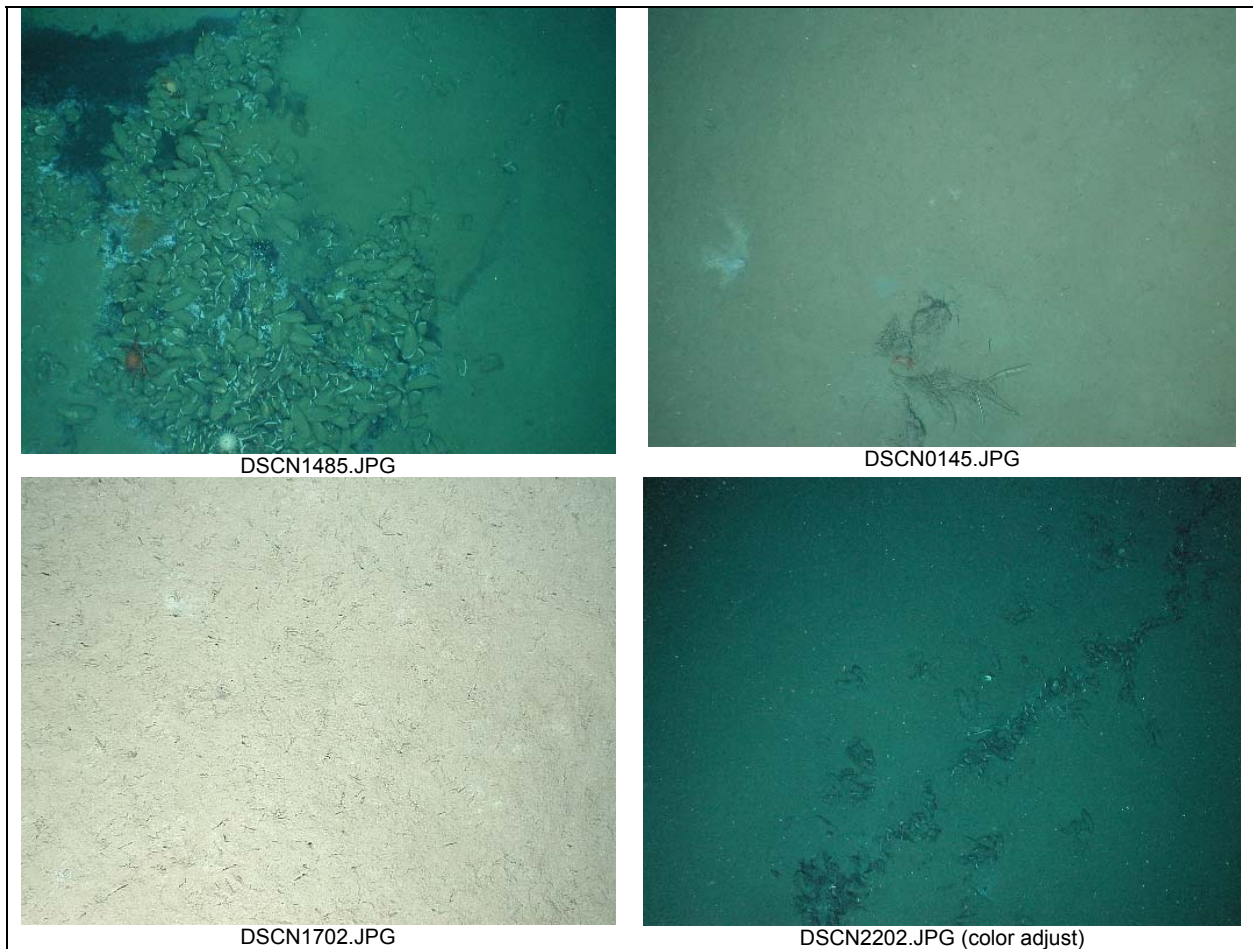


Figure 62. Representative photography from MC640.

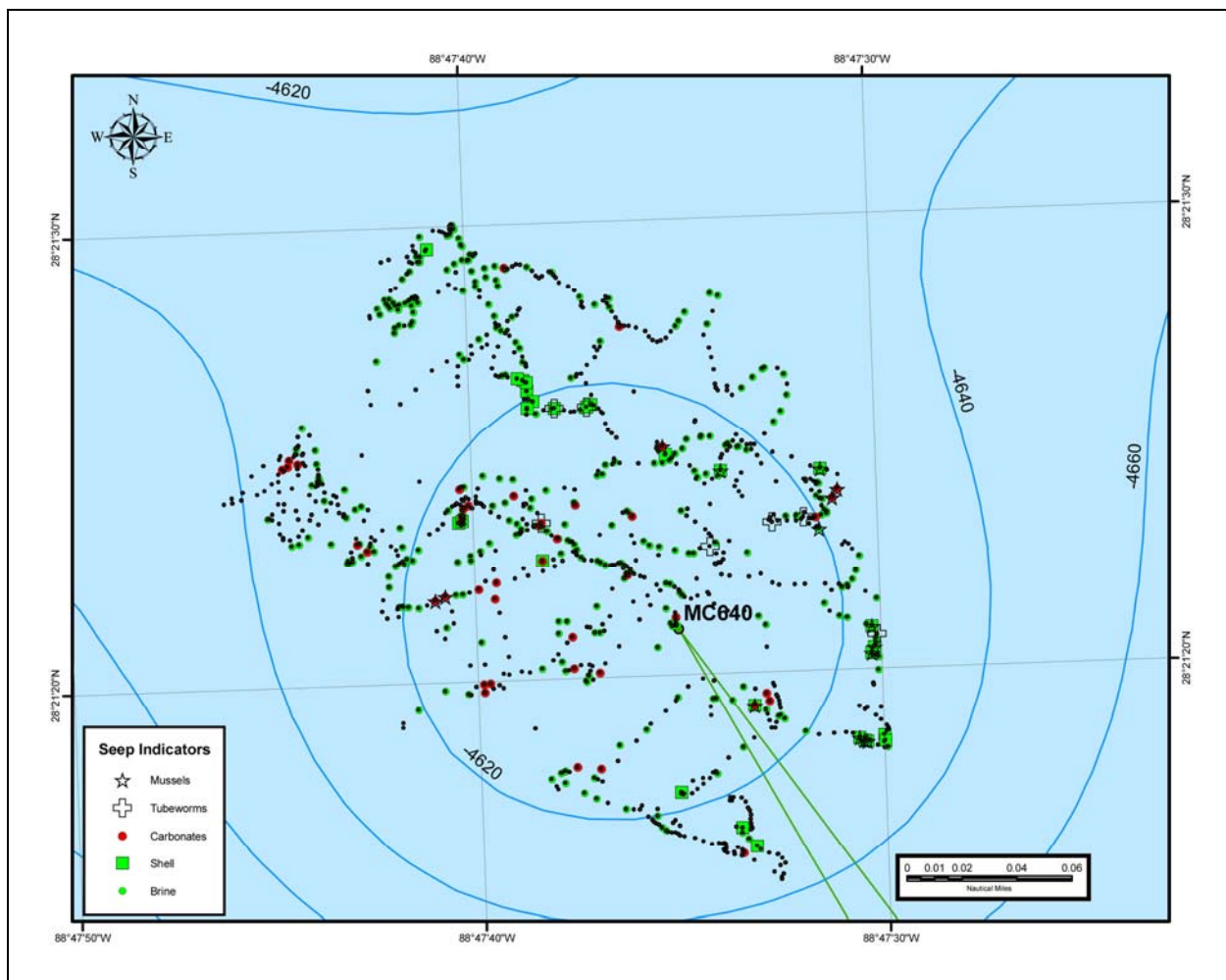


Figure 63. Survey results from MC640 station.

Atwater Valley 340

This site was two low-relief mounds with numerous geophysical targets distributed down-slope to the east with a depth of about 2,240 m. The DCS reached bottom at 14:20 hrs on 20 March and collected images with a 12 second repeat rate until 16:49 hrs. A total of 502 images were collected with the bottom in view and acceptable navigation. This site showed a high diversity of chemosynthetic fauna and habitat variations. Brine flows and channels were common. Carbonates included large boulders and solitary pieces. Tube worms occurred as individuals or tufts, but also as small bushes in one location. The community appears to be spread over a large area, implying that there may be yet more variability to discover. This site is an excellent candidate for further study (**Figures 64 and 65**).

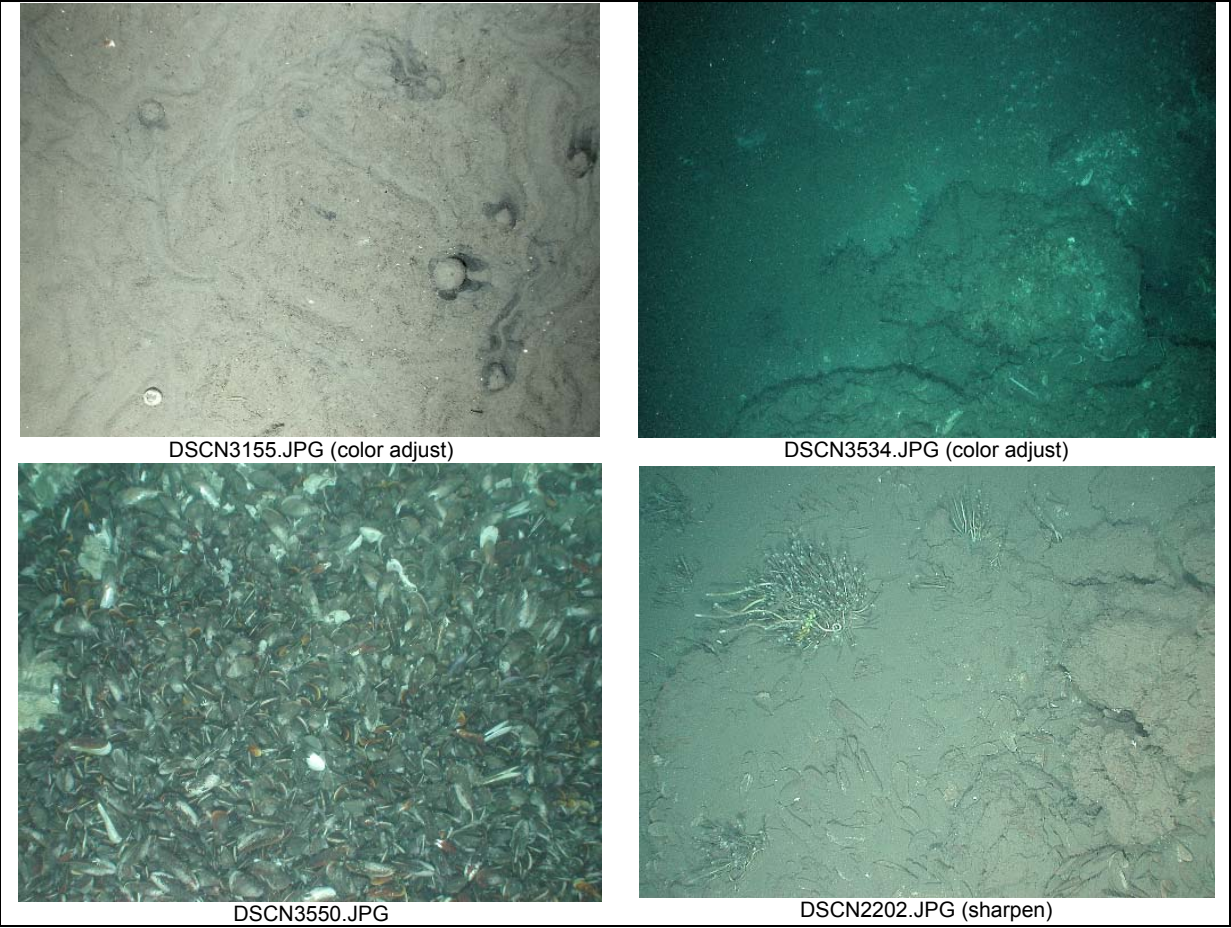


Figure 64. Representative photography from AT340.

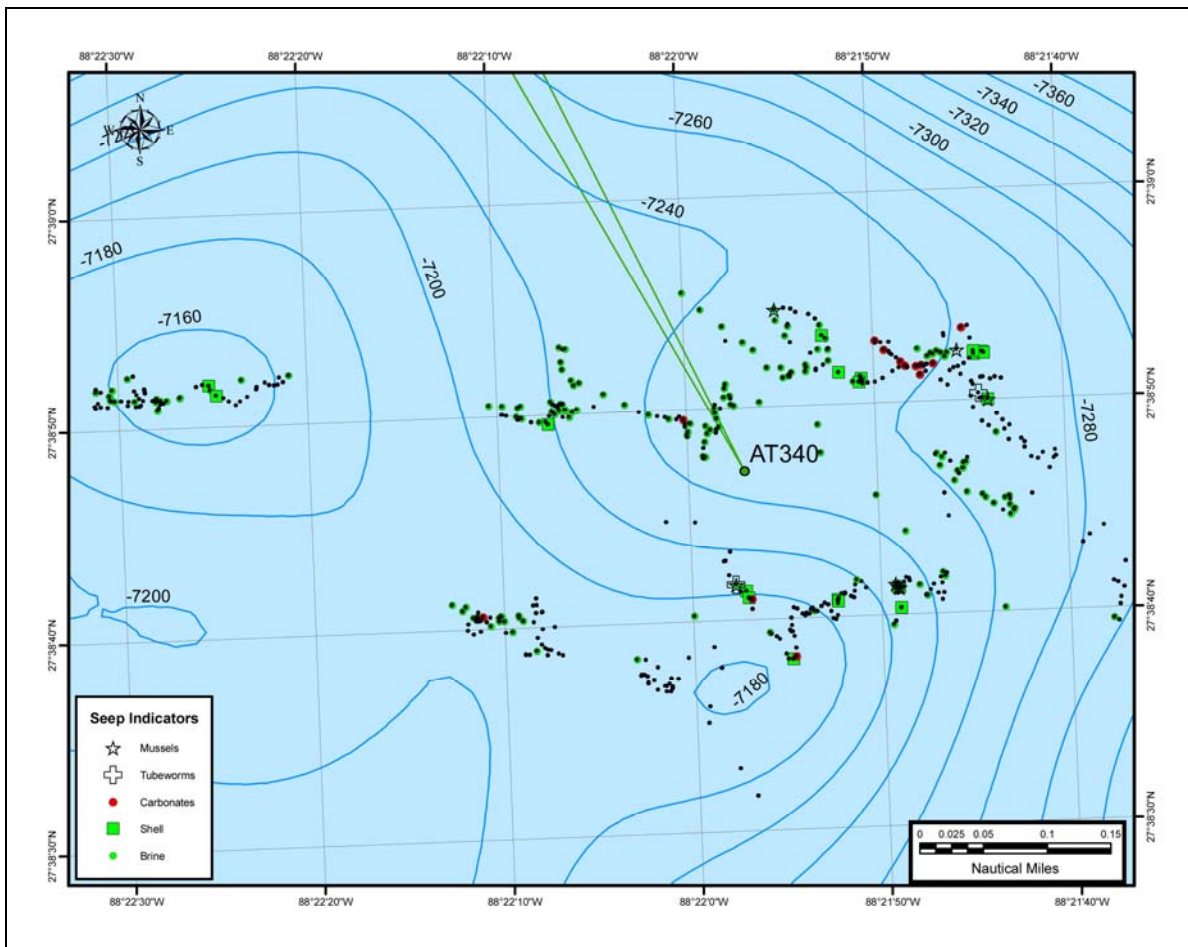


Figure 65. Survey results from AT340 station.

Atwater Valley 342

This site was a low-relief mound with numerous geophysical targets distributed to the east and west with a depth of about 2,375 m. This site was the deepest surveyed during the photo reconnaissance cruise. The DCS reached bottom at 14:20 hrs on 20 March and collected images with a 12 second repeat rate until 16:49 hrs. A total of 516 images were collected with the bottom in view and acceptable navigation. This site included at least two large brine pools with active mud flows and brine channels. Sediment slumping was widespread. Vesicomid clam shells were widespread, but few living individuals could be identified with certainty. Tube worms occurred as individuals. Mussels were common, but not locally dense. This site is a good candidate for further study (**Figures 66 and 67**).

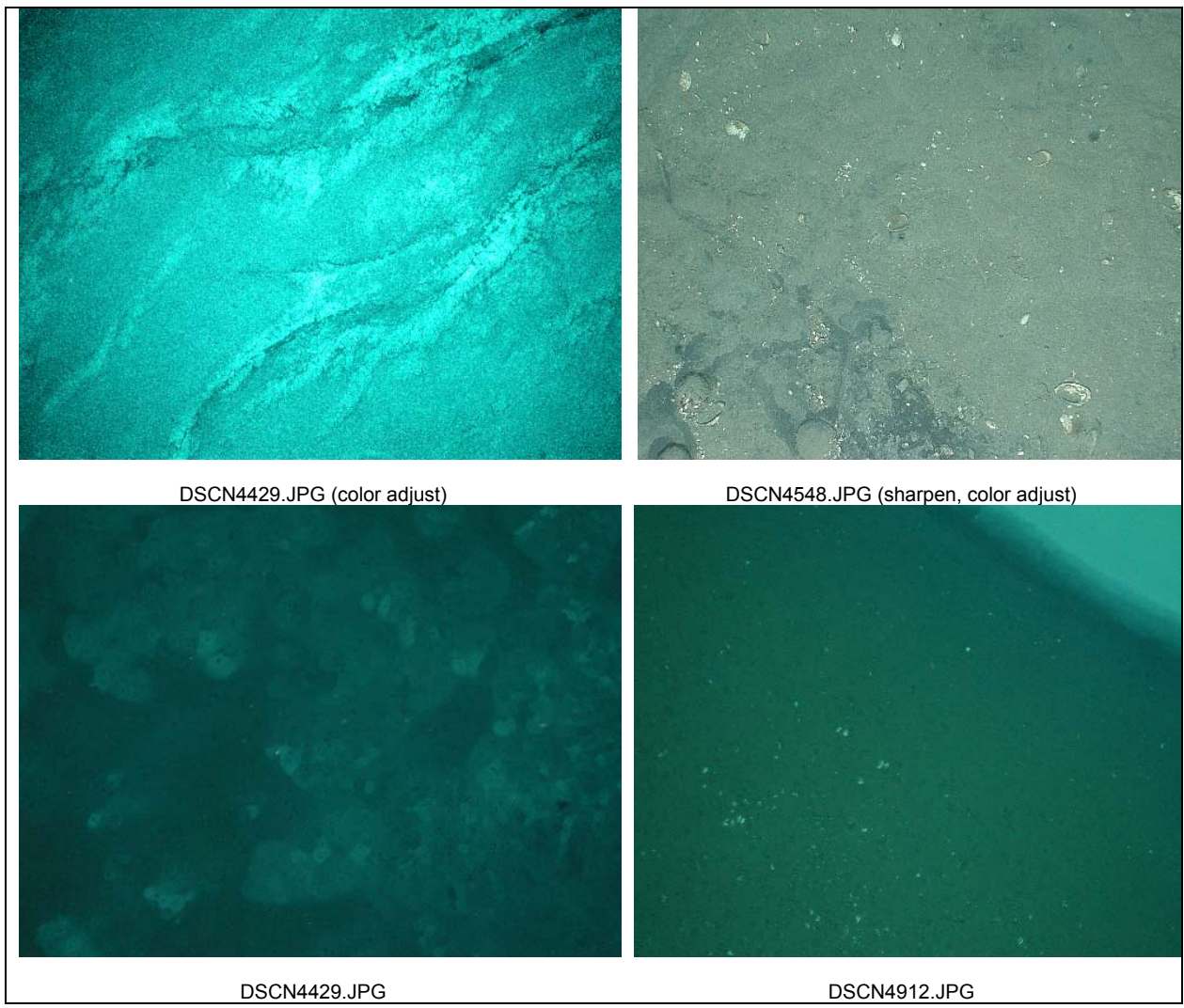


Figure 66. Representative photography from AT342.

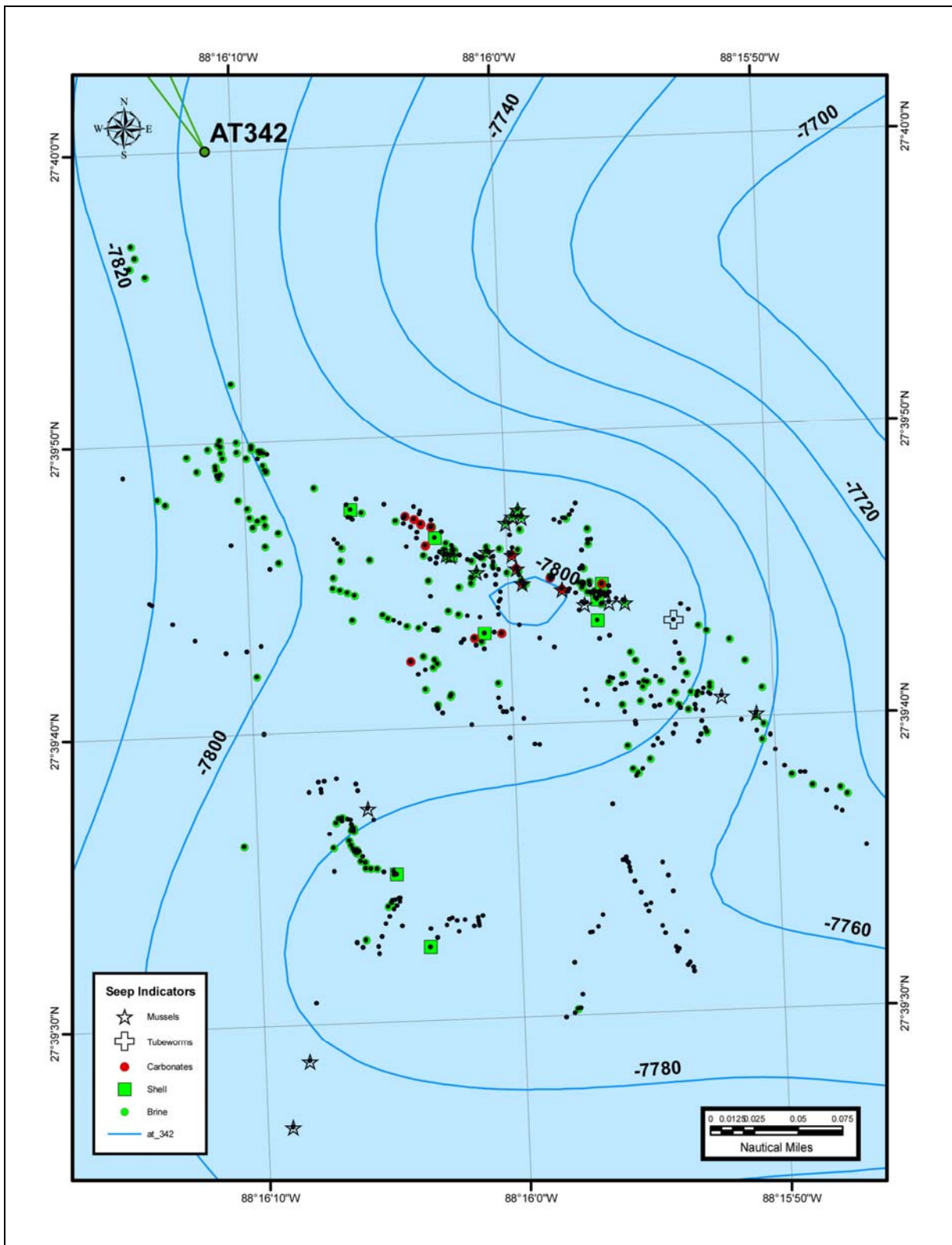


Figure 67. Survey results from AT342 station.

Green Canyon 868

This site was a series of geophysical targets distributed over a very steep slope over a depth range of 1,360 to 1,460 m. The steep slope and worsening sea conditions presented particular challenges to effective survey, so the survey track was limited to the upper portion of the escarpment. The DCS reached bottom at 18:16 hrs on 22 March and collected images with a 10 second repeat rate until 19:04 hrs when a minor power malfunction in the DCS prematurely ended the survey sequence. A total of 236 images were collected with the bottom in view and acceptable navigation covering the major part of the targeted area. The sediment here appeared unstable and subject to granular sorting saltation down the visibly steep slope. Apparent small brine flows were seen on upper portion of slope. Fauna included a few fish, an isopod, and several examples of stalked anemones attached to sediment boluses. This site is a poor candidate for further study (**Figures 68 and 69**).

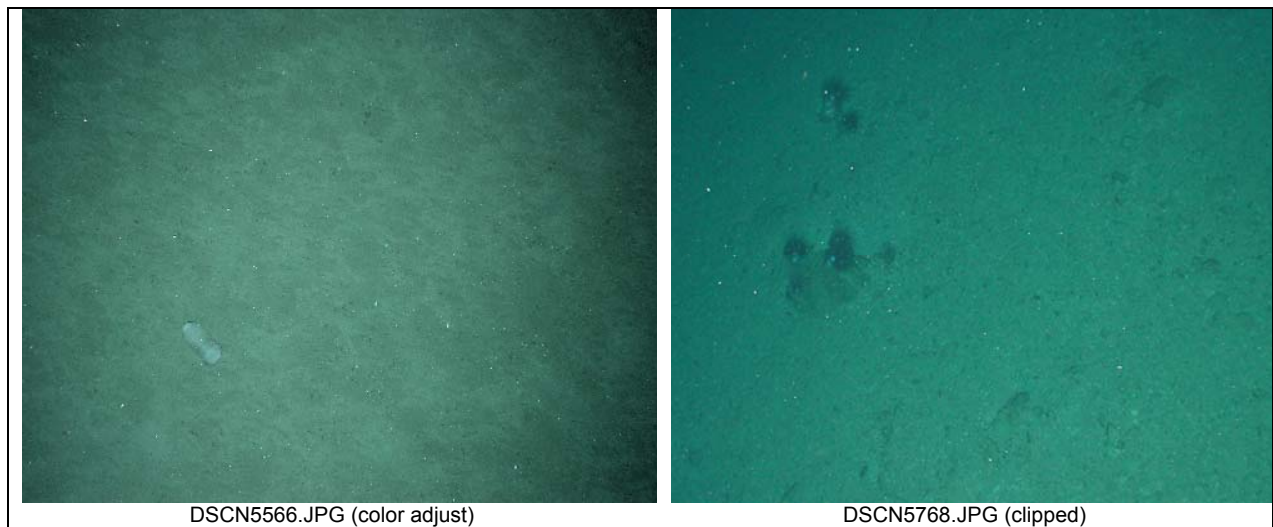


Figure 68. Representative photography from GC868.

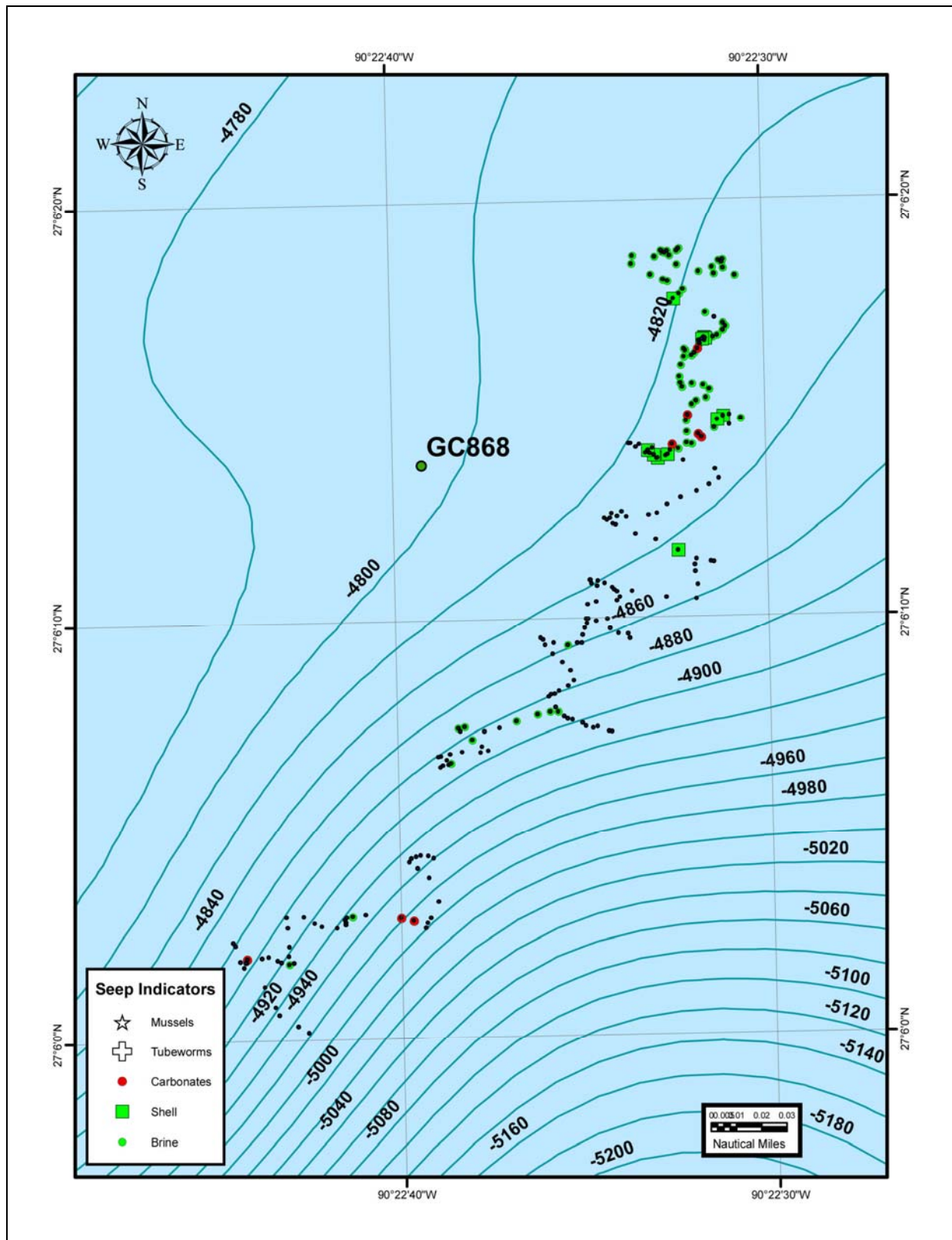


Figure 69. Survey results from GC868 station.

Walker Ridge 269/270

This site was a series of geophysical targets distributed over sloping terrain at a depth of about 1,950 m. The sea conditions were at the limit of what could be tolerated as can be seen from the very numerous bottom strikes where several images in a row would be obscured by sediments. The DCS reached bottom at 10:48 hrs on 23 March and collected images with a 10 second repeat rate until 13:11 hrs when a minor power malfunction in the DCS prematurely ended the survey sequence. A total of 467 images were collected with the bottom in view and acceptable navigation covering the major part of the targeted area. There were definitive indicators of seepage at this site including small, but widespread bacterial mats, shells, and several individual mussels. This site is a very marginal candidate for further study (**Figures 70 and 71**).

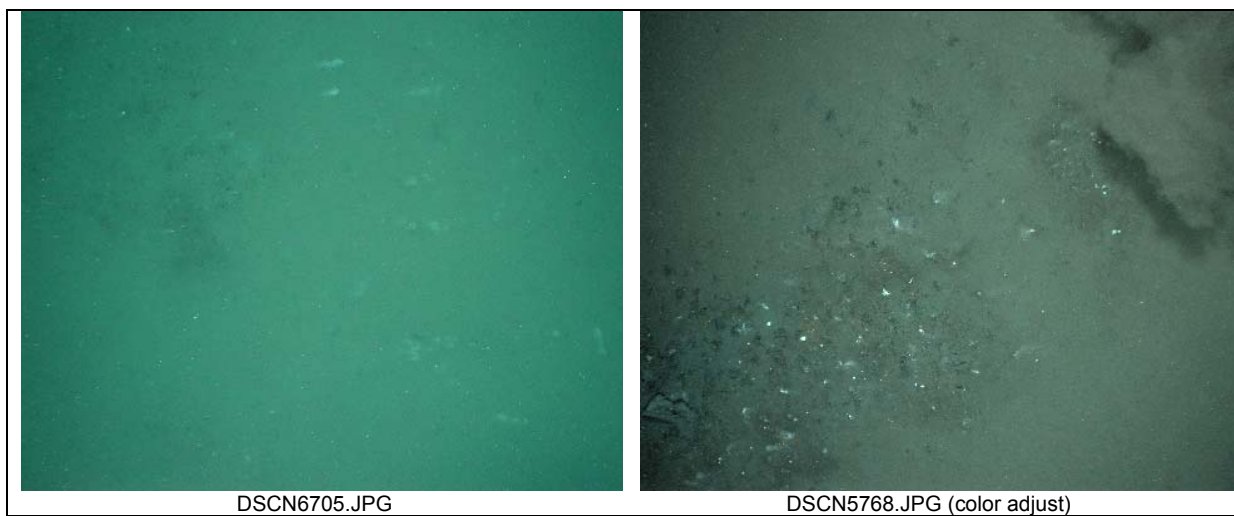


Figure 70. Representative photography from WR269/270.

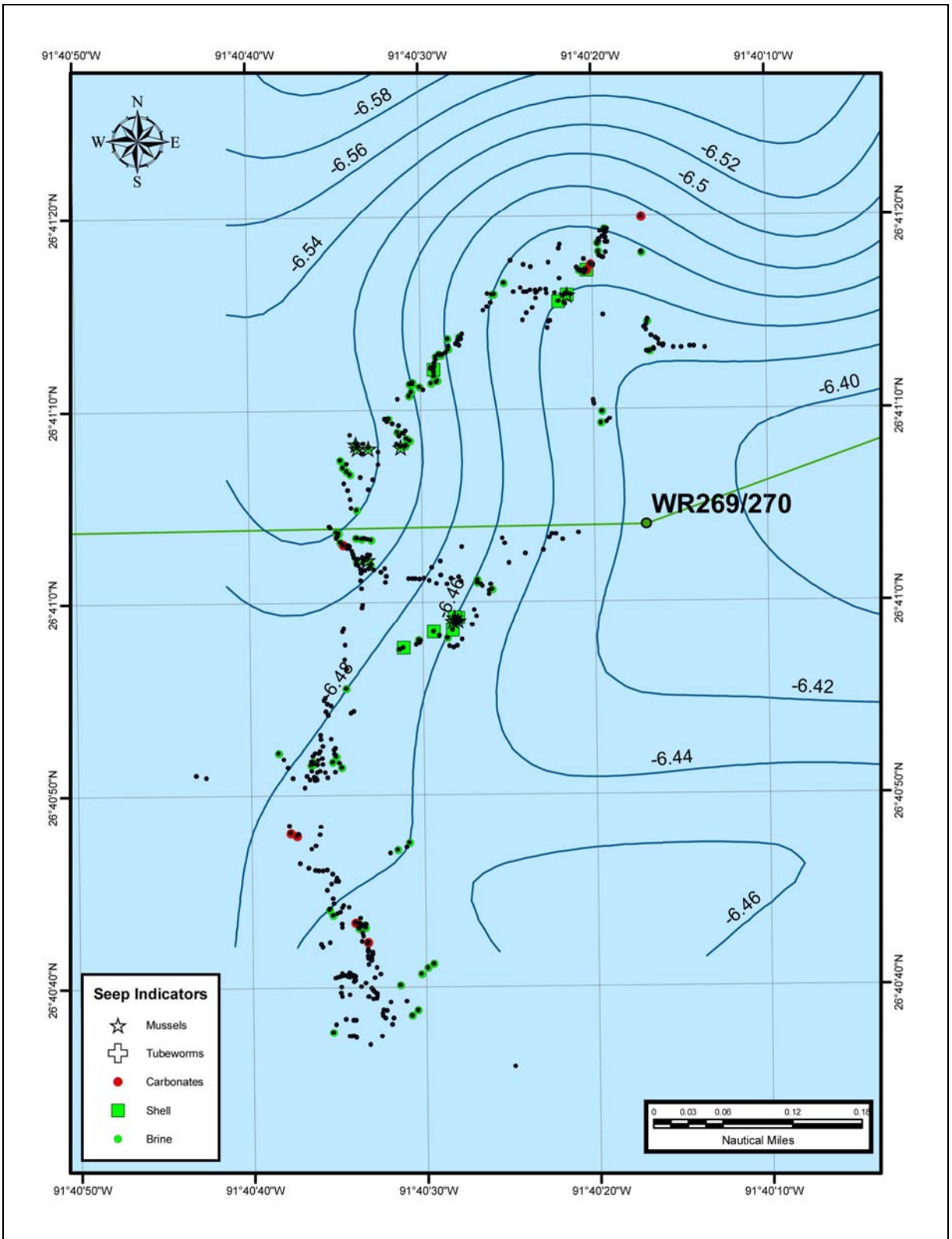


Figure 71. Survey results from WR269/270 station.

Walker Ridge 268

This site was a low mound with a tight focus of geophysical targets at about 1,860 m. Despite continued heavy seas, the survey was completed because the target was concentrated and the ship could hold station in a tight radius while the DCS covered the objectives. The DCS reached bottom at 22:50 hrs on 23 March and collected images with a 10 second repeat rate until 00: 56 hrs on 24 March. A total of 523 images were collected with the bottom in view and acceptable navigation covering the major part of the targeted area. There were widespread indicators of sparse seepage at this site including small bacterial mats, shells, and individual tubes. Some of these “tubes” were probably sea whips misclassified as tube worms, but others appeared to be solitary pogonophorans. This site is a very marginal candidate for further study. This was the final station in the photo reconnaissance cruise (**Figures 72 and 73**).

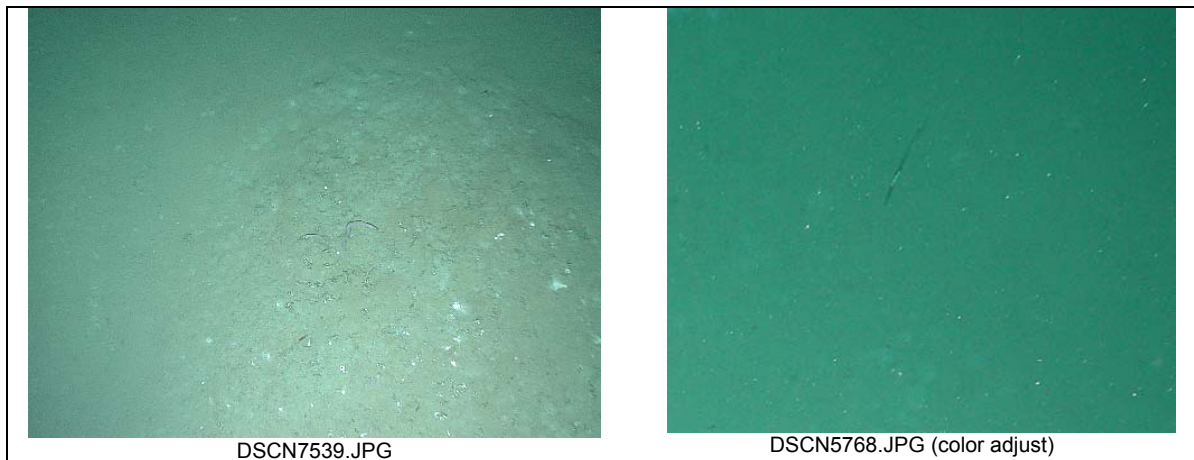


Figure 72. Representative photography from WR268.

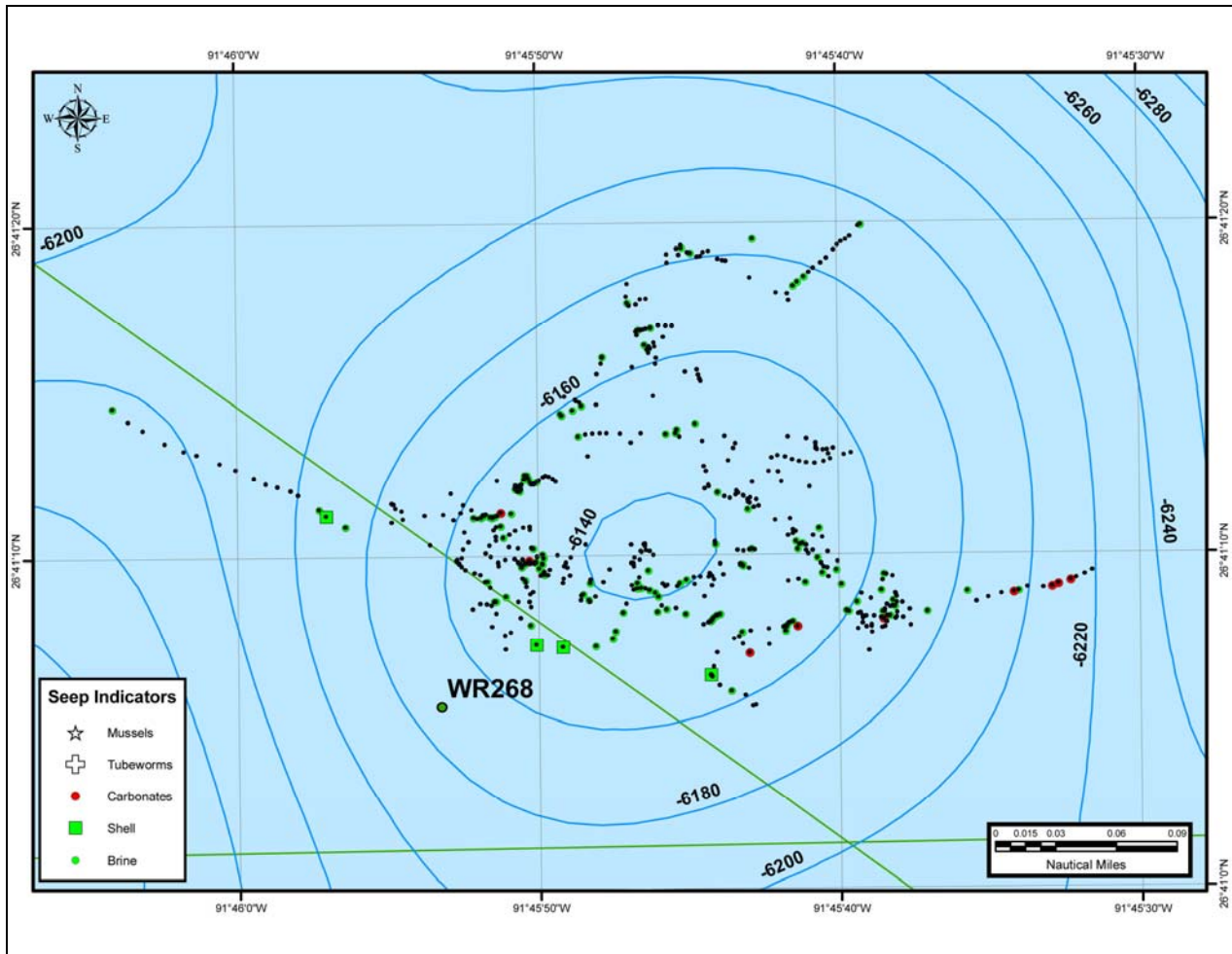


Figure 73. Survey results from WR268 station.

DIVE SUMMARY – DCCC CRUISE ALVIN

Twenty four dives were completed on ALVIN. At some sites, multiple dives were made while at other sites only a single dive was completed. **Table 30** and **Figure 74** summarize the ALVIN dive activity. Detailed dive information is presented on the pre-dive planning (**Appendix 9**) samples collected (**Appendix 10**), dive activities (**Appendix 11**).

Table 30.

Dive Summary

DIVE_NUM	Site	Depth(m)	Date	Time	Lat Mean	Lon Mean
4173	AT340	2,216	5/9/2006	14:59	27.64532147	-88.36397849
4174	GC600	1,250	5/10/2006	14:04	27.37043846	-90.56947755
4175	WR269	1,950	5/11/2006	16:20	26.68598286	-91.66054682
4176	KC243	1,610	5/12/2006	14:29	26.73075164	-92.83065783
4177	GC852	1,450	5/13/2006	15:27	27.10628141	-91.16609942
4178	MC853	1,070	5/14/2006	14:35	28.12471393	-89.14148176
4179	AT340	2,200	5/15/2006	14:47	27.64507002	-88.36439901
4180	AT340	2,200	5/16/2006	16:45	27.64477891	-88.36475654
4181	AT340	2,200	5/17/2006	16:22	27.64648744	-88.36891570
4182	MC640	1,410	5/18/2006	15:37	28.35677424	-88.79270267
4183	AT340	2,175	5/19/2006	14:58	27.64634439	-88.37037384
4184	GC600	1,250	5/20/2006	14:25	27.36961335	-90.56930234
4185	GC852	1,410	5/21/2006	14:45	27.10911676	-91.16565528
4186	GC852	1,410	5/22/2006	15:56	27.10614074	-91.16601572
4187	GC852	1,410	5/23/2006	14:19	27.11026061	-91.16568461
4189	GC852	1,410	5/24/2006	16:39	27.11002842	-91.16590412
4190	GC852	1,410	5/25/2006	14:33	27.10836764	-91.16621835
4191	WR269	1,950	5/26/2006	15:25	26.68606157	-91.66147458
4192	AC818	2,740	5/27/2006	16:34	26.18030207	-94.62308449
4193	AC601	2,340	5/28/2006	14:27	26.39123684	-94.51446418
4194	AC645	2,240	5/29/2006	14:32	26.35448427	-94.49977357
4195	AC818	2,740	5/30/2006	14:42	26.18026385	-94.62294105
4196	AC601	2,330	5/31/2006	15:11	26.39164934	-94.51394832
4197	AC645	2,200	6/1/2006	14:29	26.35403655	-94.49670376

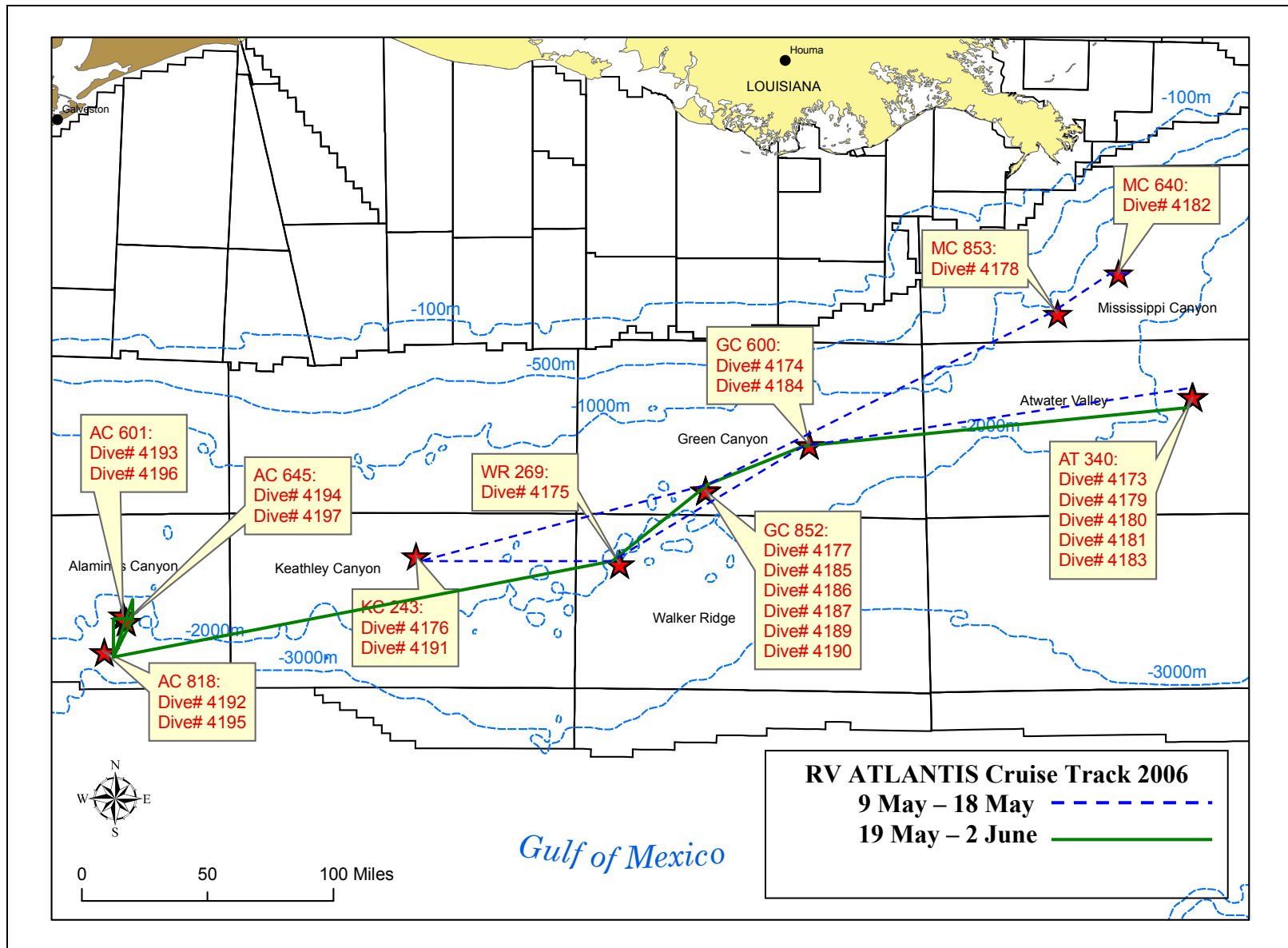


Figure 74. Site locations of ALVIN dives.

DCC CRUISE – SITE CHARACTERIZATION

The following section describes site characteristics and geological settings of the dive site locations visited during the cruise. Dive maps showing ALVIN’s track and sampling locations, as well as representative photographs, are presented as individual figures at each site. The 10 dive sites are discussed in the chronological order visited, although later dives could have been made at the same site (**Table 31**).

Table 31.

Sites Characterized Listed in Chronological Order

Site	DIVE_NUM	Depth(m)	Date	Time	Lat Mean	Lon Mean
AT340	4173	2,216	5/9/2006	14:59	27.64532147	-88.36397849
AT340	4179	2,200	5/15/2006	14:47	27.64507002	-88.36439901
AT340	4180	2,200	5/16/2006	16:45	27.64477891	-88.36475654
AT340	4181	2,200	5/17/2006	16:22	27.64648744	-88.36891570
AT340	4183	2,175	5/19/2006	14:58	27.64634439	-88.37037384
GC600	4174	1,250	5/10/2006	14:04	27.37043846	-90.56947755
GC600	4184	1,250	5/20/2006	14:25	27.36961335	-90.56930234
KC243	4176	1,610	5/12/2006	14:29	26.73075164	-92.83065783
GC852	4177	1,450	5/13/2006	15:27	27.10628141	-91.16609942
GC852	4185	1,410	5/21/2006	14:45	27.10911676	-91.16565528
GC852	4186	1,410	5/22/2006	15:56	27.10614074	-91.16601572
GC852	4187	1,410	5/23/2006	14:19	27.11026061	-91.16568461
GC852	4189	1,410	5/24/2006	16:39	27.11002842	-91.16590412
GC852	4190	1,410	5/25/2006	14:33	27.10836764	-91.16621835
MC640	4182	1,410	5/18/2006	15:37	28.35677424	-88.79270267
MC853	4178	1,070	5/14/2006	14:35	28.12471393	-89.14148176
WR269	4175	1,950	5/11/2006	16:20	26.68598286	-91.66054682
WR269	4191	1,950	5/26/2006	15:25	26.68606157	-91.66147458
AC818	4192	2,740	5/27/2006	16:34	26.18030207	-94.62308449
AC818	4195	2,740	5/30/2006	14:42	26.18026385	-94.62294105
AC601	4193	2,340	5/28/2006	14:27	26.39123684	-94.51446418
AC601	4196	2,330	5/31/2006	15:11	26.39164934	-94.51394832
AC645	4194	2,240	5/29/2006	14:32	26.35448427	-94.49977357
AC645	4197	2,200	6/1/2006	14:29	26.35403655	-94.49670376

Atwater Valley 340

Geologic Summary of Atwater Valley 340

The AT340 dive site is geologically characterized as a bathymetric high along the eastern extension of Mississippi Canyon where it transitions from a canyon to a submarine fan. The site consists of three mounded areas on top of the overall bathymetric high. Geophysical data indicate that the feature is supported by salt in the shallow subsurface. Seismic profiles identify a clear vertical migration pathway for the flux of fluids and gases to the modern seafloor. This pathway is defined by acoustic blanking of the seismic record, suggesting both reflection of acoustic energy by hard bottom conditions at the surface and perhaps gas in the subsurface along the migration route. The surface reflectivity maps, created by analyzing the first return from the seafloor from 3D seismic data, indicate high reflectivity in the areas localized around the three mounded features. Five dives have been made on the overall AT340 feature. Three dives concentrated on the local mounded area in the SE quadrant. On the 3D seismic surface reflectivity maps, this area displayed a complex pattern of high to moderate reflectivity. Observations from ALVIN confirm extensive hard bottom conditions that result from authigenic carbonate precipitation, a by-product of microbial utilization of seeping hydrocarbons. Inspection of these carbonates reveals that they contain abundant mussel shells. In addition, carbonate precipitation occurs around the bases of tubeworm bushes. Scattered among the blocks and pavements of authigenic carbonate are living mussel beds and tube worm colonies. One site named the “mussel brick road” represents an elongate (about 75 m long) and densely packed bed of living mussels forming in a joint or separation in the underlying authigenic carbonate pavement. Between the blocks of carbonates, clumps of tubeworms, and beds of mussels are patches of sediment colonized by urchins (**Figure 75**), a few soft corals, and other sparsely distributed organisms.

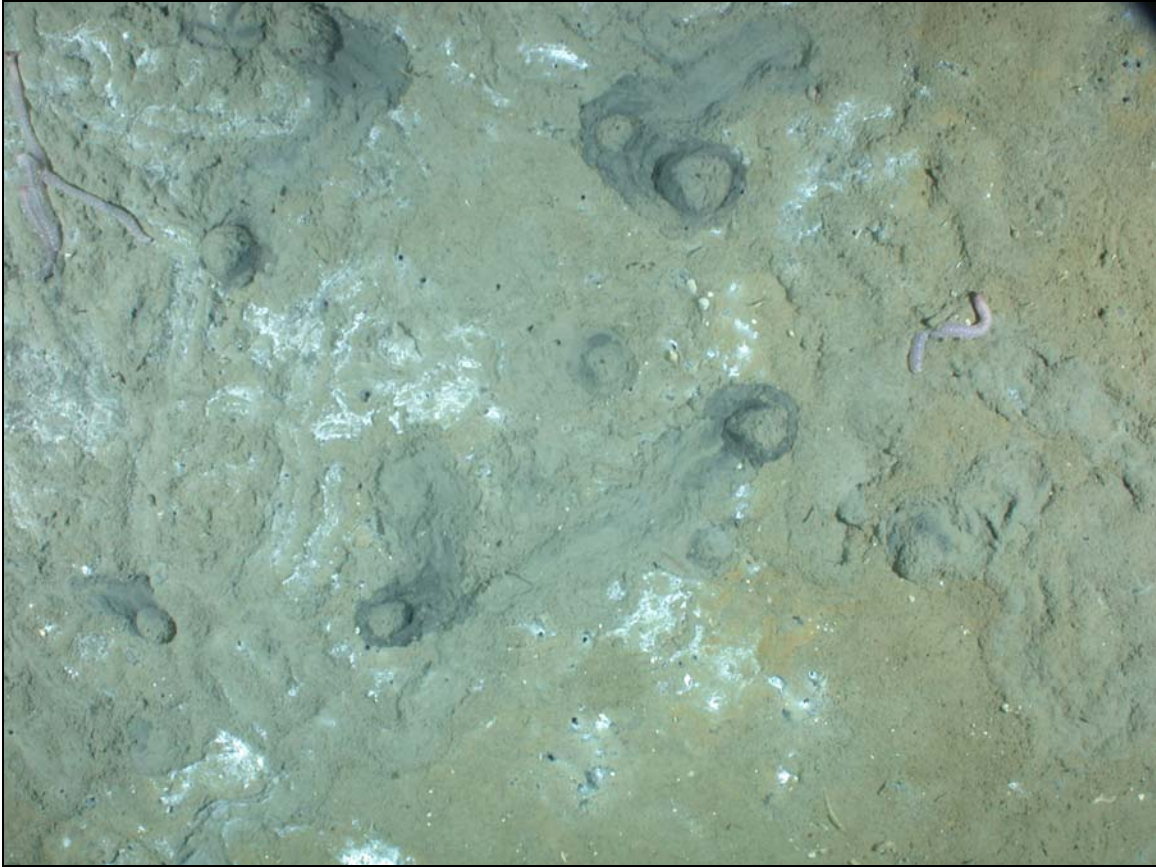


Figure 75. Urchins were abundant in portions of the AT340 site.

In the NW quadrant of the AT340 study area, a distinct mound occurs. On surface reflectivity maps derived from 3D seismic data, this mound stands out as a very high amplitude feature. Two dives on this feature confirm the fact that it is composed almost entirely of hard bottom. Inspection of the areas of lithified seafloor shows that the carbonate block and pavements (**Figure 76**) are composed almost entirely of mussel shells, one layer on top of another.

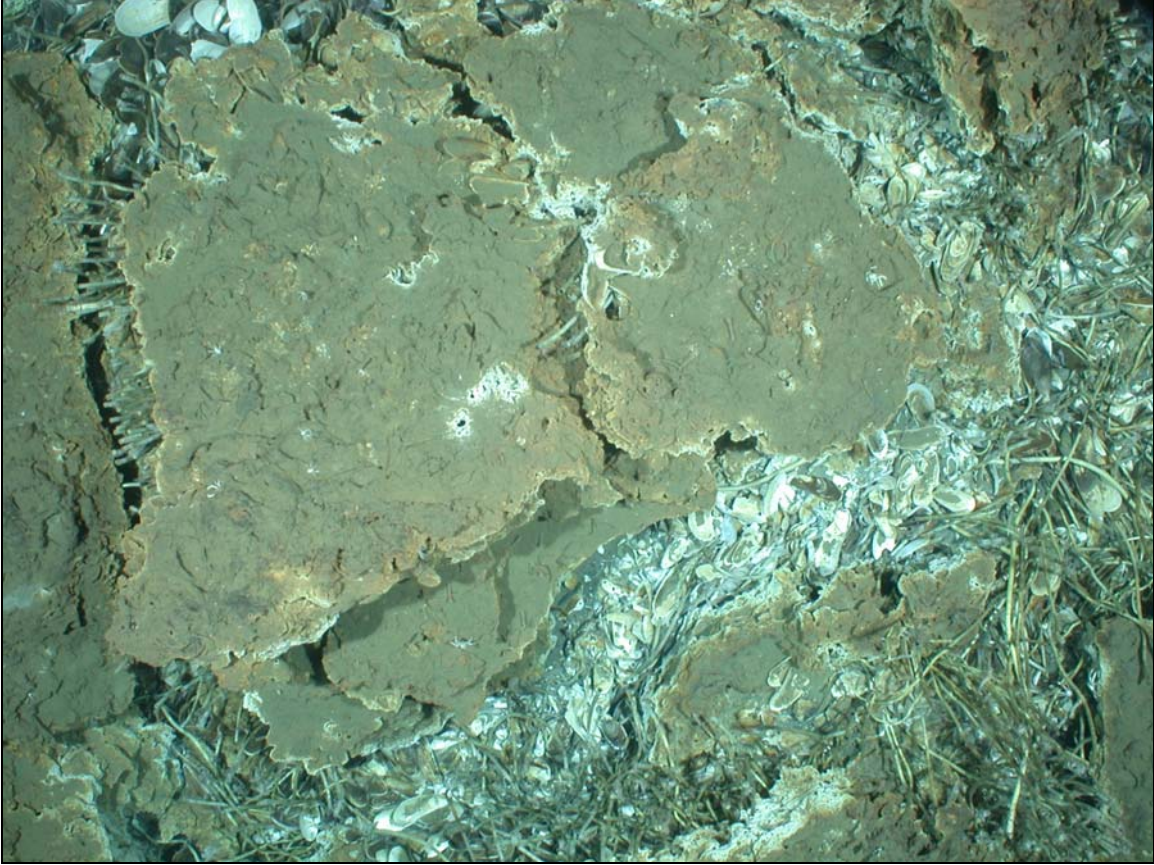


Figure 76. Extensive carbonate pavements indicate protracted seepage.

Because of this unique construction we named the site “mussel mound.” Many blocks seemed to have very little sediment matrix, just mussel shells and binding carbonate cements. Although most of the mussel shells did not house live mussels, several patches of live mussels were observed at the apex of the mound. Both the crest areas and flanks of the mound were covered with tubeworms. Many tubeworm colonies occurred beneath and at the edges of carbonate blocks, but free-standing colonies were also present. To the east and off the flank of the mound a brine vent is present. Fluidized sediment, brine, and hydrocarbons are being vented at this site (Figure 77).

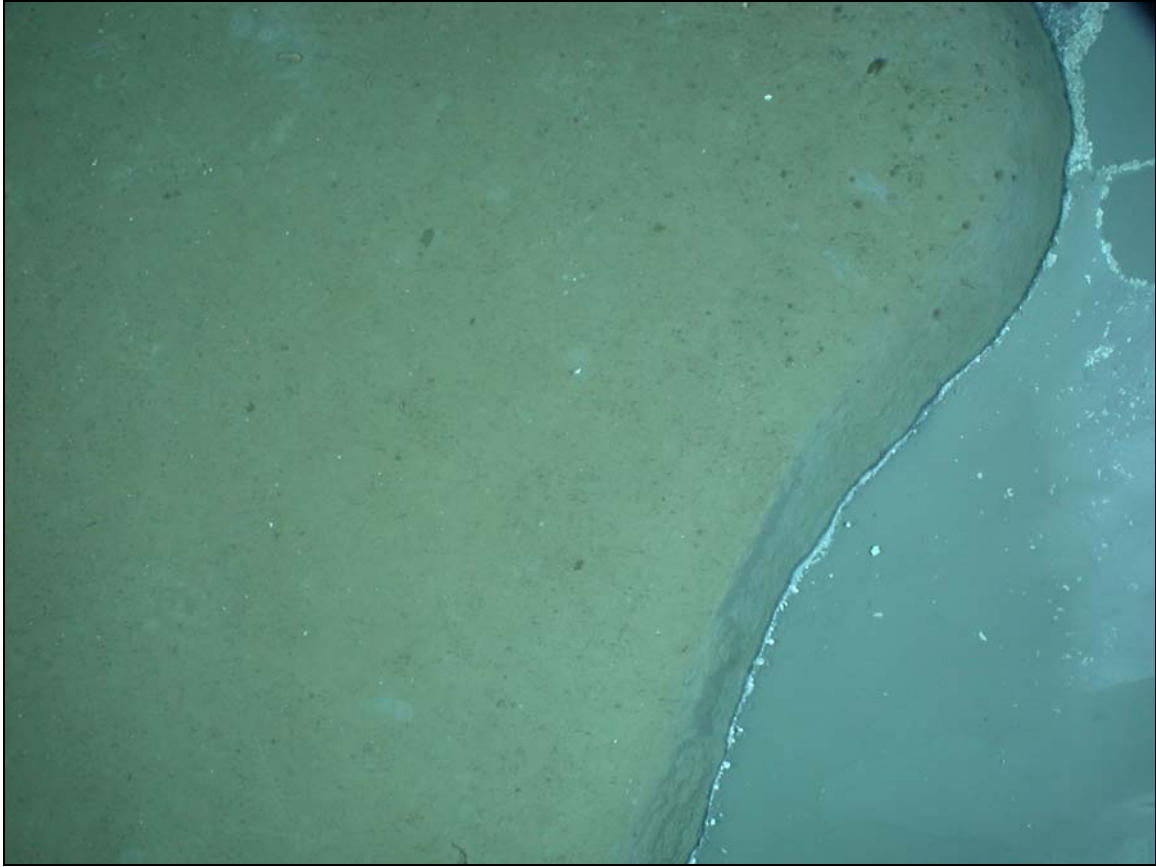


Figure 77. Surface brine flows generate extensive pools and channels that support mussel aggregations at AT340.

Around the vent site and along the flow field there are extensive mussel beds. Seismic profiles across the AT340 feature indicate the presence of salt in the relatively shallow subsurface. The brine is likely coming from the dissolution of this salt body.

Site Summary - Atwater Valley 340

Atwater Valley 340 is a large and complex site with abundant and varied chemosynthetic communities spread over a relatively large area. It has the largest mussel beds of any site yet visited. Two of these were especially spectacular. One is a solid bed of mixed species and sizes of live mussels that we estimate is over 10 m wide and 20 m long, and we nicknamed “Brooksi Banks” (**Figure 78**). The other was a relatively continuous linear bed over 70 m in length that was nicknamed the “Mussel Brick Road.” Both of these were imaged intensively enough to allow almost complete photographic reconstruction of the entire features.

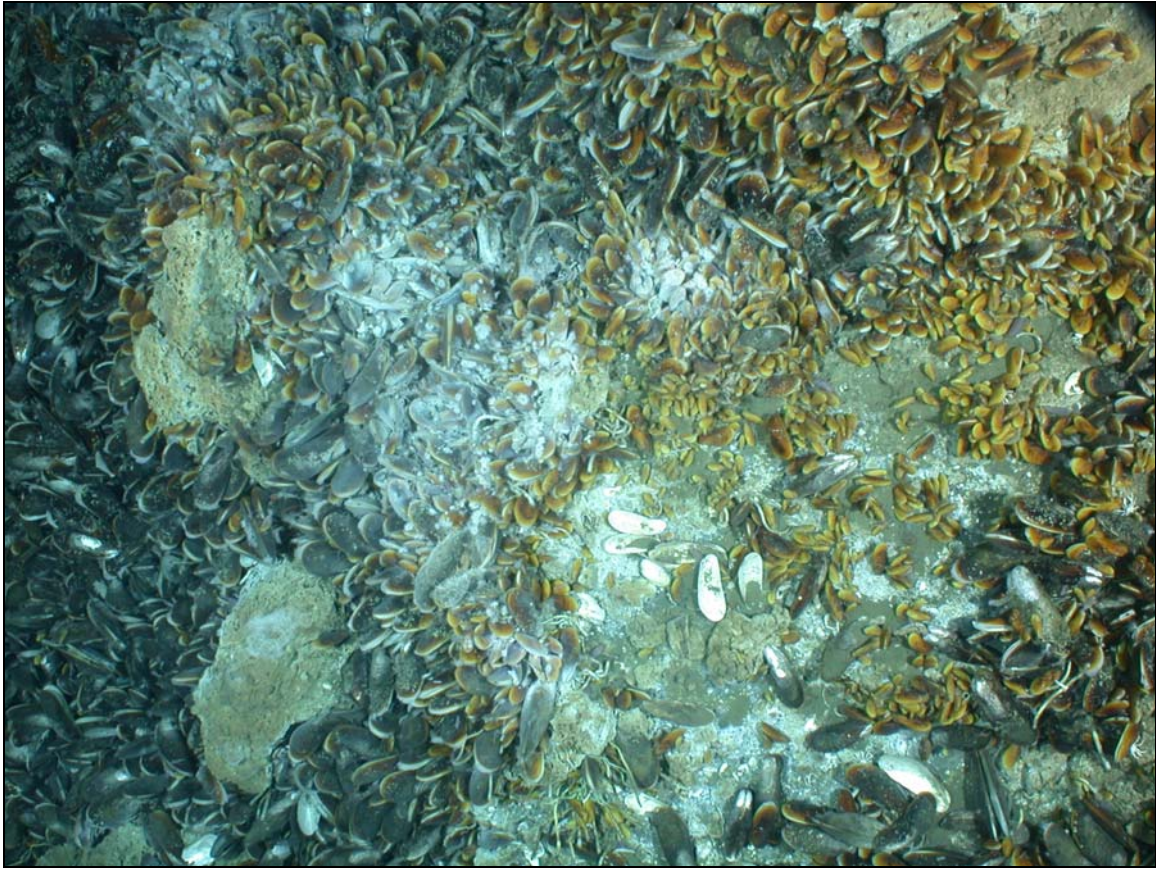


Figure 78. This down-cam image shows two species of seep mussels in a dense bed.

Further detailed study of these beds will be especially informative, as this is the one site where we have collected both *B. heckerae* and *B. brooksi*, the two bathymodioline mussels that harbor both methanotrophic and chemoautotrophic symbionts. It appears from the pictures that *B. childressi* is also present in the large mussel bed, but confirmation will await sampling this bed in 2007. Both of these features are in the SE quadrant of the site. There are patchy small mussel aggregations (of large individuals) in the NE quadrant, and scattered intermediate sized mussel beds near the topographic high in the far W edge of the site and in the bottom of what appears to be 2 m diameter blowout craters in that area.

Tubeworms are also very abundant at this site. They occur in large numbers among the large carbonate slabs in the SE and W portions of the site. *Escarpia laminata* is the dominant species in the aggregations (“bushes”) sampled and appears to be dominant in most of the aggregations seen. However, *Lamellibrachia* sp is also quite abundant; as large individuals and in small groups protruding from underneath and between carbonate slabs and in mixed aggregations with *E. laminata*. In addition to two large areas with abundant tubeworms, several smaller ridges with carbonates were also colonized by both species.

The most dominant megafauna species associated with the tubeworm aggregations was the shrimp *Alvinocaris muricola*. This shrimp species was also abundant in the mussel collections,

co-occurring with the abundant brittle star *Ophioctenella acies* in this habitat. The *B. heckeriae* that were collected also contained the commensal polychaetes *Branchipolynoe seepensis* and a nautilinellid. A large proportion of the *E. laminata* collected contained a phyllodocid polychaete that is likely a blood-sucking parasite.

Another animal that was abundant (and dominant) in some areas of soft sediment with visual evidence of seep impact was a spatangid heart urchin. Several (at least five) beds of these were found over the course of the five dives to this site. None of these beds were associated with carbonates, but some were close to the other sites or isolated mussel clumps. In areas where the sediments around the urchins were stained black and white, the urchins did not appear to be moving much. In areas where seepage was less apparent, there were often long trails associated with the urchins.

Few colonial cnidarians were seen at this site. However small gorgonian colonies were present near the scattered mussel beds in the NE quadrant of the site and noted on the carbonates in the W edge. Isolated whip corals were present in many areas. In some areas a small colonial anemone was abundant on tubeworm tubes and dead mussel shells. Individual anemones were often noted over non-seep affected sediments and a small crab with an orange anemone was a regular site in the vicinity of the active seep areas as was anthropogenic debris (**Figure 79**). Five dives were completed at AT340. **Figures 80-84** show activities and dive track of ALVIN.



Figure 79. Anthropogenic debris like this monofilament line was common at AT340.

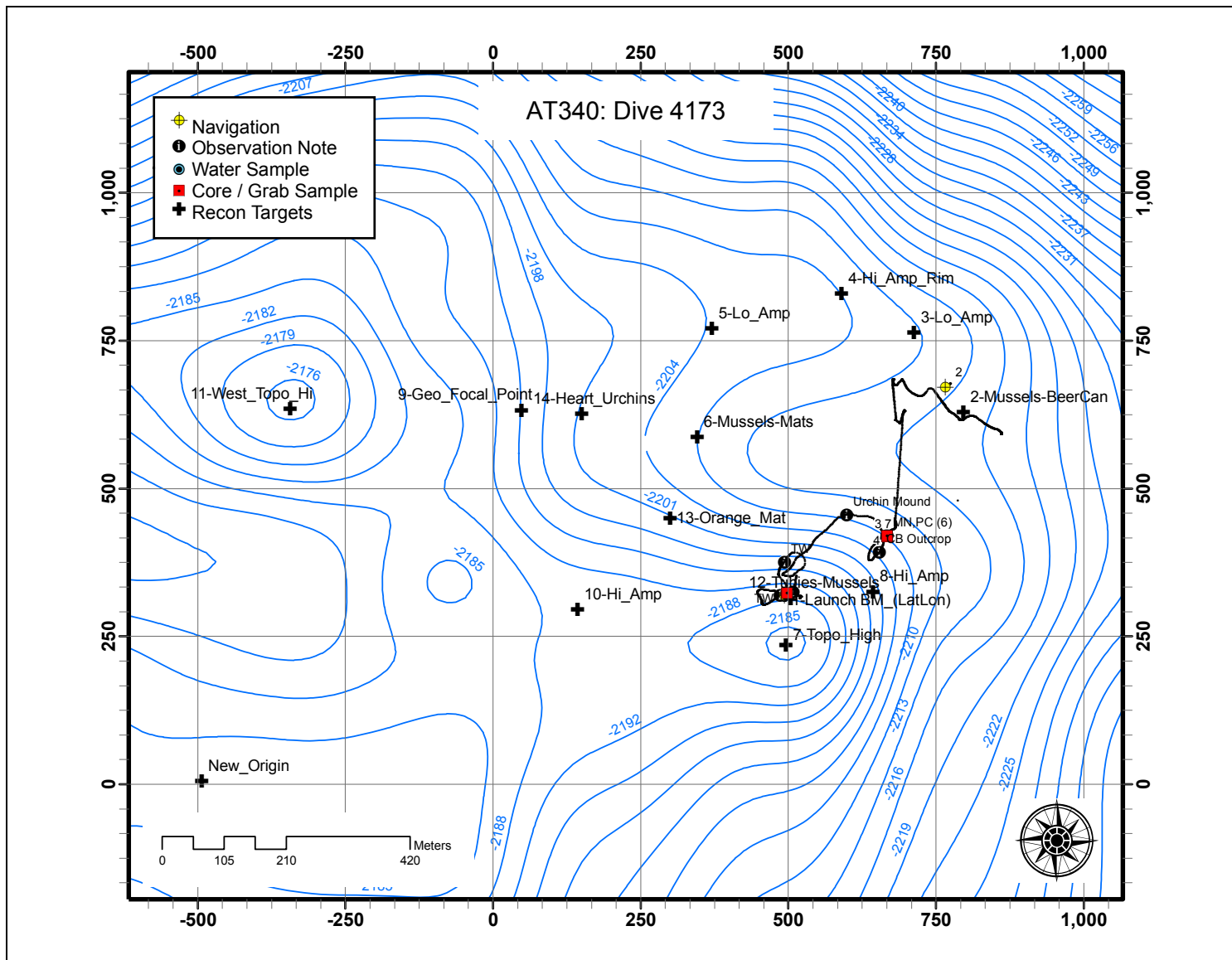


Figure 80. Dive 4173 on 5/9/2006 at an average depth of 2,216 m.

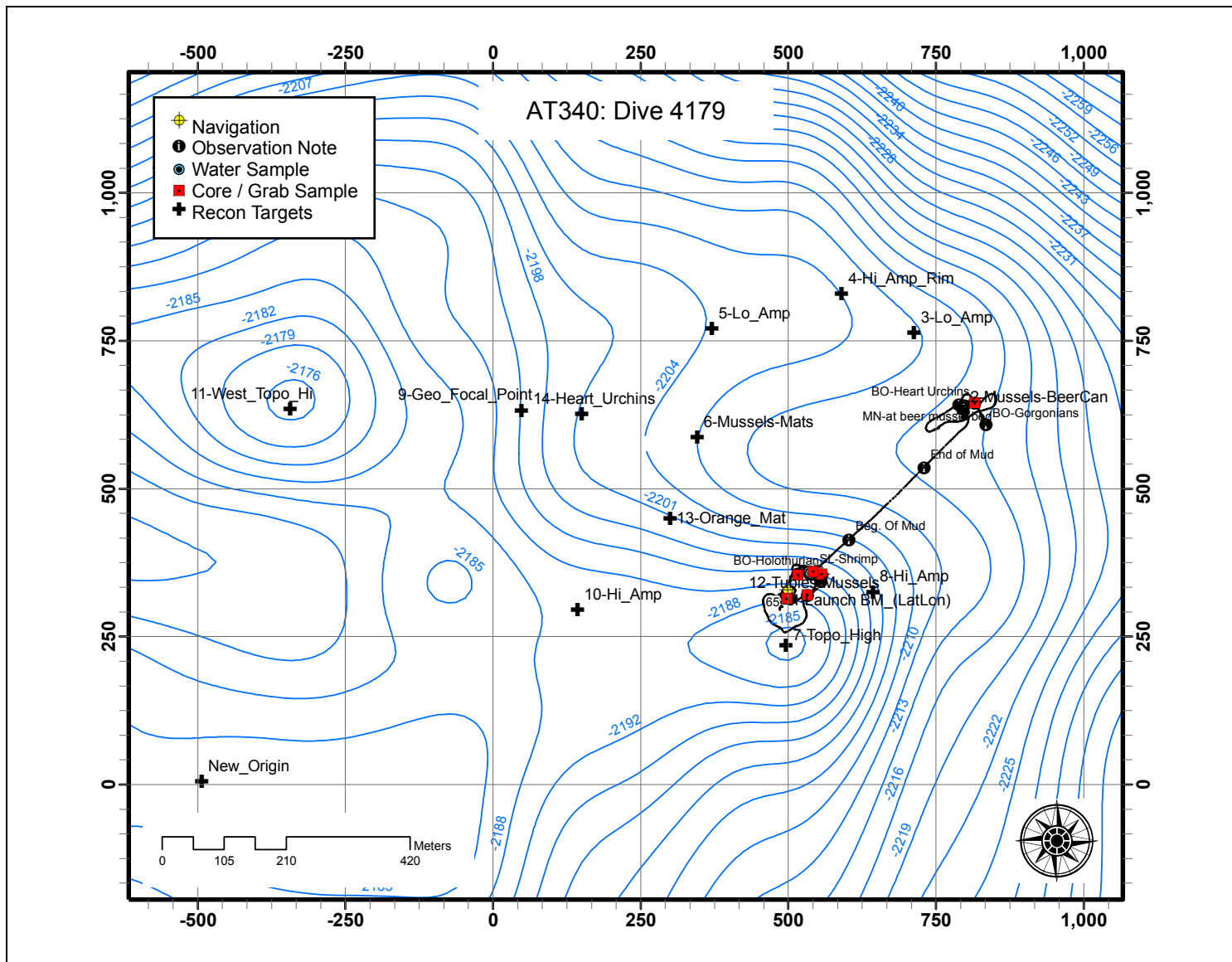


Figure 81. Dive 4179 on 5/15/2006 at an average depth of 2,200 m.

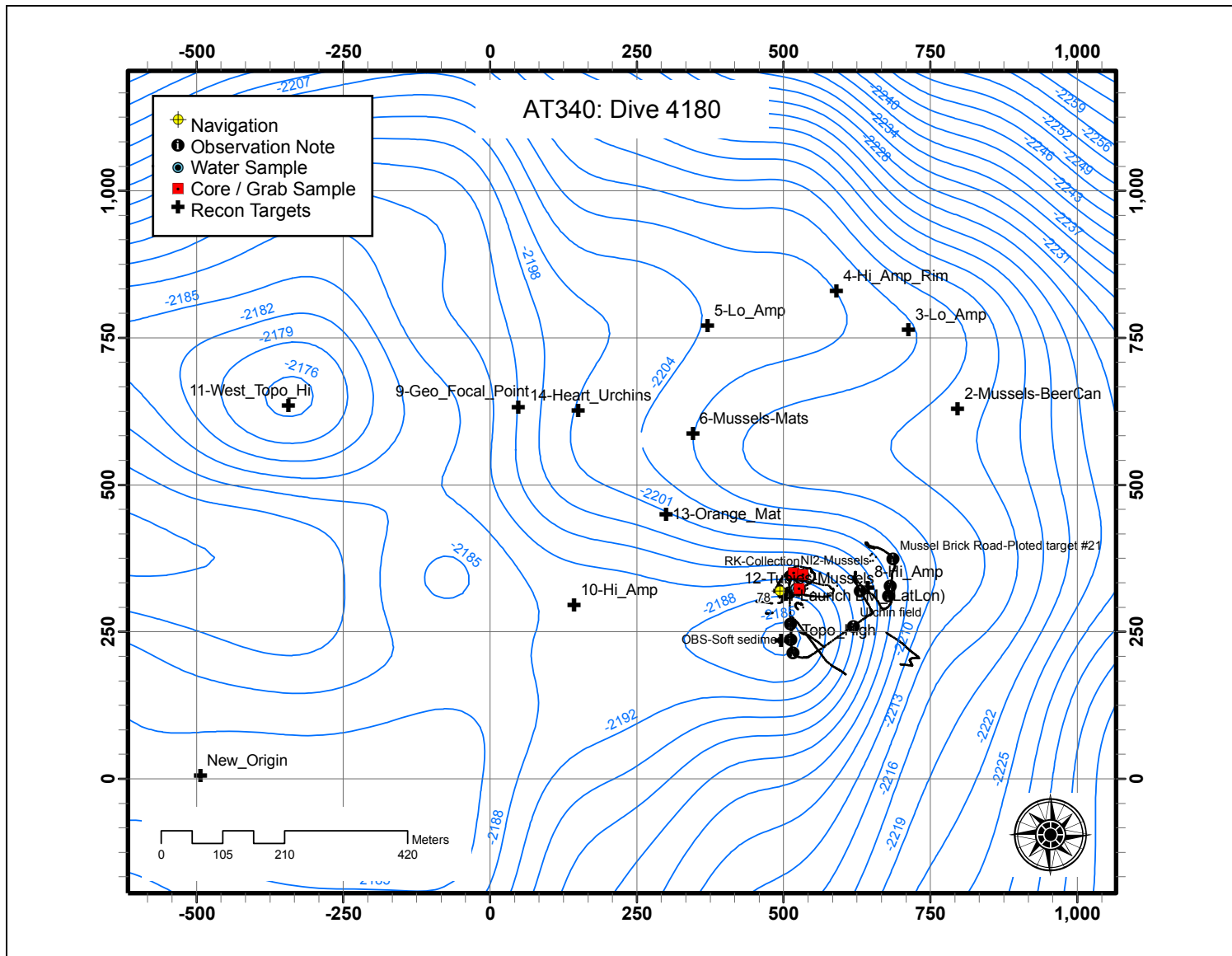


Figure 82. Dive 4180 on 5/16/2006 at an average depth of 2,200 m.

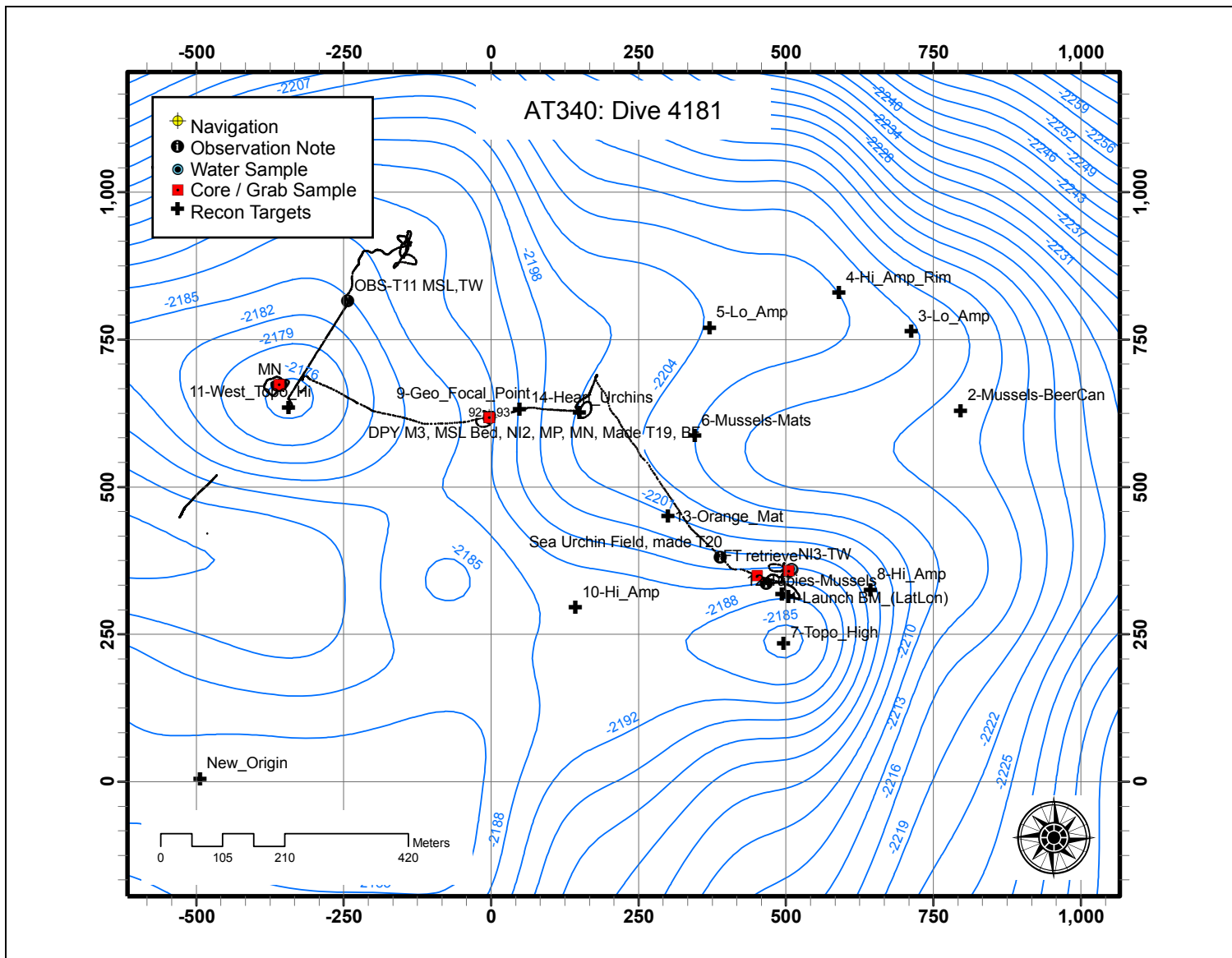


Figure 83. Dive 4181 on 5/17/2006 at an average depth of 2,200 m.

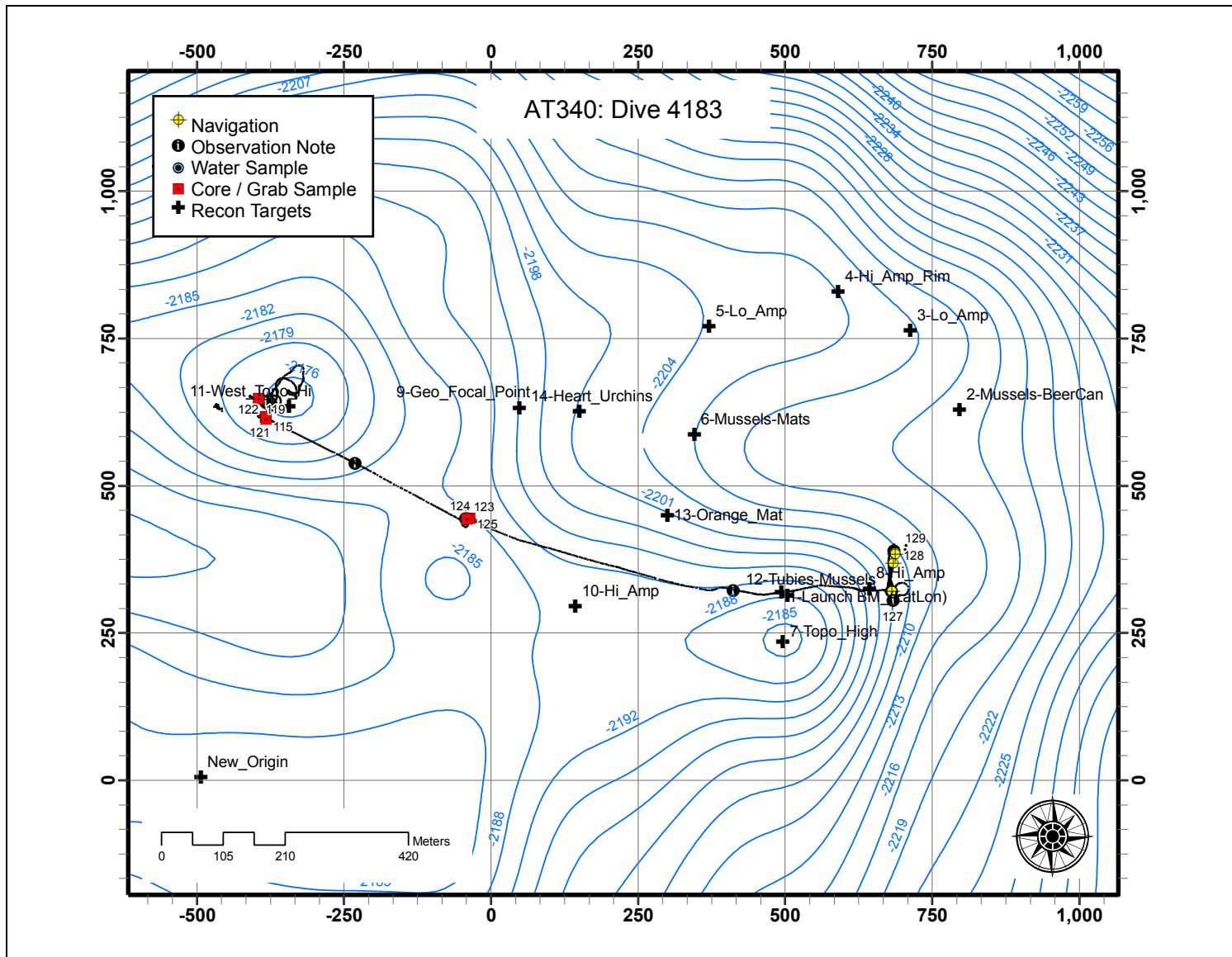


Figure 84. Dive 4183 on 5/19/2006 at an average depth of 2,175 m.

Green Canyon 600

Site Summary - Green Canyon 600

Depth 1,170-1,200 m, explored during ALVIN Dives 4174 and 4184, surveyed during the survey cruise.

Previous data: The GC600 site was selected for consideration as an ALVIN dive site based on several lines of evidence, including characteristics determined from seismic data, the presence of persistent oil slicks on radarsat data, and photo reconnaissance. The site is located in a water depth of approximately 1,180 m on the upper-middle Continental Slope. The overall geometry of the area of interest is an elongate NW-SE trending ridge that separates two intraslope basins. The 3D seismic surface reflectivity maps and accompanying seismic profiles suggest that this is an area of very active expulsion of fluids and gases from the deep subsurface. Clear migration pathways are visible on the seismic profiles and radarsat images of this part of the Gulf show persistent oil slicks originating from the GC600 site. Two areas of high surface reflectivity occur at this site, and these were the objective of the ALVIN dives. The area of complex surface reflectivity anomalies to the NW center around a localized bathymetric high, the apex of which occurs at a water depth of approximately 1,177 m. The second area of high amplitude surface reflectivity anomalies occur to the SE and is also a localized mound, but with very subtle bathymetric relief.

Summary of Dive Observations

This site extends along a NW-SE axis, with about 1 km between the tubeworm area (NW) and the clams and mussel pockmarks (SE), Bench Marker 2 (X264, Y912) in the tubeworm area and Ian marker 5 (X1426, Y167) in the SE pock-mark area with clams and mussels.

Geology

Direct observational data from both photo reconnaissance work using a drift camera system and the ALVIN confirms the geologic and biologic complexity of the area. In the areas of high surface reflectivity mapped from seismic data, massive hydrocarbon seep-related carbonate hardground pavements and isolated blocks occur (**Figure 85**).

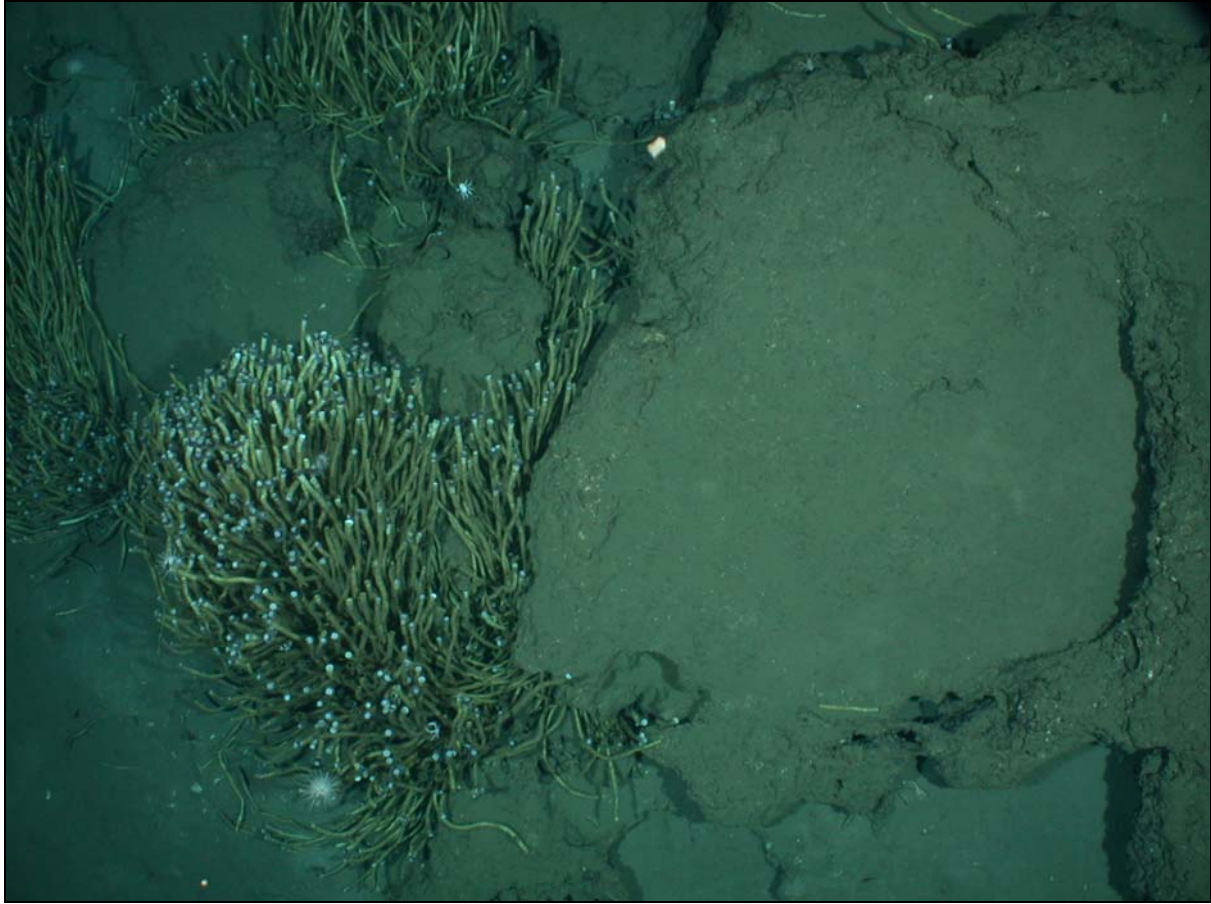


Figure 85. Massive carbonates and sparse tubeworms are characteristic of GC600.

Gas was observed bubbling through cracks in the carbonates on ALVIN Dive 4174. Patches of tubeworms and mussels were observed growing out of fissures in the carbonate pavements. *Beggiatoa* mats and small coverings around open burrows, both white and orange, occurred throughout the area where pockets of sediment occurred between areas of hardground. Pockmarks were observed, some with crude oil bubbling out. Although there were few living communities found, mussel and clam shells littered the area of both mound-like anomalies. Cnidarians (sea pens, sea feathers, and anemones) were observed on the hard substrates.

This site corresponds to a low ridge, with carbonate outcrops at the NW corner, and pockmarks over most of the area. Some small carbonate outcrops sometimes present on the rims of the pockmarks. Due to time limitations, we did not explore the topographic high point. Target 10 (geo target) had a mud bottom only, target 9 had bacterial mats. Gas was observed bubbling through cracks in the carbonates on ALVIN Dive 4174. Pockmarks were observed, some with crude oil bubbling out.

Biology

The tubeworm area was covered extensively during Dive 4184 while searching for a suitable bush tubeworm for collection. It corresponds to a topographic high, with tubeworms as isolated

individuals or small groups in cracks. A few bushes were also found. The only species observed on the bottom was *Lamellibrachia* sp. nov. Patches of tubeworms and mussels were observed growing out of fissures in the carbonate pavements (Dive 4174).

Two extensive areas with pockmarks and clams were also covered. Target 11 should have had mussels, but none were seen. At the end of the dive (near target 12, described as clams), large mussels were seen at the bottom of a pockmark. Gorgonians and other cnidarians (anemones) were common close to tubeworms (especially on the NW corner of the tubeworm area) and on some carbonate pieces around pockmarks (**Figure 86**).

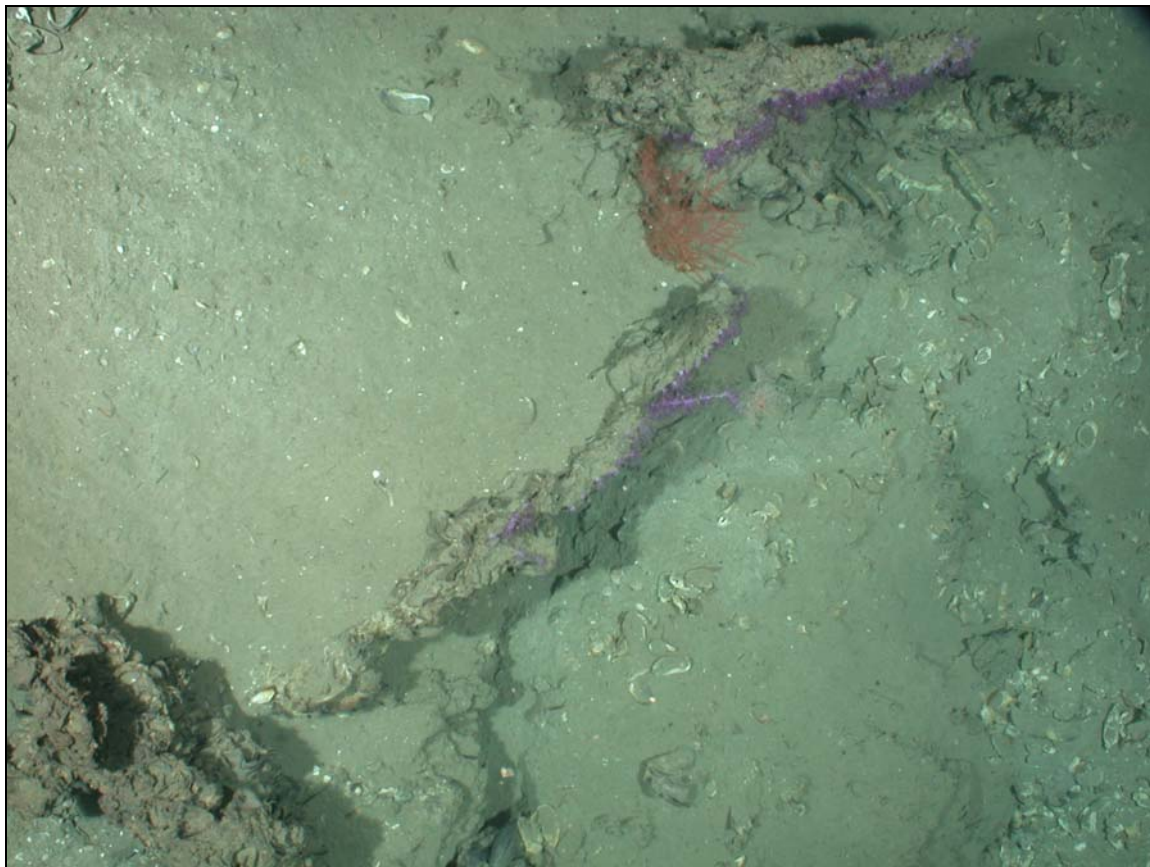


Figure 86. Varieties of soft corals were seen on some of the carbonate boulders, but no significant aggregations were observed during the two dives at the site.

Most of the area surveyed during the dive showed bacterial mats of various sizes. No *Alvinocaris* shrimp were associated to them. The mussel appears to be *B. brooksi*. The clams were *Calyptogena ponderosa*.

Mosaic

No mosaic was done on this site. Two dives were completed at site GC600. **Figures 87** and **88** show the dive track of ALVIN and activities performed during the dives.

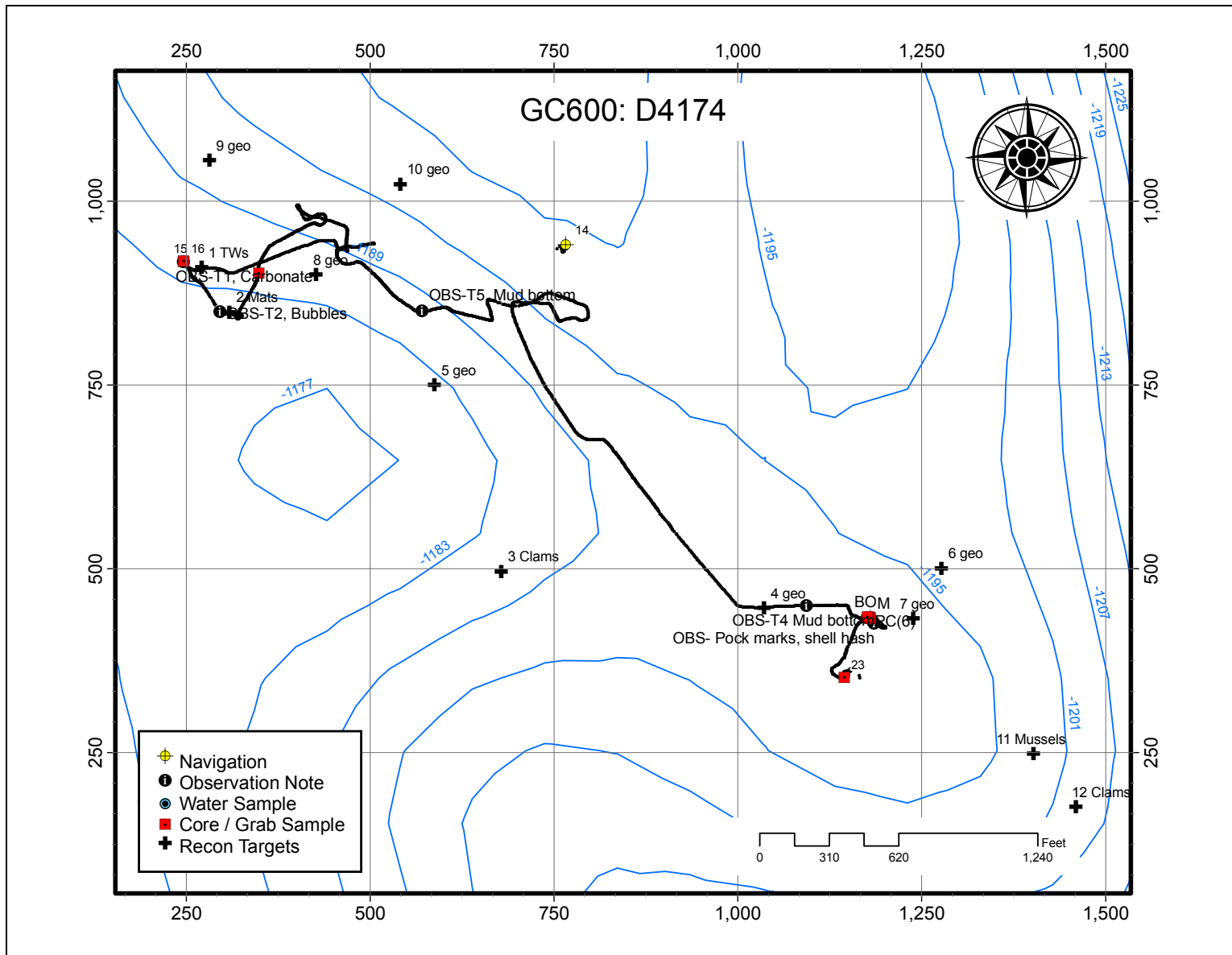


Figure 87. Dive 4174 on 5/10/2006 at an average depth of 1,250 m.

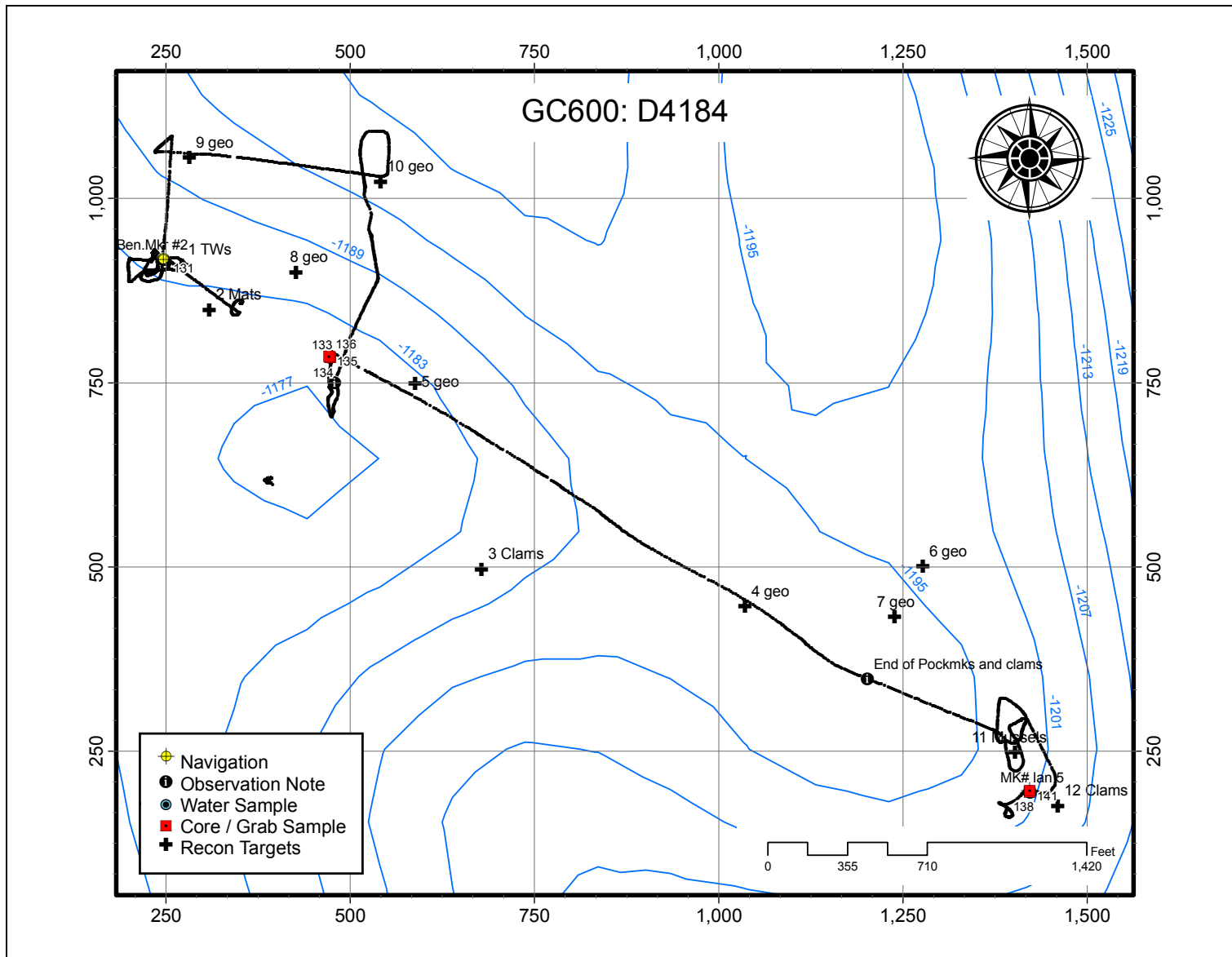


Figure 88. Dive 4184 on 5/20/2006 at an average depth of 1,250 m.

Walker Ridge 269

Geologic Setting for Walker Ridge 269

The dive site is at the northern edge of a suprasalt intraslope basin on the lower Continental Slope, approximately 10 lease blocks away from the Sigsbee Escarpment. The site consists of a series of mound-like areas that extend to the east into WR270. These mounded features are on a ridge that separates two very distinct intraslope basins that are floored by salt or salt welds.

Previous studies, using high quality 3D seismic data, indicate the presence of a well-defined bottom simulating reflector (BSR) that cuts across stratigraphic reflectors of the basin fill to the south of the area of interest. This feature, which is interpreted to indicate the base of the gas hydrate stability zone, appears to have free gas trapped beneath the BSR. The mounds on the modern seafloor are updips of the interpreted gas hydrates and associated free gas. It appears that gas is bypassing the gas hydrate stability zone along permeable beds that are upturned along the basin margin. The topographic buildups that are the focal points of our investigation are interpreted as being several large expulsion features that have built mounds through the extrusion of fluidized sediment along with other products such as hydrocarbons.

Surface reflectivity maps of the area derived from 3D seismic data suggest the location of several active vents (circular low amplitude zones) and associated flows that have localized areas of high reflectivity. The areas of high reflectivity are interpreted as regions of local seafloor lithification and perhaps fields of clam shells.

The particular area selected for investigation is characterized by rather subtle topography except for a localized mound that rises some 30 m above the surrounding seafloor. The area was selected on the basis of its characteristics on geophysical records. The mound-like feature was interpreted as a sediment extrusion site and the surrounding areas as overlapping mud flows. The surface reflectivity maps suggest that there are some highly reflective zones that surround and are located to the west of this central vent feature. These highly reflective zones are usually lithified seafloor areas or fields of clam shells in this setting.

If the vent is active, fluidized mud is frequently found with bacterial mats usually in abundance. If the vent is not very active, the central crater sites are usually the sites of complex chemosynthetic communities. The fact that the surface reflectivity maps show a low amplitude response in the vent area suggests the presence of gas or soft bottom condition. Small islands of slightly higher reflectivity suggests variable bottom conditions in the area of the vent and a reasonable probability of finding tube worm, mussels, and carbonate rocks. This proved to be the case at this site. Even though the flows themselves may not be highly productive in terms of chemosynthetic communities, there are “hot spots” in the flows that support communities and result in localized cementation of the seafloor. The highly reflective areas to the west of the vent site are interpreted as being of this nature. One of the areas is circular and probably represents an old venting site.

If hydrocarbons are still being migrated to the seafloor in this area, it could support a sizeable area of chemosynthetic communities. Unfortunately, our dive to explore this area was cut short

because of weather, and we were not able to ground truth our interpretations of the areas west of the main venting site. Our interpretations of venting sites and highly reflective areas near it were correct (**Figures 89 and 90**).



Figure 89. Although there were extensive areas of seep-affected sediments at the WR269 site, development of tubeworm or mussels aggregations was very restricted.



Figure 90. Surface sediment in the regions of seepage featured a rich assortment of pogonophorans, holothurans, and crustaceans.

Two dives were completed at site WR269. **Figures 91-92** show the dive track of ALVIN and activities performed during the dives

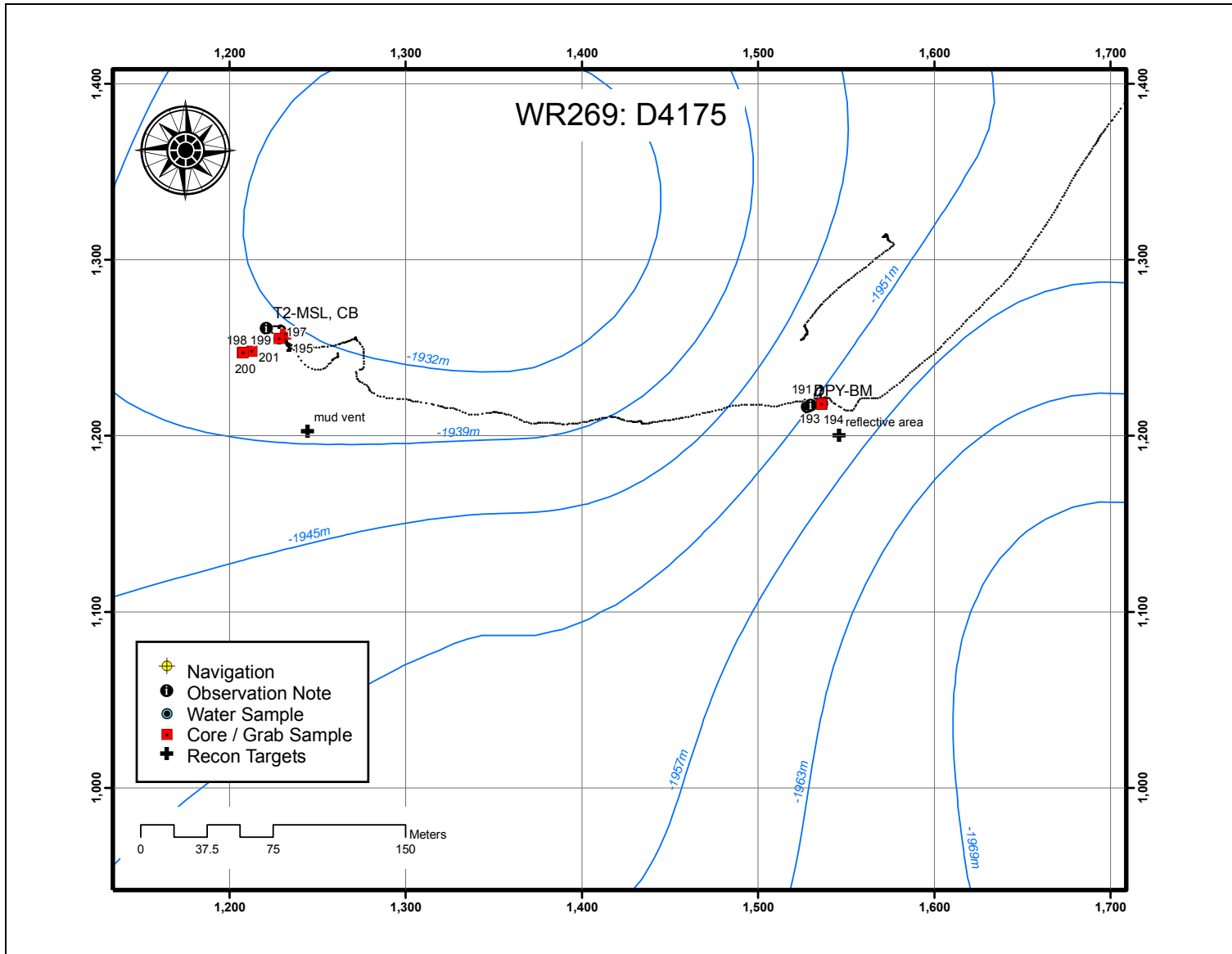


Figure 91. Dive 4175 on 5/11/2006 at an average depth of 1,950 m.

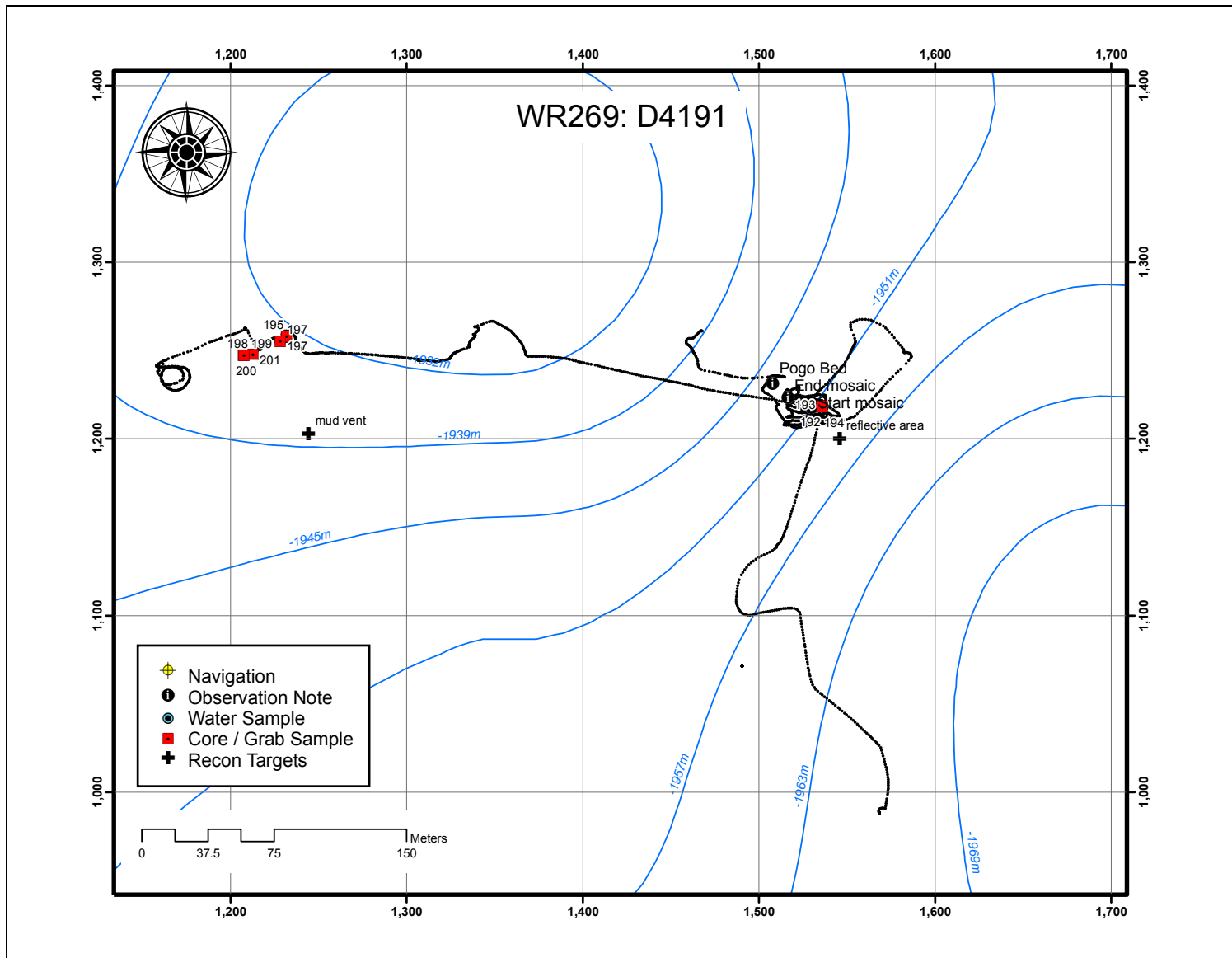


Figure 92. Dive 4191 on 5/26/2006 at an average depth of 1,950 m.

Keathley Canyon 243

Geologic Summary of Keathley Canyon 243

This site occurs on a ridge separating a large intraslope basin to the south from three smaller intraslope basins to the north. Surface reflectivity mapping of 3D seismic data indicates two areas of scattered seafloor anomalies along the southeastern and eastern upper flanks of the ridge. Seismic profiles across the ridge indicate well-defined and vertically oriented “chimneys” that have no internal acoustic character, acoustic “wipe-out zones.” These features are interpreted as gas-rich migration pathways for fluids and gases to be transported from the deep subsurface to the ocean floor. Photo reconnaissance work prior to the ALVIN cruise confirmed the presence of chemosynthetic organisms in the vicinity of the southern anomaly identified from 3D seismic data. The site is mainly covered by soft sediment. It shows some steep features, with drop-offs and pronounced slopes. Exposed carbonate is frequent, sometimes located at the top of drop offs. The carbonate was mostly forming large slabs, that were cracked and fissured (**Figure 93**).



Figure 93. Relatively few carbonate structures were observed, indicating little flux of hydrocarbons.

The carbonates were mainly rubble at the beginning of the dive. No exposed methane hydrate was observed. Small depressions filled with brine were common near mussels and a few other places, including near target 3. No rocks were collected.

Site Summary - Keathley Canyon 243

Depth 1650-1600 m, Launch target 26°43.812'N, 92°49.835'W.

This site was explored during ALVIN Dive 4176 only (May 12, 2006) and during the survey cruise.

This site is relatively small. We explored only part of it, due to a torn boot at the beginning of the dive and some issues with navigation and target positions. Most of the exploration was centered on markers 1 and 2. ALVIN was called to the surface just after reaching target 3 and little of that area was explored. Bench Marker 1 (X162, Y 293) was dropped at the beginning of the dive, about 160 m W of the mussel beds. A ball marker was dropped on the mussel bed as a reference for a mosaic.

Biology

Scattered mussel shells were found almost everywhere on the dive track. They were denser in some areas. Briny areas were common, with bacterial mats and a restricted area with live mussels stretching NW-SE halfway between the targets. These mussels were most often found in small patches, with a few larger beds (**Figure 94**).



Figure 94. KC243 site had relatively little development of chemosynthetic communities, comprising sparse mussel beds for the most part.

Tubeworms were seen on a hand-held camera photo after the dive but none were collected. A mussel pot and a mussel scoop in the mussel bed (right next to each other) were collected. The only species of *Bathymodiolus* was *B. brooksi*. Other species found were: *Ophiactenella acies*, *Harmothoe* sp., *Prionospio* sp., *Capitella* sp., and *Nereis* sp. Other fauna found were: large round sponge, *Chaceon affinis*, *Nematocarcinus*, and *Paralomis* sp.

One dive was completed at site KC243. **Figure 95** shows the dive track of ALVIN and activities performed during the dive.

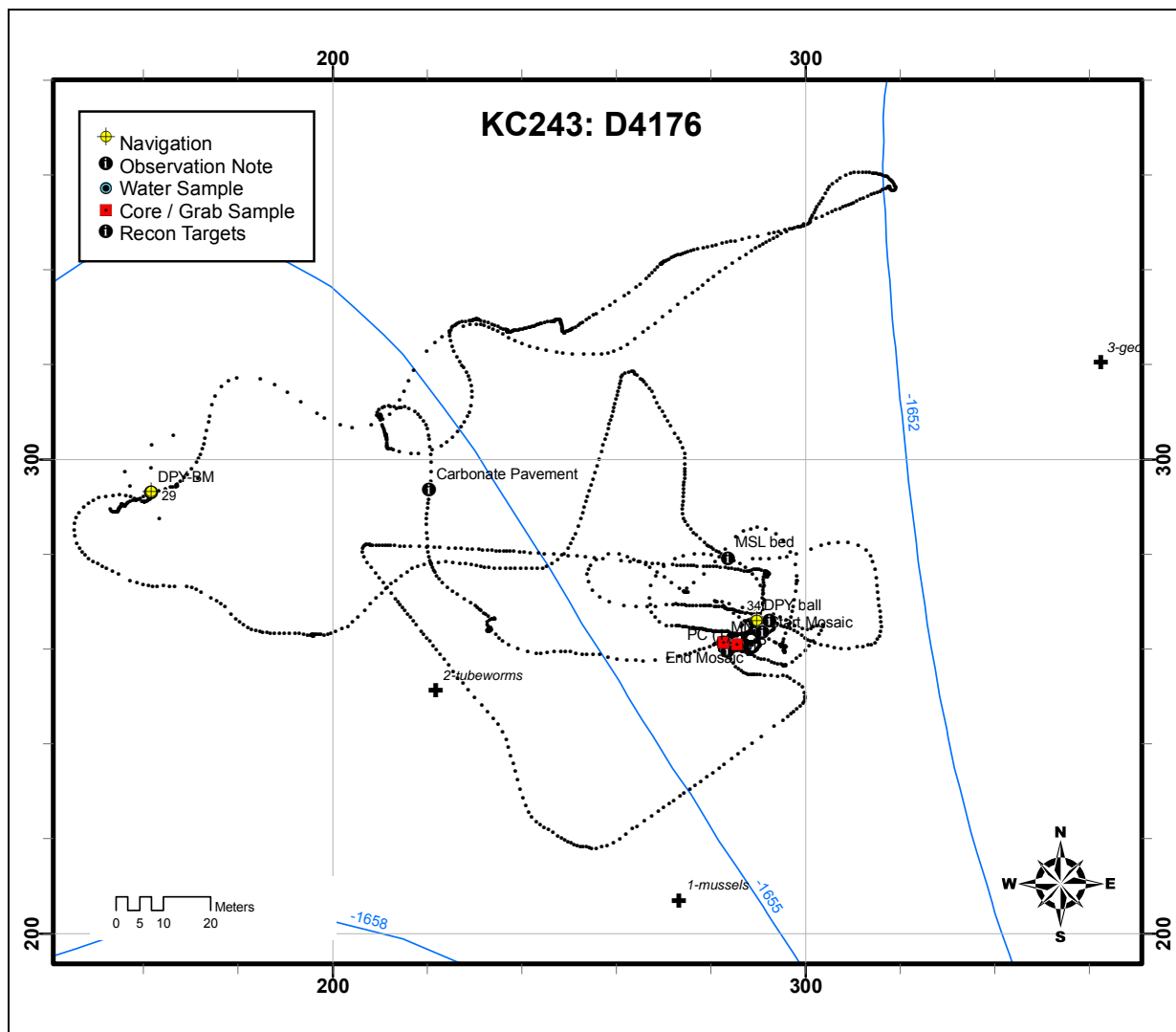


Figure 95. Dive 4176 on 5/12/2006 at an average depth of 1,610 m.

Green Canyon 852

Geologic Setting - Green Canyon 852

The GC852 site is one of the most diverse on our dive schedule. The area of interest is a N-S oriented elongate mound that rises from the seafloor at the southeastern edge of a middle-to-

lower slope suprasalt sedimentary basin. The top of this mounded region is at a water depth of approximately 1,435 m. The overall elongate-mounded area is approximately 2 km long, the highest elevation on this feature is at the southern end. This southern area is characterized by a localized mound that rises more than 20 m above the northern crest of the overall feature. The 3D seismic surface reflectivity data indicate that the entire crest of this feature exhibits a high amplitude response, suggesting the presence of hard bottom conditions. Scattered highly reflective targets are also present around the upper flanks of the ridge-like feature. Profiles of the subsurface configuration of this feature indicate acoustically turbid migration pathways to the modern seafloor. These vertically oriented acoustic “wipeout zones” are migration routes for fluids and gases to the modern seafloor. The structural and stratigraphic framework of the subsurfaces focuses these products (including hydrocarbons) to the GC852 mounded area.

Photo reconnaissance work in March 2006, as well as direct observations made with the aid of ALVIN, indicates the presence of numerous chemosynthetic communities around the mounded area in the southern half of the study area. Tubeworms, mussel beds, and carbonate outcrops are common around the flanks of the southern mound. Although the ALVIN did not travel to the northern end of the N-S trending overall feature, the photo reconnaissance indicated brine seeps and carbonates, but no chemosynthetic communities. At the apex of the southern mound, carbonate blocks and hardgrounds are common, and soft corals are taking advantage of the hard substrates as a place to attach and grow. Bacterial mats seem to be few and far between.

Site Description - Green Canyon 852

This site lies on the southern extent of a steep-sided N-S trending elongated mound rising from over 1,500 to 1,395 m depth. This feature occurs at the SE edge of a well-defined sedimentary basin. The overall mounded area is approximately 2 km long with the highest elevation at the southern end. This area of primary interest is characterized by a localized mound that rises more than 20 m above the rest of this overall feature. The 3D seismic surface reflectivity data from this area indicate that the entire crest of the elongated feature exhibits a high amplitude response relative to surrounding seafloor, suggesting the presence of hard bottom conditions. Scattered highly reflective targets are concentrated in the vicinity of the southern mound. Profiles of the southern end of the elongated mound indicate acoustically turbid migration pathways to the modern seafloor. These “wipeout zones” are interpreted as routes for upward transport of fluids and gases from the deep subsurface. Submersible operations confirmed the indicators of hydrocarbon seepage in this area. These operations were conducted on the crest of this feature in an area approximately 650 m N-S and 300 m E-W. The crest of the feature has extensive carbonate that appears to have been scoured by currents removing sediment from between 2-3 m high carbonate pillars. At the tops of the pillars are numerous types of corals: gorgonians, antipatharians, bamboo coral, and scleractinians (**Figure 96**), as well as numerous individuals of a globose soft-ball sized hexactinilid sponge, a few anemones, and a yellow *zoanthid* sp encrusting dead bamboo corals.



Figure 96. Chemosynthetic communities at the GC852 site comprised a series of features situated along a 1.5 km ridge line.

Numerous plumate polychaetes and hydroids were visible in macrophotos of the carbonates. The hard coral *Solenosmilia variabilis* was collected and *Madrepora oculata* was observed. A potential identification of *Lophelia pertusa* was also made from the photographic record, but this could not be confirmed since there were no specimens of this species collected. There was an unidentified species of chirostylid crab commonly associated with the soft corals and a species of ophionerid brittle star on the gorgonians (**Figures 97 and 98**).

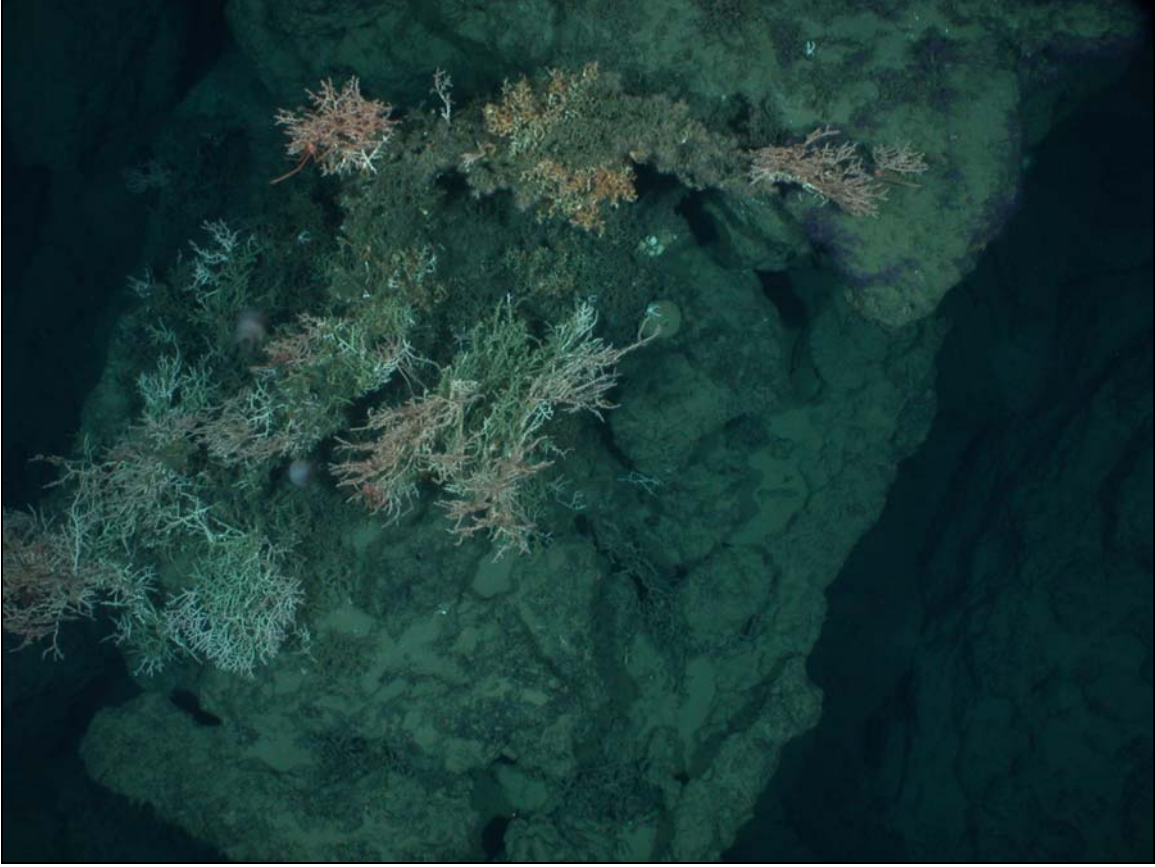


Figure 97. Northern portion of GC852 with massive carbonates colonized by scleractinian corals.

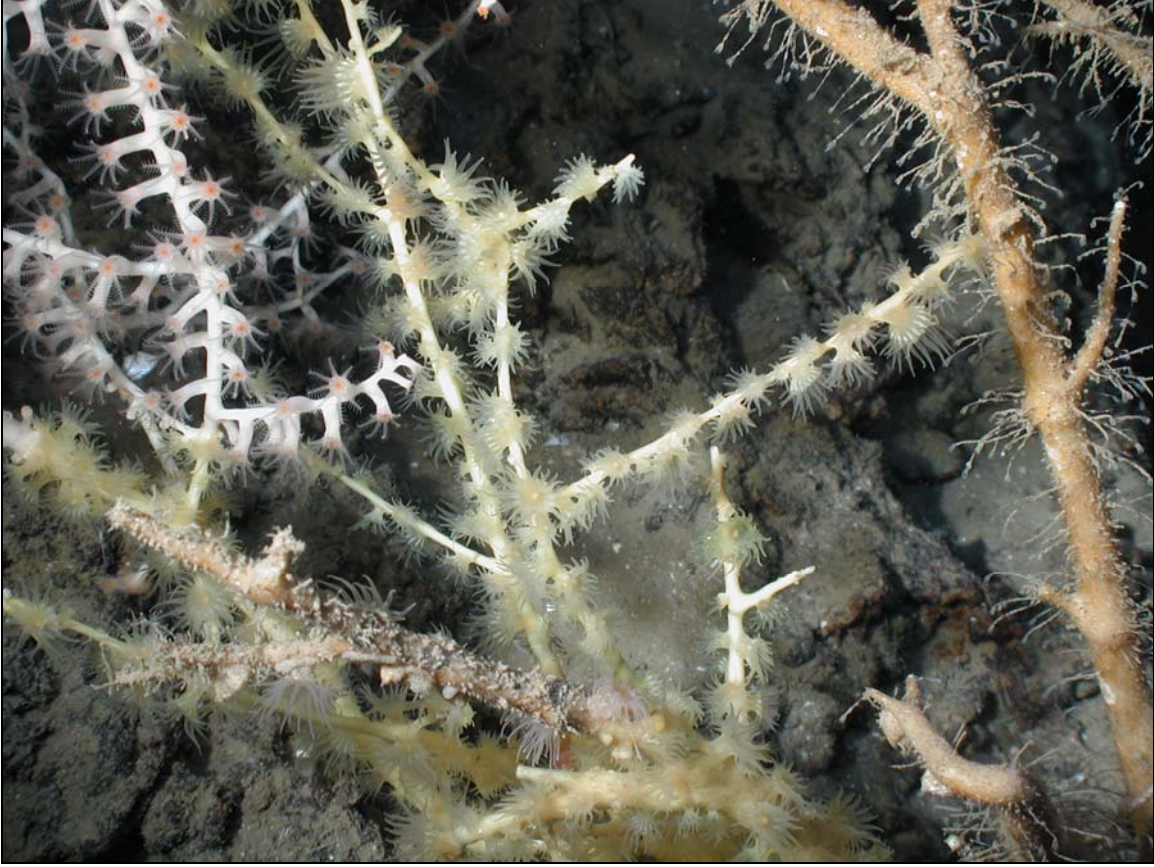


Figure 98. Soft corals included living octocoral polyps and dead skeletons colonized by zooanthids at GC852.

Also on top of the mound are some scattered tubeworms and smaller carbonates and an area of active oil seepage. On the flanks of the mound were two areas of active seepage and authigenic carbonate. One feature is about 80 m to the NE of the corals and consisted of low-lying cracked carbonate blocks, occasional methane bubble streams, and oily sediments. Aggregations of both species of tubeworms, *Escarpia laminata* and *Lamellibrachia* sp., were collected here. Small mussel beds nested in carbonate (**Figure 99**) comprised *Bathymodiolus brooksi* and *B. childressi*.



Figure 99. Tubeworm colonies at GC852 were generally sparse assemblages attached to carbonate and cemented shells.

The most common associated fauna were *A. muricola* and *O. acies*. Many of the *E. laminata* collected contained a species of phyllodocid polychaete, which is an apparent blood-sucking parasite. Dead tubeworm tubes often contained this species and another polychaete filling their tubes. A second area of active seepage was found approximately 400 m to the south of the corals near the top of a ridge extending down from the other sites. The substrate in this area consisted of numerous small to medium sized carbonate slabs and boulders and areas of carbonate rubble. Numerous transits between the two areas found only mud between the sites.

The same species noted above were present in the second area. The tubeworms were present as scattered individuals as well as small aggregations associated with the carbonates and mussels were present in beds among the carbonates as well as in small groups apparently nestled in the sediment. Vesicomid clams were also present in this area, although none were collected. These collections extend the depth range of the common upper slope gastropod *Cataegis meroglypta*, the mussel *Tamu fisheri*, and the methane ice-worm *Hesiocaeca methanicola* to 1400 m, and extends the geographic range of *S. variables* to the NE from previous Gulf records in the Straits of Florida.

Oil slicks were visible on the sea surface during much of the time ATLANTIS occupied this site. Streams of bubbles, probably lined with oil, were observed escaping through beds of mussels at

several positions on the bottom. Gas hydrate was inferred from hard layers encountered while collecting push cores and was photographed in an exposed patch with the macro camera. Six dives were completed at site GC852. **Figures 100-105** show the dive track of ALVIN and activities performed during the dives.

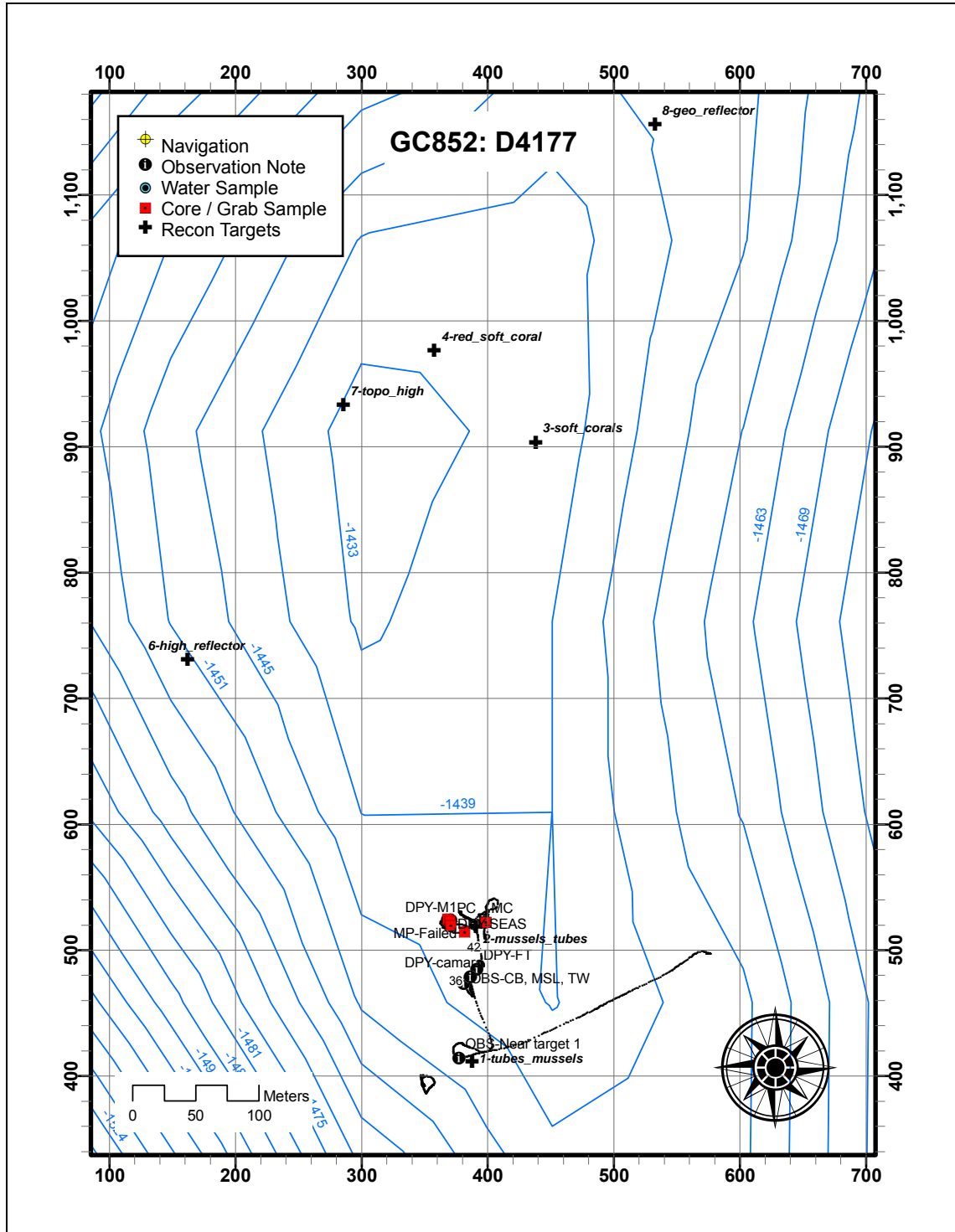


Figure 100. Dive 4177 on 5/13/2006 at an average depth of 1,450 m.

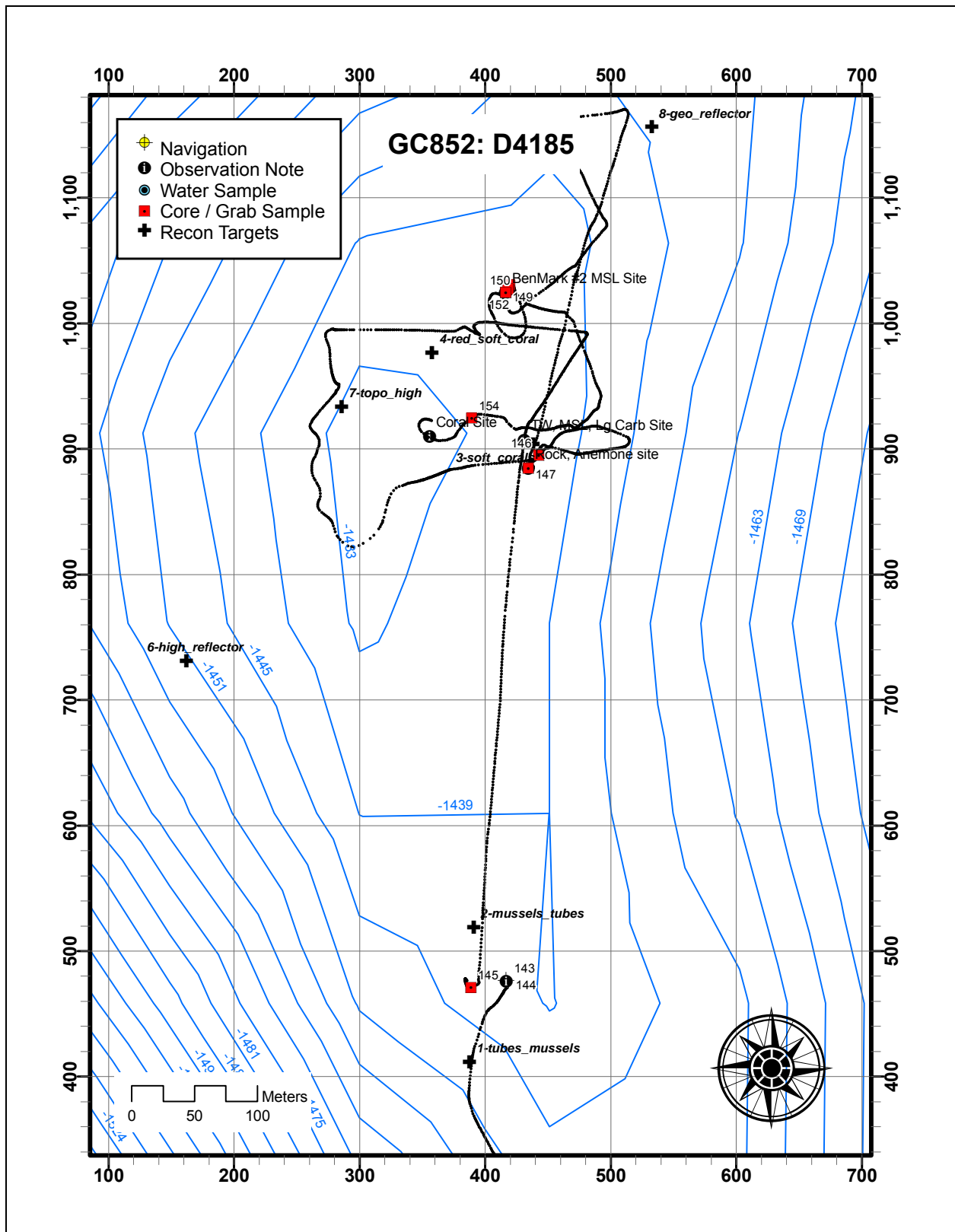


Figure 101. Dive 4185 on 5/21/2006 at an average depth of 1,410 m.

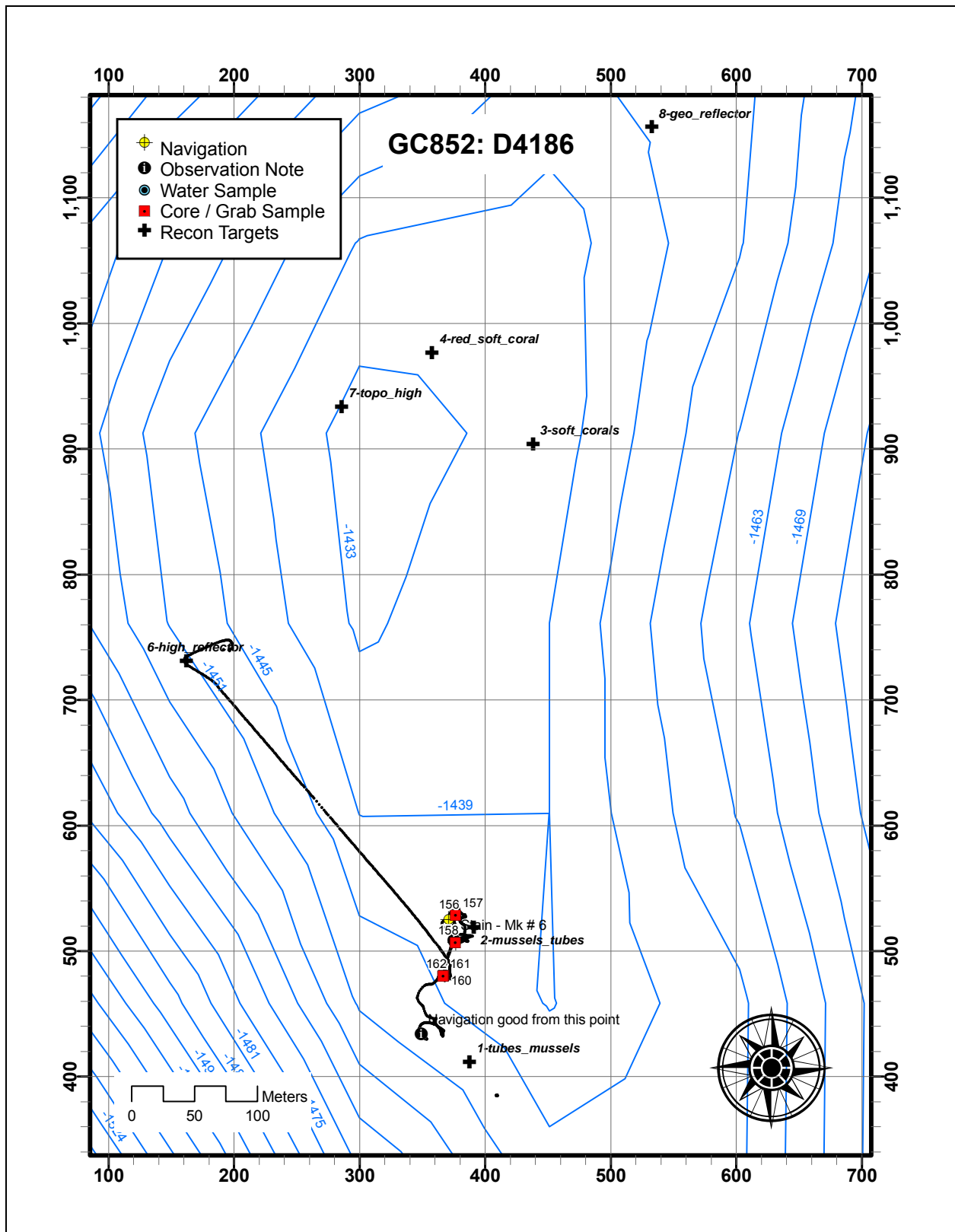


Figure 102. Dive 4186 on 5/22/2006 at an average depth of 1,410 m.

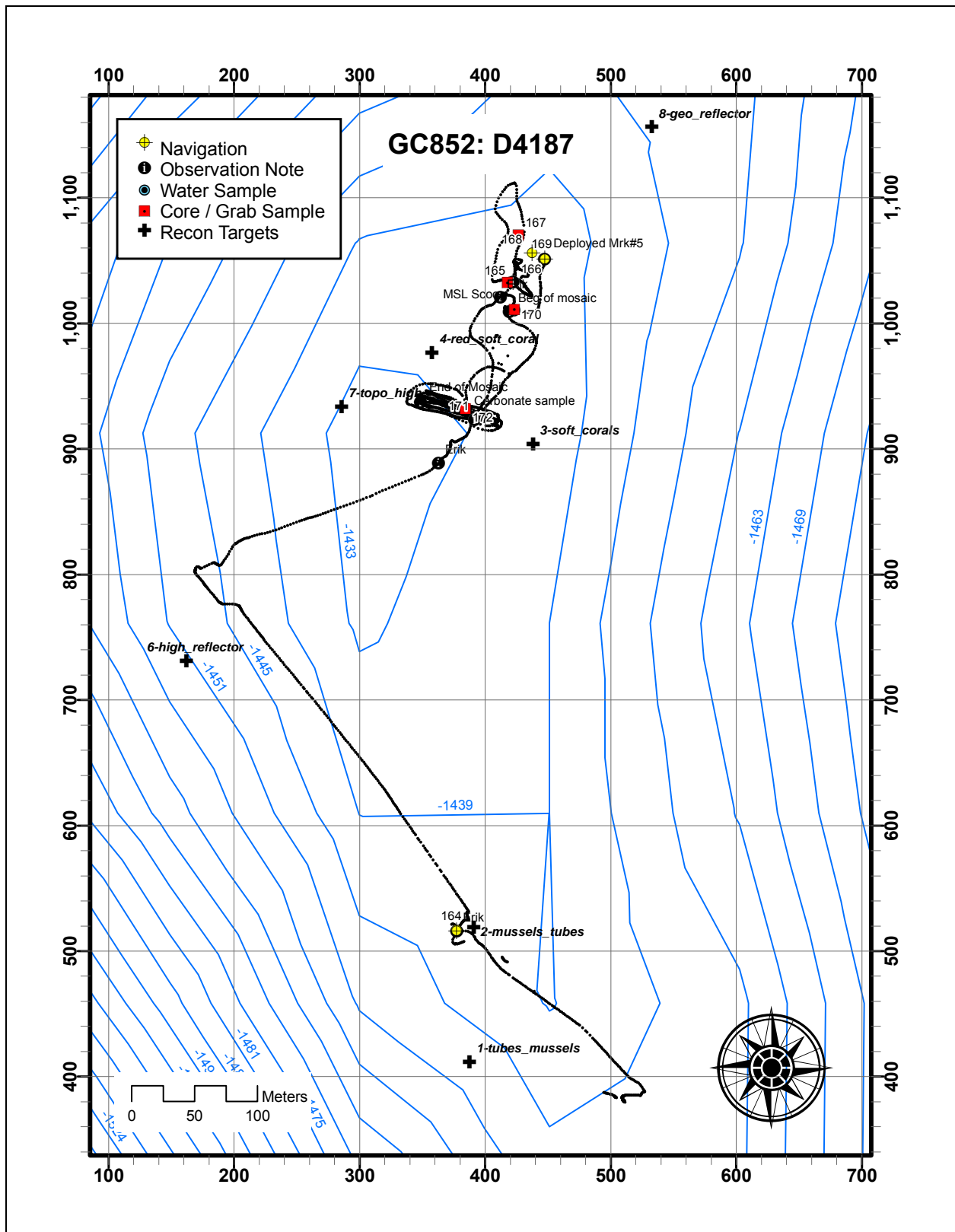


Figure 103. Dive 4187 on 5/23/2006 at an average depth of 1,410 m.

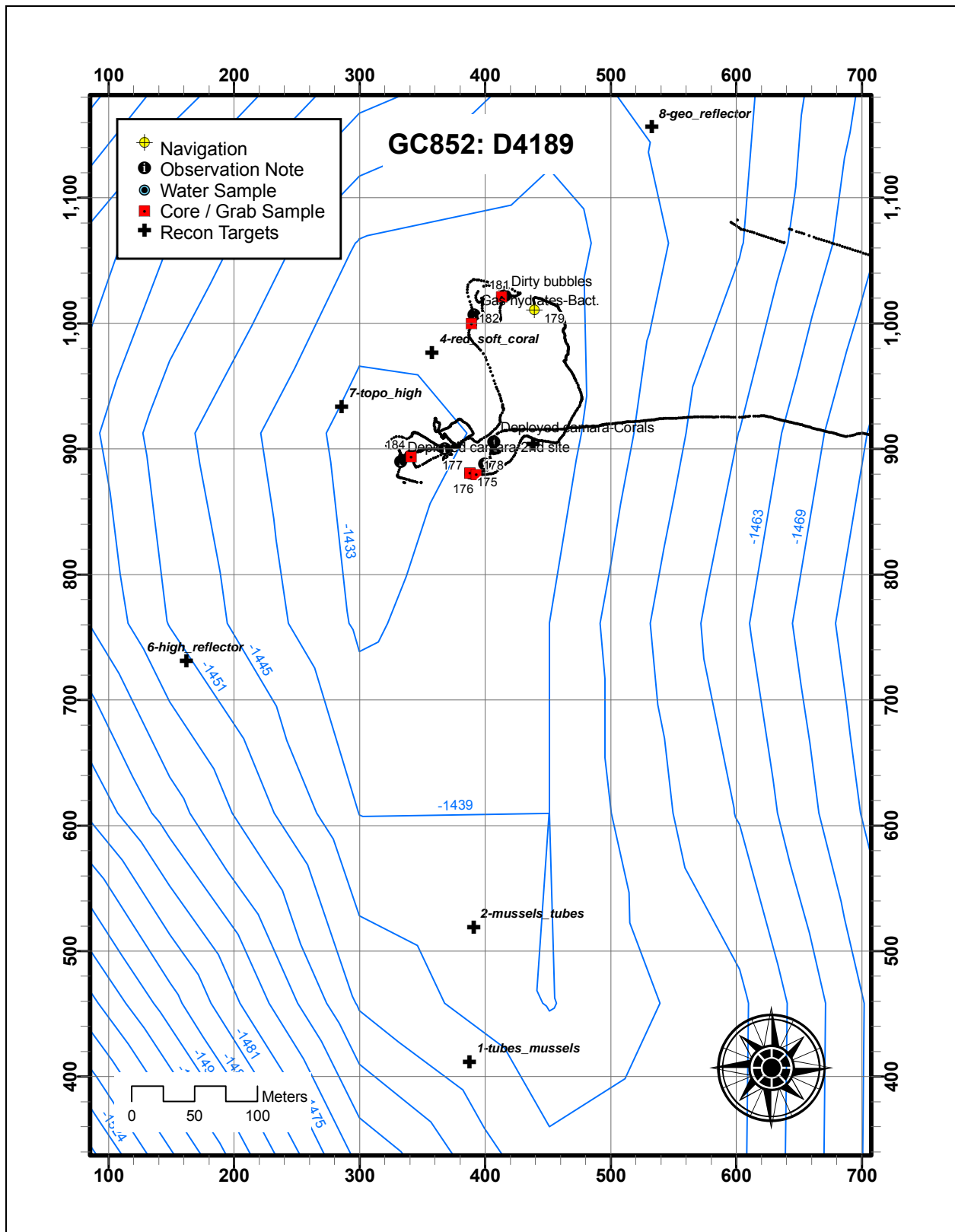


Figure 104. Dive 4189 on 5/24/2006 at an average depth of 1,410 m.

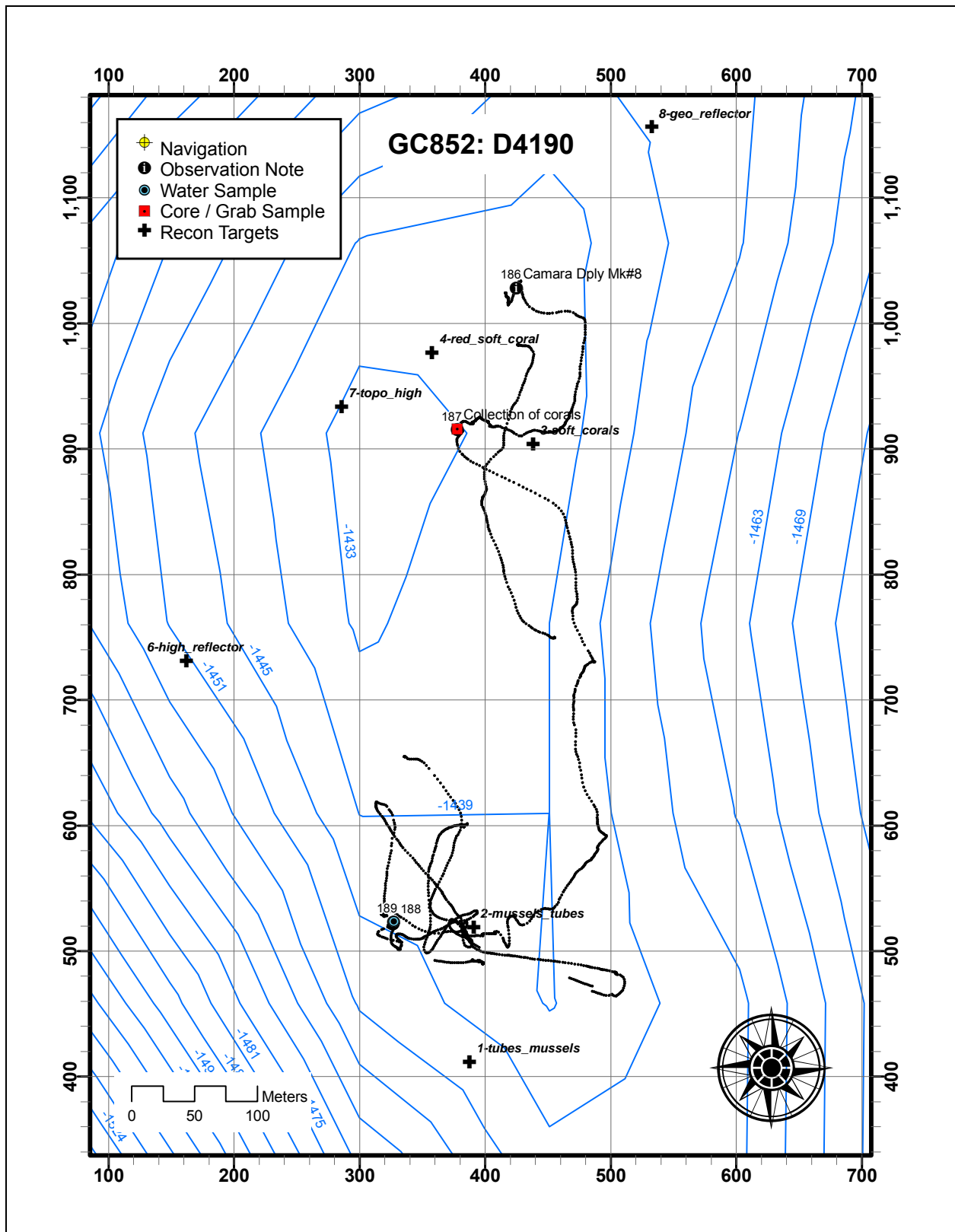


Figure 105. Dive 4190 on 5/25/2006 at an average depth of 1,410 m.

Mississippi Canyon 853

Geologic Summary of Mississippi Canyon 853

The MC853 site consists of an oblong NW-SE trending mound that rises over 100 m above the surrounding seafloor. It is located along the eastern margin of the Mississippi Canyon and the mound rises above the levee deposits that are a part of this regional geologic feature. The top of the mound has a water depth of approximately 1065 m. The 3D seismic surface reflectivity data over the mound area describe a pattern of highly reflective seafloor in the middle of the mound and scattered high reflectivity targets around the NW and SE parts of the mound top and upper flanks. Seismic profiles across the mound indicate a subsurface stratigraphic and structural configuration highly influenced by the presence of a large salt mass in the shallow subsurface. When viewed in the optimal perspective, it is apparent that the high amplitude surface reflectivity zone in the middle of the mound is salt at or extremely close to the seafloor. Even though the salt blocks fluid and gas migration to the central part of the mound, there are numerous leak points along the edges of the salt mass. This geologic interpretation of the MC853 mound was verified by both drift camera reconnaissance pictures and direct observations, plus sampling from ALVIN.

A previous ALVIN dive and photo reconnaissance confirmed the existence of chemosynthetic communities at the MC853 site. As suggested by the geophysical data, the occurrence of mussels, bacterial mats, clams, carbonates, and a few gorgonians on the hard substrates clustered away from the center of the mound along the upper flanks of the feature. The center of the mound was characterized by hummocky bottom topography with brine seeps and associated gullies. Small slumps of mussels and areas of hard bottom with scattered bacterial mats are common to this region of the mound. Tubeworms were generally absent from this area, although a few isolated tubes were spotted.

Site Summary - Mississippi Canyon 853

Depth: 1070 m, Latitude, Longitude: 28° 07.643 N, 89° 08.470 W. Explored during ALVIN Dive 4178. Surveyed during the survey cruise. Visited previously by Ian MacDonald in 2000.

Summary of Dive Observations

This is the shallowest of the study sites. During the dive, we transited from the N end to the S end, across a topographic high (a carbonate mound). Abundant microbial mats, live clams and giant mussels were observed consistently along the dive path. Numerous pockmarks and carbonate pavements were evident. Exposed gas hydrate was observed in the crater where clams were collected towards the end of the dive (S end of the site).

- Bench Marker (X367, Y1167) near target #1.
- Marker #2 (X342, Y1171) in epic mat area.
- Marker #3 (X548, Y706) near mussel collection area

Biology

The dominant fauna at this site were mussels, clams, microbial mats and various fish. A few gorgonians (several of which were quite large) were also observed. One of the most interesting creatures we observed during the dive was a large, colorful siphonophore (1525 in dive log),

which was slurped up by Pat. Live clam tracks were present along most of the dive track although (dead) clam shells were just as common. Microbial mats of the sulfide-oxidizing bacteria *Beggiatoa* were observed on sediments characterized by intense seepage-derived staining (sediments beneath were black and reducing). Mainly, white mats were observed, but small patches of cantaloupe orange *Beggiatoa* was also observed (these were photo-documented during the dive). The light (cantaloupe) orange color of these *Beggiatoa* is interestingly different from the bright orange color that typifies *Beggiatoa* of the shallow slope. *Beggiatoa* mats occupied areas varying in size between 10s of cm to m in diameter and mat localities were often co-inhabited by mussels. Numerous small fish were observed in the mat areas as well. Many of these fish were sitting in the sediment surface directly on top of *Beggiatoa*. In the laboratory, the *Beggiatoa* filaments were observed to be quite small (about 5-10 μm in diameter) compared to the giant *Beggiatoa* (>100 μm in diameter) commonly observed at shallow slope sites.

During the dive, black streams from topographic highs were assumed to be brine flows, but geochemical examination of sediment cores back in the lab showed no evidence of brine (the pore water salinity at all sites was ~35). Based on video watched from other sites, the microbial mats at this site are the most extensive and prolific of all the sites. Obviously, some factor or factors is limiting the development of *Beggiatoa* populations at sites along the deep slope.

Numerous dense accumulations of mussels and clams were observed all along the dive track. Two mussel pots were attempted during the dive, but only one was successful. Additional mussel collections were made with the manipulator arm. Several enormous specimens of *B. brooksi* were recovered using this approach. The scoop sampler was used to recover several live clams of various sizes (including some live small (<5 cm long) ones) from two sites. Clams (and mussels) were particularly abundant at the topographic highs. These huge pockmarks and carbonate banks seems to be areas of intense seepage, which supports dense accumulations of chemosynthetic fauna.

No tubeworms were observed during this dive though tubeworms have been noted previously at the site. A more extensive survey of the site with the ROV JASON would aid in determining tubeworm abundance at this site.

One dive was completed at site MC853. **Figure 106** shows the dive track of ALVIN and activities performed during the dive.

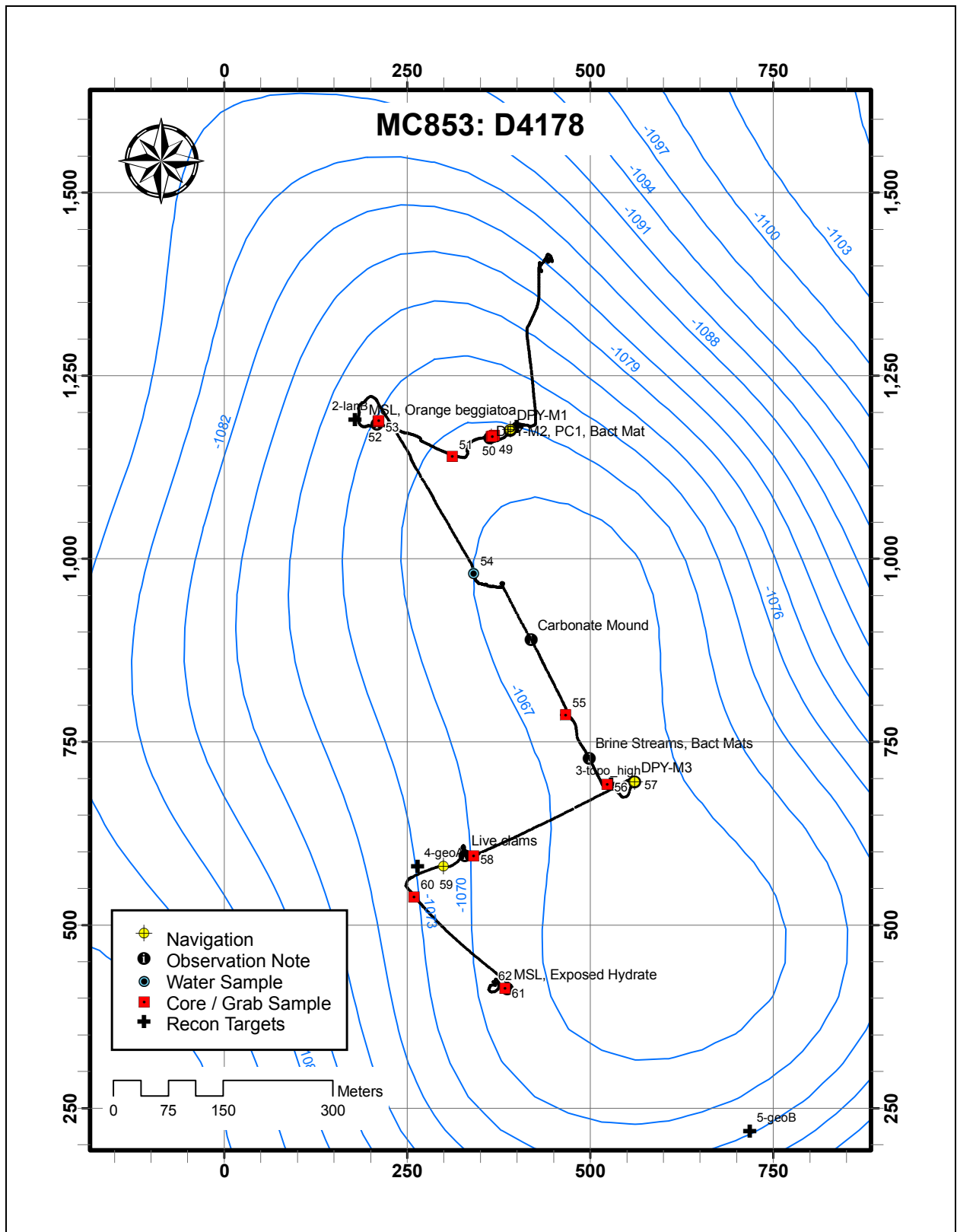


Figure 106. Dive 4178 on 5/14/2006 at an average depth of 1,070 m.

Mississippi Canyon 640

Geologic Setting - Mississippi Canyon 640

The Mississippi Canyon 640 (MC640) dive site is located on the upper Continental Slope, east of Mississippi Canyon and south of the modern Mississippi “birdfoot” delta. The overall feature is roughly circular in plan-view outline. At the top of this larger feature is a mound that rises roughly 15 m above the surrounding seafloor, which is at a water depth of 1420 m. The 3D seismic surface reflectivity data indicate variable patches of high and low amplitude responses over the area of the mound. This pattern suggests that the bottom will be covered with soft mud alternating with areas of seafloor hardgrounds, pavements, and other hydrocarbon seep-related carbonate blocks. Additional patterns of moderate seabed reflectivity describe linear patterns that originate from the mound and radiate from that point to deeper water areas surrounding the mound. These features are interpreted as fluidized sediment flows that originate from highly productive vents at the top of the circular mound-like feature. This type of geologic feature is usually indicative of rapid and episodic expulsion of fluids and gases. These rapid flux systems frequently are the sites of oil slicks on the sea surface. These slicks are usually visible in calm seas and from radarsat satellite images. Inspection of the seismic profiles across this feature reveal a highly focused migration pathway from the deep subsurface. This subsurface configuration generally leads to rapid venting and the construction of mud mounds on the seafloor.

Drift camera reconnaissance tracks and direct observations from ALVIN confirm the variability of seafloor types at this site, reflecting the variations in patterns observed on the surface reflectivity maps. The surface of the mound displays scattered pockmarks and craters of varying sizes. These features indicate gas seepage. Some were as much as 10 m in diameter and 2 m deep. Frequently, mussels and carbonates are found in the bottoms of these localized vents. Scattered exposures of authigenic carbonate account for the very high localized reflectivity patterns on our maps made from 3D seismic data. Bacterial mats and clumps of tubeworms (**Figure 107**) are scattered throughout the mound area.

Irregular patches and small streams of brine occur at the mound top and along the upper flanks of the feature (**Figure 108**). One dive was completed at site MC640. **Figure 109** shows the dive track of ALVIN and activities performed during the dive.



Figure 107. Sediments away from the brine pools were carpeted with pogonophora.



Figure 108. Extensive brine pools and flow channels supported bacterial mats and mussel colonies at the MC460 site.

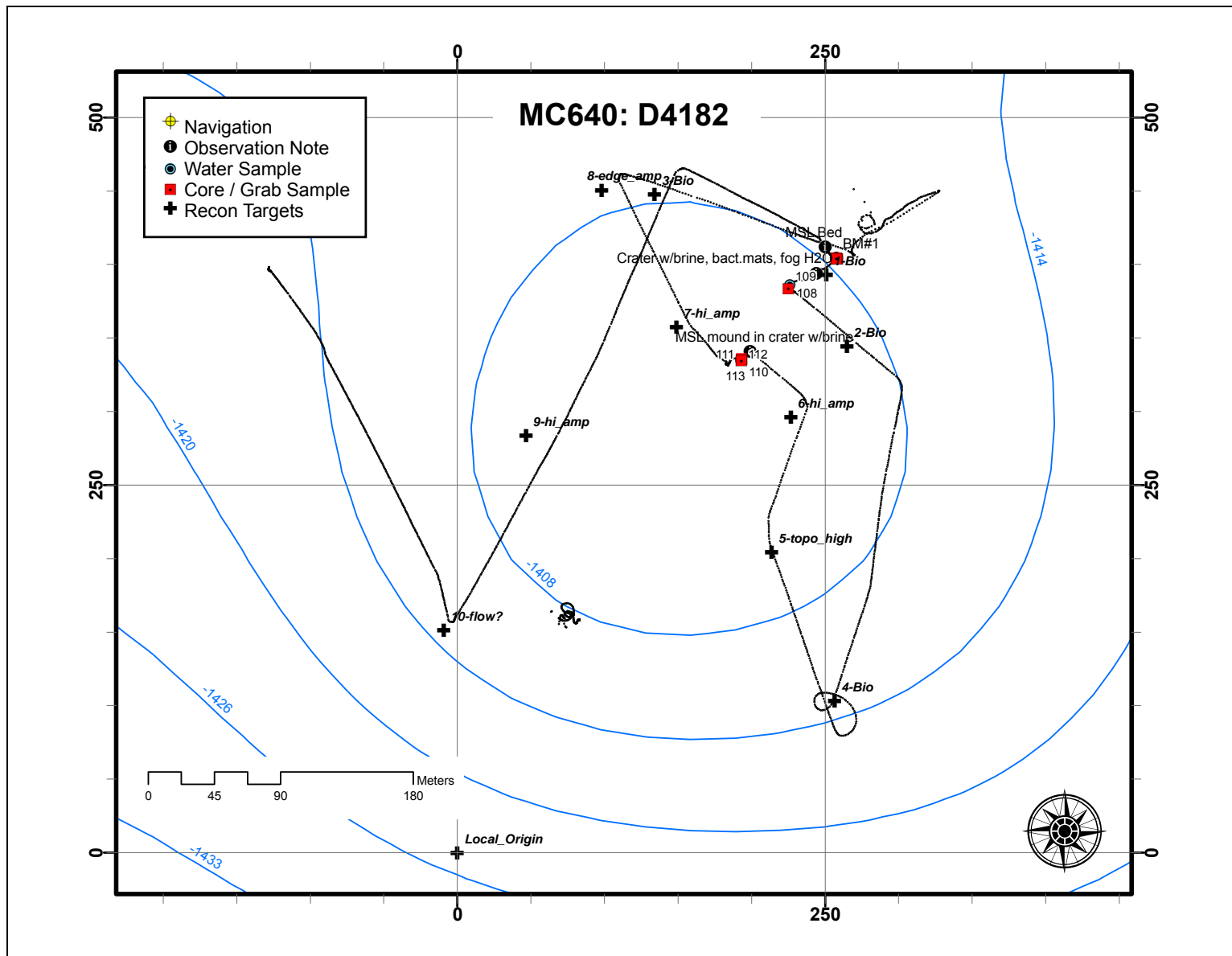


Figure 109. Dive 4182 on 5/18/2006 at an average depth of 1,410 m.

Alaminos Canyon 818

Geologic Summary of Alaminos Canyon 818

The AC818 site is located seaward of the Sigsbee Escarpment and slightly to the west of Alaminos Canyon. The site is associated with the ChevronTexaco Tiger Prospect in a water depth of approximately 2,750 m. A wellhead is present in the vicinity of a well-developed chemosynthetic community discovered on an ROV survey of the immediate wellhead area. The regional geology of this region is that of a rather flat area of relatively low reflectivity on 3D seismic surface reflectivity data. Immediately to the southwest is a highly reflective area of seafloor that corresponds to a submarine fan extending seaward and to the southeast from Perdido Canyon. This fan has very high surface reflectivity on 3D seismic reflectivity data and is interpreted to be composed largely of sand. The chemosynthetic community site is located on a regional fault that trends north-northeast to south-southwest. This fault is clearly defined in seismic profile data, but the location of the known chemosynthetic community and perhaps others along the fault are not well defined on surface reflectivity data. However, there are small and very localized reflective anomalies along the fault like beads on a necklace. The lack of seismic response is probably due to the small sizes of the chemosynthetic community sites.

Direct observation from our first ALVIN dive at the AC818 community site near the wellhead confirmed the localized nature of this assemblage of chemosynthetic organisms. The seismic data suggest that there should be a number of these small communities distributed along the fault.

Site Description - Alaminos Canyon 818

Depth 2,740-2,750 m, Explored during ALVIN Dives 4192 and 4195.

Previous data: This site is about 50 m north of an exploratory drill site (wellhead left in place X555, Y 892). During clean-up surveys with an ROV, a small community was discovered.

Summary of Dive Observations

Along a N-S fault, there is an area of diffuse seepage, as evidenced by sediment stains, pogonophorans, sea urchins, and a relatively small area with tubeworms and mussels. It starts about 50 m north of the wellhead and stretches for about 50 m. After a short break, there is a second, smaller area north with two small mussel beds and one tubeworm patch. Dive 4195 explored about 350 m north of the area covered during Dive 4192 and south of the wellhead.

Bench Marker 1 (X534, Y958) in the tubeworm area. A survey at the bench marker during Dive 4195 gave X 535, Y 1013.

This area follows a fault on a north-south axis. Sediment stain and some oil bubbling out were observed. Thi site has the most active seepage colonized by tubeworms and mussels and is close to exposed carbonate. Carbonate sometimes forms overhangs and pits, with obvious bacterial stain.

Biology

Sea urchins were very common in the area where the sediment was stained (**Figure 110**). The snail *Phymorhynchus* were abundant on the stained areas. Beds of dead clam shells were also common. No live clams were observed, but five small live individuals were found in a mussel

scoop sample collected during Dive 4195. The clams that were collected were a different species from *Calyplogena ponderosa* and appear to be the same as observed in the clam beds on the sea-floor. Tubeworms (*Escarpia laminata*) are common in the central area (**Figure 111**), found close to mussels (mainly *Bathymodiolus brooksi* and a few *B. heckerae*) and spatangoid sea urchins. No *Lamellibrachia* sp. were observed on either dive. The sea-cucumber *Chiridota* sp. is very abundant in mussel beds. The shrimp collected were *Alvinocaris muricola* and a single specimen of a possibly new *Alvinocaris* species. Two species of brittle star were collected (*Ophioctenella acies* and *Ophienigma spinilimbata*).

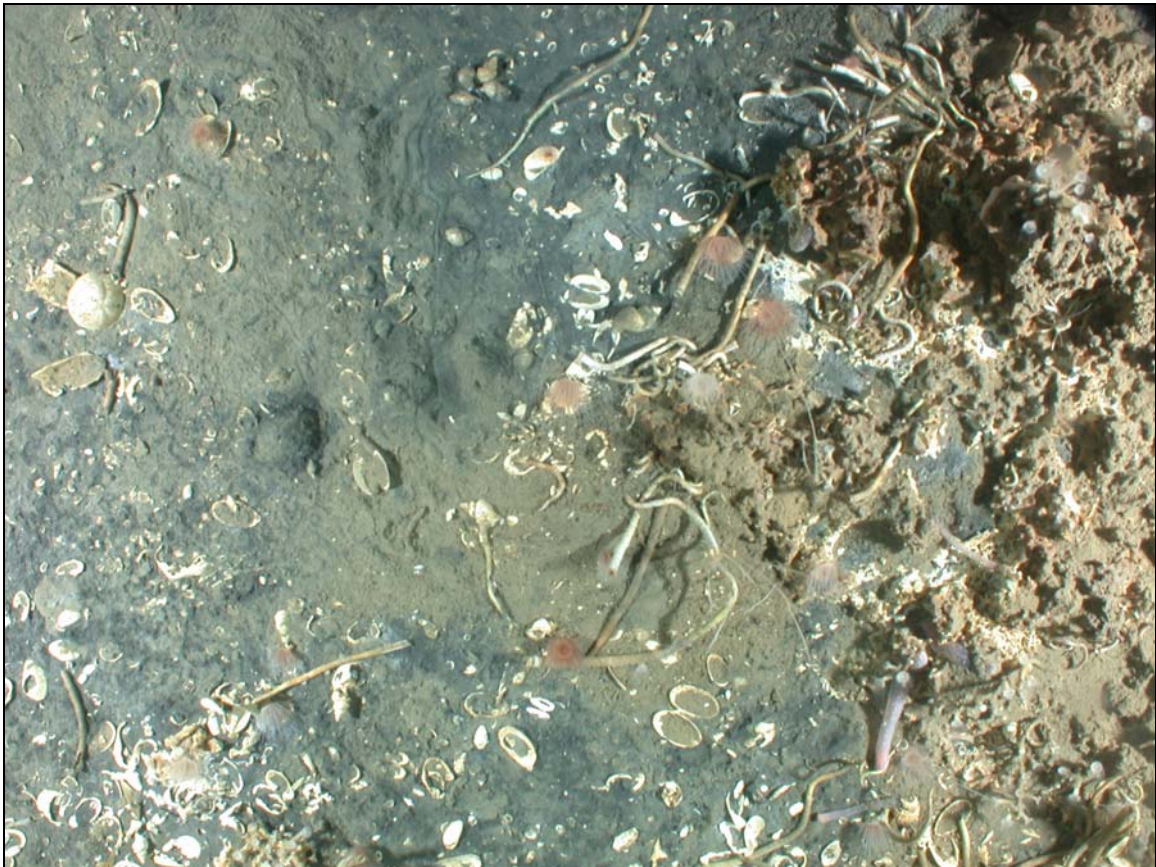


Figure 110. AC818 site featured extensive bacterial mats and hard urchin aggregations, but relatively few and isolated tubeworm clusters.



Figure 111. Tubeworms at the AC818 site were stained to study their growth rate.

Mosaic

No mosaic was done on this site, but a series of photos taken during a fly-by covers most of the area and served as a base map for the site during the second dive.

Two dives were completed at site AC818. **Figures 112-113** show the dive track of ALVIN and activities performed during the dives.

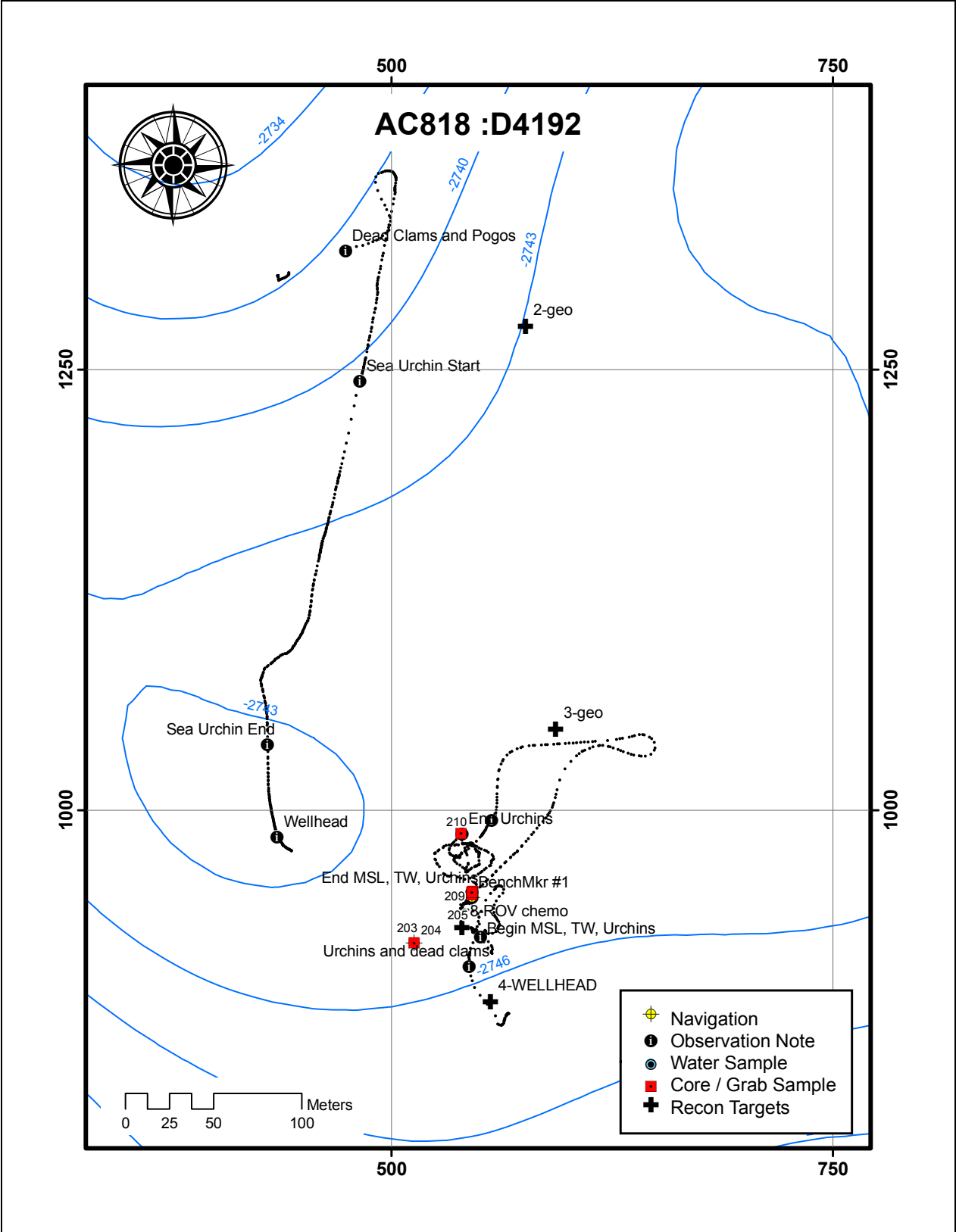


Figure 112. Dive 4192 on 5/27/2006 at an average depth of 2,740 m.

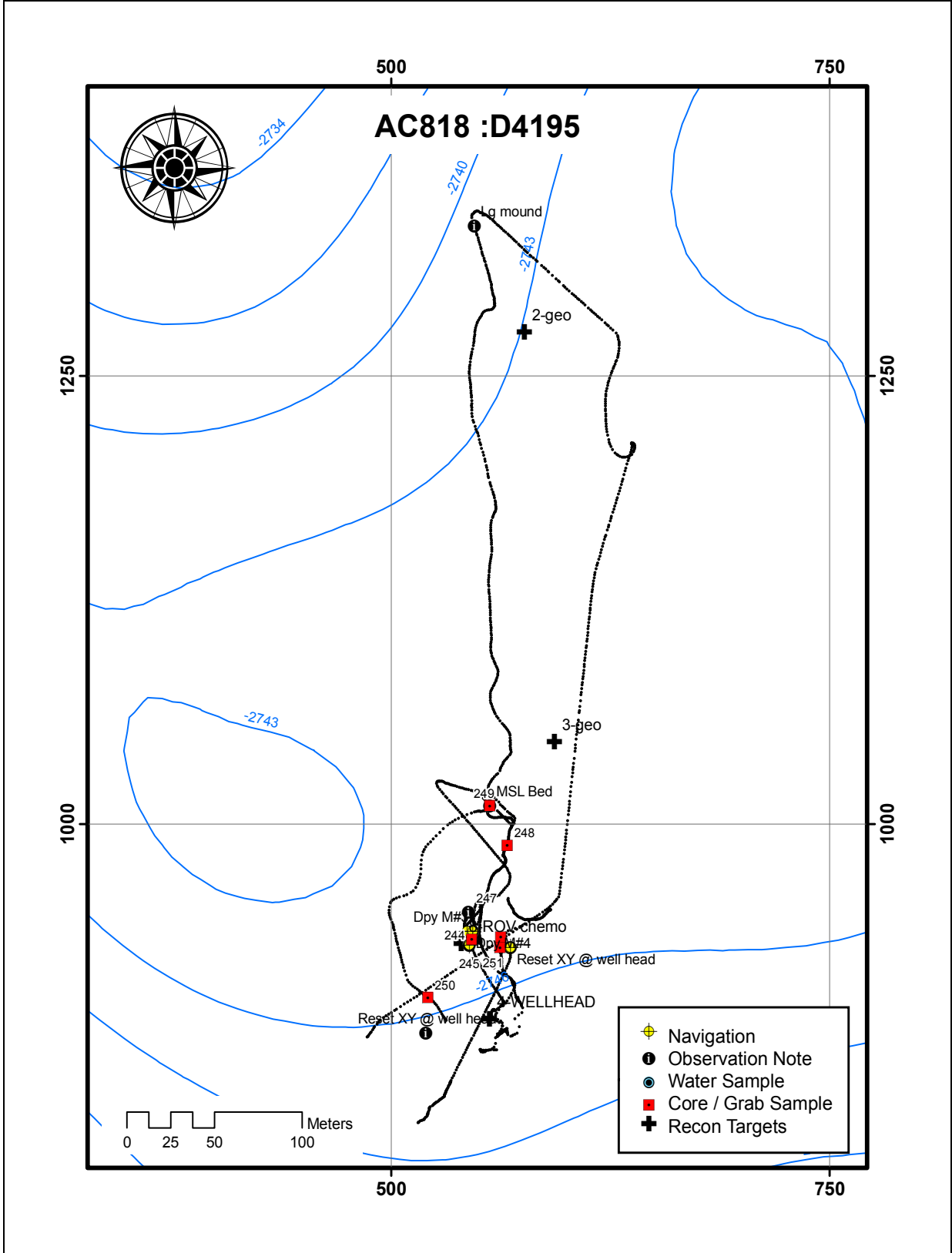


Figure 113. Dive 4195 on 5/30/2006 at an average depth of 2,740 m.

Alaminos Canyon 601

Geologic Setting - Alaminos Canyon 601

Alaminos Canyon is a reentrant into the Sigsbee Escarpment at the base of the Continental Slope off western Louisiana-eastern Texas, slightly west of the longitude of the Sabine River. From the edge of the Sigsbee Escarpment, the Alaminos Canyon extends landward a distance equivalent to 6-7 lease blocks. Our dive sites in AC601 are located in approximately the middle of the canyon and toward the eastern side. Geologically, the sites are located on the top of a breached anticline that generally trends E-W. The base of the Continental Slope is a compressional environment forced by the sedimentary loading upslope. Compressional folding characterizes the strata underlying the Louann salt sheet that is being thrust out over the basin floor. The AC601 area of interest is stratigraphically above one of these compressional features that has been fractured and faulted. The fractures and faults that breach the crestal area of the anticlinal structure provide the migration pathways for transporting fluids and gases to the modern seafloor. The AC601 block is situated directly over the breached anticline crest and consequently, there are a number of well-defined expulsion features in this block. The locations of these features are easily identified on 3D seismic surface reflectivity maps. On subsurface profiles, clear migration pathways to the seafloor can be identified. There are four major reflectivity targets and a number of smaller targets in AC601. The anomaly of interest for this project is in the NW corner of the block. It was mapped with deep tow side-scan sonar and subbottom data in the 1990s. It became clear from analysis of these data that the feature in the NW quadrant of the block was a mounded fluid and gas expulsion feature with some evidence of mudflow activity radiating from the crestal area of the mound. More recent analysis with 3D seismic data indicates high reflectivity targets associated with the mound top and a low amplitude zone to the north of the mound. The high amplitude targets at the crest and on the upper flanks of the mound suggest lithification of the seafloor which usually indicates inactivity of fluidized sediment venting, an old feature. In 2005, a MMS-sponsored ROV survey confirmed the presence of chemosynthetic communities at this site. This survey also found that the low amplitude zone to the north of the mound represented a sizeable brine lake.

Site Summary - Alaminos Canyon 601

There were several impressions of the biology of the brine lake and environs. The first thing noticed after crossing the shoreline and moving over the lake, was an abundance of pelagic sea cucumbers. However many of these were swimming very slowly (even for a sea cucumber) and many others were not swimming at all. After poking a few it was confirmed that many were simply drifting through the "fog." Occasional fish were seen in a similar state.

The first impression of the brine lake was that there was a clear interface and shoreline of brine, with flock aggregations of various sizes floating at this interface. Over that is a more amorphous layer that was referred to as fog. It looks almost smokey. In places, it is thick, in others, especially near some shorelines, it is almost non-existent. The brine below the visible interface is quite clear in some areas, and very cloudy in others. We possibly stirred it up a bit and it will take time to settle. We stay light and move slowly as our "bow wave" is clearly disturbing the interface. After stopping to sample, ALVIN gets just heavy enough to settle on the interface, where it floats nicely. From here the smokey layer can reach the level of the camera bar, but is sometimes

below it (about 1.5 m thick). Looking out the port view-port the interface normally can be seen, but is sometimes in the murk. There are no signs of sea monkeys in the brine or in the smoke.

The shoreline, intertidal, and beach are shown in **Figure 114**. It is very similar in appearance to a beach, with areas of shell deposition, areas of what looks like sand and rocks, and areas of relatively clean beach. The fact that it is littered with trash also brings up images of beaches. There are even carbonates in the shallows that are only partially submerged in the brine. The brine on the shorelines is so clear that it is sometime hard to see. The bathymetry of the shoreline is quite variable on different areas of the lake. On the E. edge a “sand spit” was observed and the shallows extended for quite a distance. On the NW edge, it was a relatively steep dropoff. In areas where we moved along the shoreline 10 m away from the pool (the N-NE edges), an old shoreline (resembling a high tide mark) was clearly visible. Urchins could be seen and, what appeared to be pogonophorans, occasionally small mussel clumps, and very occasionally a few tubeworms on the shoreline 5-10 m from the pool.

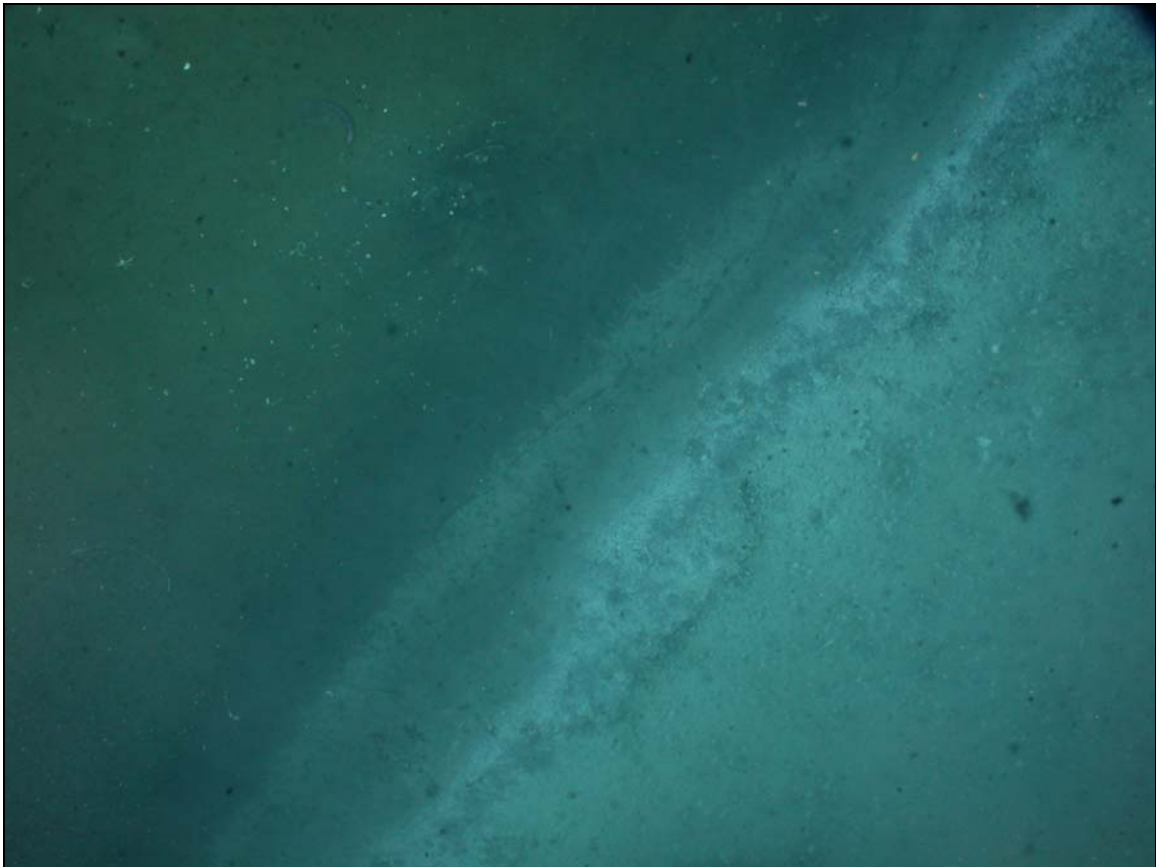


Figure 114. Shoreline of a brine pool at AC601, which was approximately 150 m in diameter.

Up slope to the south, mud prevailed. The common pelagic sea cucumber was very abundant, feeding on the mud. 8-10 were often in view. Near the top of the ridge, the bigger species was moderately abundant with scattered smaller ones (3-4 in the field of view at a time). Near the tops of the ridges, usually on the flanks, scattered exposed carbonates and tubeworm clumps

were observed. Many were isolated clumps without visible carbonates (one of these was collected, along with pieces of the buried carbonate it was attached to.) Many of the clumps were heavily colonized with attached fauna. They generally appeared quite old, but occasional smaller, non-encrusted aggregations were seen. No live mussels were seen on any carbonates outcrops or anywhere except near the pool. The small area of “ridge” to the south did not seem to circle the pool, but it is a minor feature and the “ridge” was not very distinct. The sub went up when it could and detoured a bit when sonar hits were noticed. Quite a few scattered areas with a few nice tubeworm clumps and associated communities and moderate sized carbonate outcroppings were observed (**Figures 115 and 116**).

Two dives were completed at site AC601. **Figures 117 and 118** show the dive track of ALVIN and activities performed during the dives.



Figure 115. Two species of shrimp and epifaunal octocorals on an Escarpia tubeworm at AC601.



Figure 116. Chemosynthetic fauna at AC601 was restricted to isolated aggregations of tubeworms and mussels.

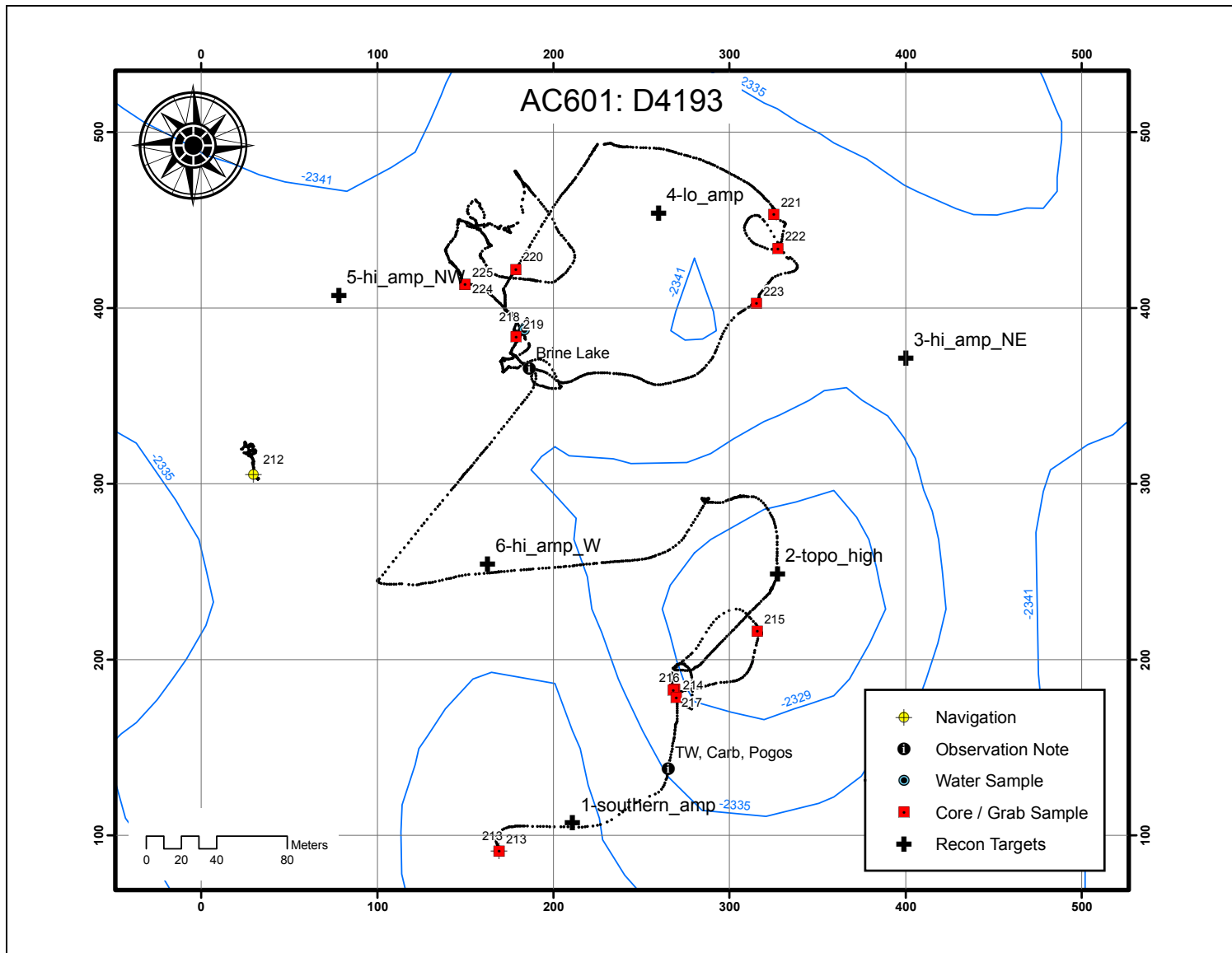


Figure 117. Dive 4193 on 5/28/2006 at an average depth of 2,330 m.

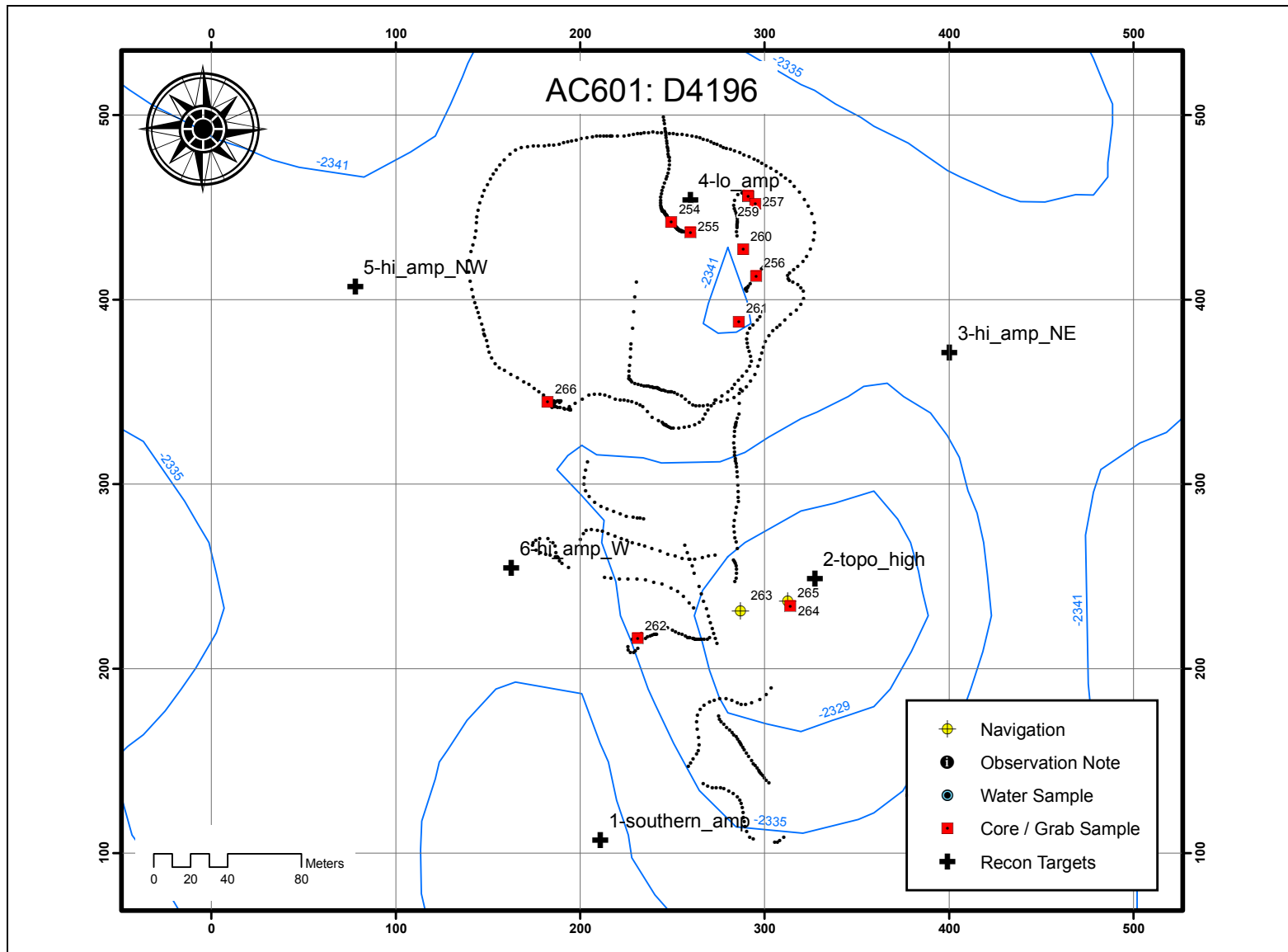


Figure 118. Dive 4196 on 5/31/2006 at an average depth of 2,330 m.

Alaminos Canyon 645

Site Description - Alaminos Canyon 645

Port Observer: Robert Carney, Dive 4194, May 29, 2006, Stbd Observer: Cindy Peterson, Pilot: Mark Speer.

The site has been surveyed as a low 1 km long E-W ridge with topographic highs at the eastern and western end. Previous ALVIN dives found abundant tubeworms (**Figure 119**) and some mussel beds associated with fractured carbonate pavement at the eastern high. The purpose of the dive was to explore for seeps at the western high and then proceed to the eastern high for sampling if sufficient material was not found.

The larger area is typical deep-sea floor covered with light brown oxidized hemipelagic sediments. Conspicuous megafauna included four holothurians (*Benthoodytes typical*, *Benthoodytes lingua*, *Euphronites* sp., and *Benthothurian* sp.) and a whip-like cnidarian. This non-seep fauna was found at targets four and three with no indication of seepage. Transiting to target five, a western-facing slope was encountered with fractured carbonate pavement. Tubeworms were abundant either as clusters among boulders or as a large field. Mussel beds (**Figure 120**) were also present among and adjacent to the carbonates.



Figure 119. Study site with marked tubeworms from 1993 was re-sampled during the final dive (4197).



Figure 120. Mussels at AC645 were coated with a white precipitate not seen at other sites.

Sediments were chemically stained. Although west and south of target five coordinates, this area of lush growth may represent that location. Progressing up slope to NE additional carbonate fields and seep fauna were encountered. Markers left in 1982 were encountered (**Figures 121 and 122**). Soft corals were scattered along the carbonates (**Figure 123**).



Figure 121. Community at AC645 was sampled by ALVIN divers in 1993.



Figure 122. Soft coral colonies were observed on the rocky slope to the north of the main sampling station and marker field at AC645.

Progressing NW and downslope towards target two, seep fauna and carbonates became less common and large expanses of bottom were again holothuroid and whip seapen dominated. In the vicinity of target two, an area of carbonate, tubeworms, dead clams, and mixed live/dead mussels was encountered. Following seep fauna sampling, exploration began westward, southward, eastward, and northward to determine the extent of the seep area. No new seeps were encountered. Only typical non-seep habitats exist surrounding the previously found communities.

Two dives were completed at site A645. **Figures 123 and 124** show the dive track of ALVIN and activities performed during the dives.

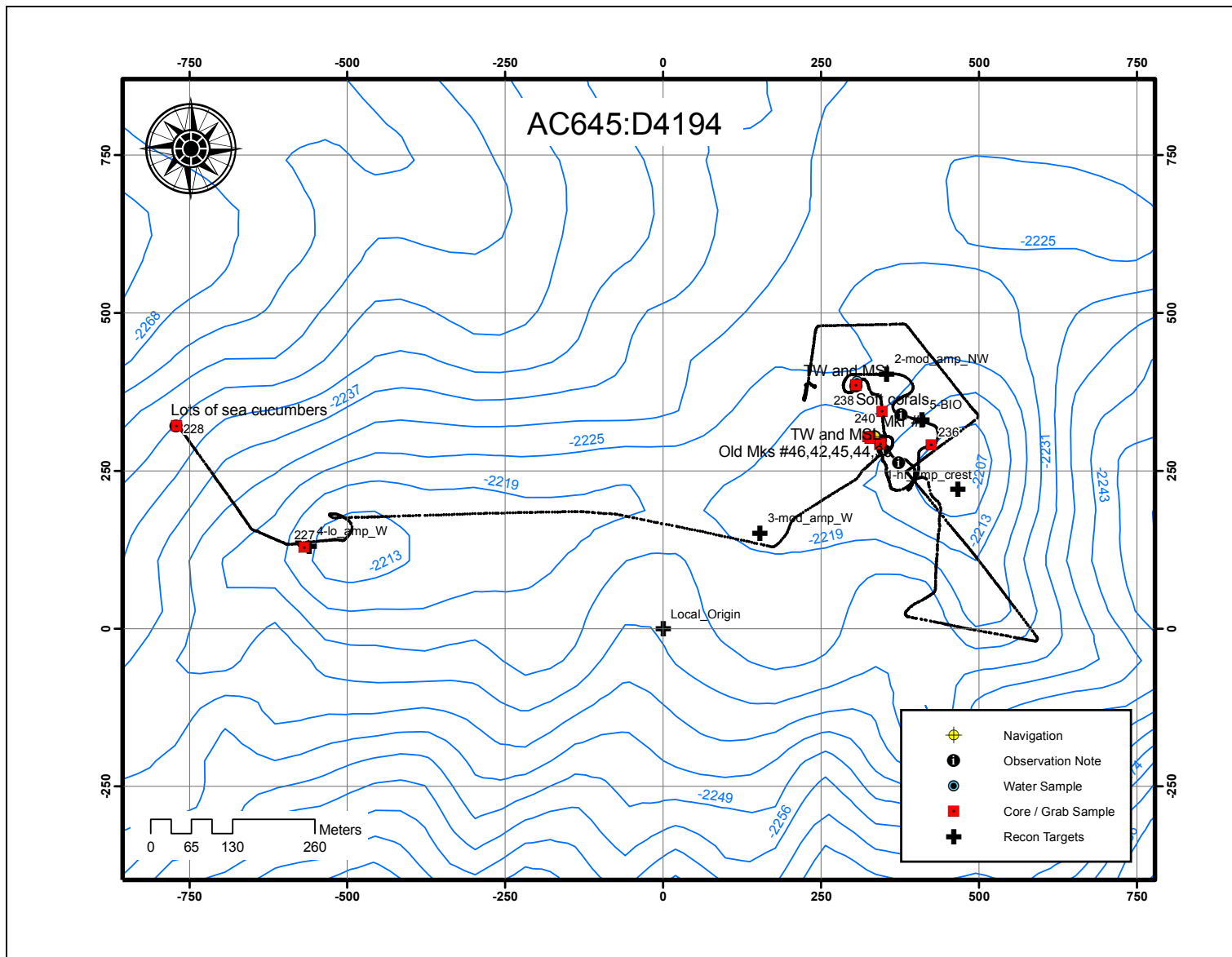


Figure 123. Dive 4194 on 5/29/2006 at an average depth of 2,240 m.

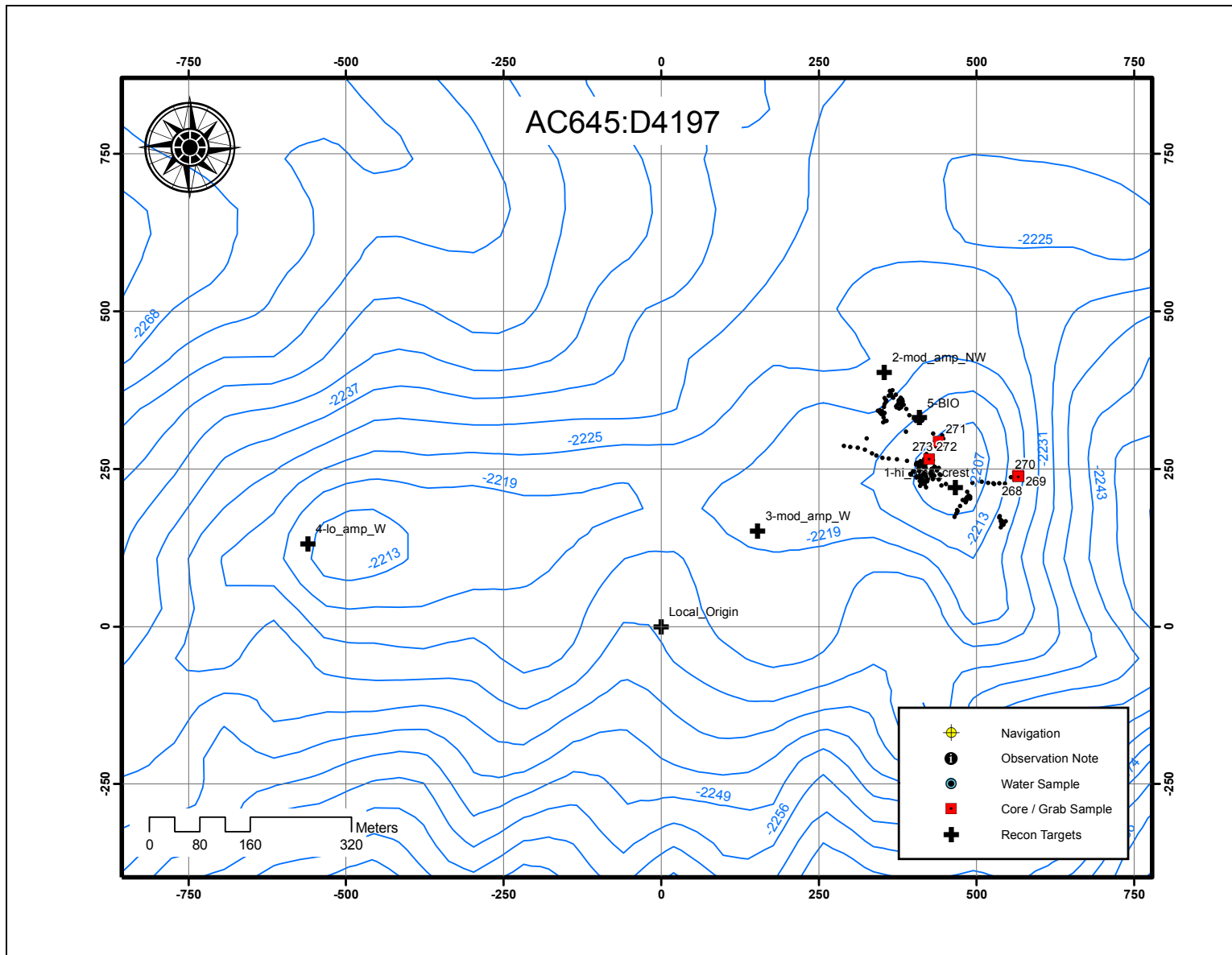


Figure 124. Dive 4197 on 6/01/2006 at an average depth of 2,200 m.

SEEP CARBONATE

During the ALVIN and JASON cruises a total of 99 samples of seep carbonate were collected. These samples were initially photographed in the laboratory, slabbed, and rephotographed resulting in a total of 712 photographs. Subsamples of the carbonate slabs were selected for thin sections (**Figure 125**). To date 108 thin sections have been made. We are just starting on the SEM work and so far only 17 samples have been analyzed. This work has resulted in 198 photomicrographs. In order to determine the mineralogy of the samples X-ray diffraction analyses were conducted. A total of 116 samples have been analyzed so far. Analyses for trace elements and rare earth elements were also conducted. So far, 116 samples have been analyzed. Dating of samples is an important analysis that is currently underway. A total of 27 samples have been submitted for AMS dating. A critical geochemical analysis for characterization of seep carbonates is stable isotopes of carbon and oxygen. A total of 478 samples have been submitted for analysis. A total of 174 of these have been completed. The following sections address details of the analysis techniques.

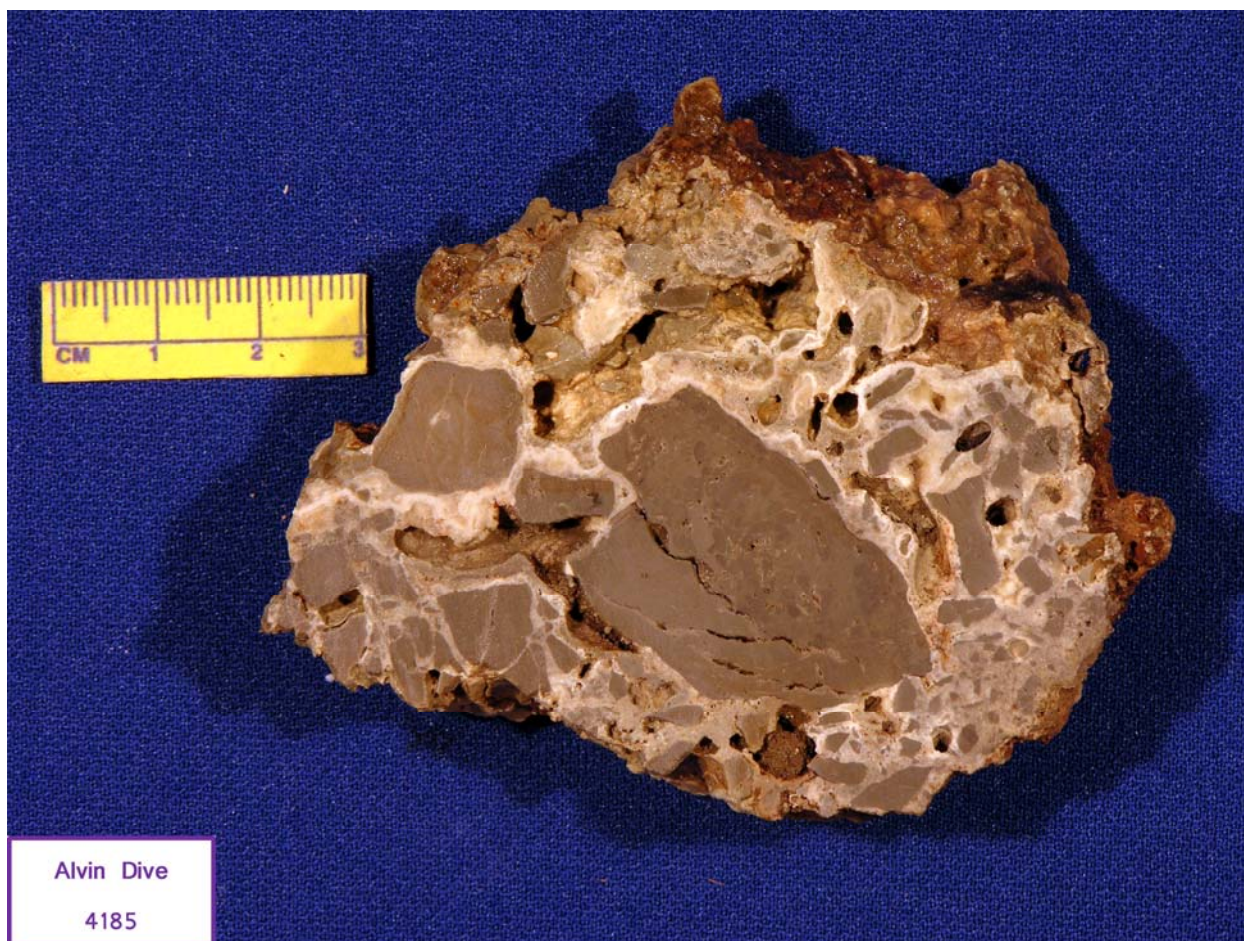


Figure 125. Example of slab sample from ALVIN Dive 4185.

Petrographic observation of thin sections of the samples was made using a LEICA-DMRX optical microscope with Leica Qwin Program. The microstructure of the seep carbonate on the fresh surfaces of fractured samples was examined with a scanning electron microscope (SEM).

The samples were prepared by gold coating to a thickness of ~200 Angstroms for the SEM observations. Photographs were taken using a Sirion 200 FE-SEM equipped with EDAX GENESIS. For X-ray diffraction (XRD), the samples were crushed into powder less than 200 mesh using an agate mortar and pestle. The XRD analyses were performed using a Rigaku DXR 3000 computer-automated diffractometer utilizing Bragg-Brentano geometry. The X-ray source was a Cu anode operated at 40 kV and 40 mA using CuK α radiation equipped with a diffracted beam graphite monochromator. The orientated samples were scanned at an interval of 5–65° (2 θ) with a step size of 0.02° and count time of 5 seconds per step. Divergence, scattering, and receiving slits were 0.5°, 0.5° and 0.15 mm, respectively. Relative abundance of the minerals was semi-quantified by Rietveld analysis of the diffractograms with the program SIROQUANT.

The powdered samples were processed with 100% phosphoric acid to release CO₂ for stable carbon and oxygen isotope analysis. Carbonate carbon and oxygen isotopic compositions in permil (‰) relative to PeeDee Belemnite (PDB) standard were measured by using the GV Isoprime II stable isotopic mass spectrometry with deviations less than 0.01‰ (2 σ) for both $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values.

The seep carbonate powder (0.1–0.5 g) was treated with 50 ml of 5% HNO₃ in a centrifuge tube for 2–3 hours to separate the carbonate mineral phase and residue phase. Then, 2500 ng of Rhodium was added as an internal standard for calculating the element concentration of dissolved carbonate mineral phase. Five milliliters of this solution was further diluted 10 times to be used for the REE and trace elements analysis by using Finnigan MAT ELEMENT high resolution ICP-MS. Precision of the REE and trace element analysis was checked by multiple analyses of international carbonate standard samples CAL-S. The average standard deviations are less than 10%, and average relative standard deviations are better than 5%.

AUTONOMOUS UNDERWATER VEHICLE (AUV)

The original dive sites for the 2006 ALVIN cruise were prioritized on the basis of character on 3-D seismic surface reflectivity maps and associated subsurface profiles coupled with bottom photographs acquired on a separate cruise prior to using ALVIN. Great success was achieved using this pre-dive analysis of existing 3-D seismic data and acquiring bottom photography on transects across critical sites. As a product of these procedures, chemosynthetic communities were found at all 10 of the dive sites visited. These sites ranged from the deep eastern Gulf (N 27 38.8'; W 88 21.7') to the far western Gulf (N 26 11.0'; W 94 37.4').

However, mapping bathymetry of our primary sites using 3-D seismic as a database was not a very accurate method, especially if the objective for a detailed bathymetric map was to provide a template for spatially constraining samples of chemosynthetic communities, surrounding sediments and hard substrates, and other non chemoautotrophic fauna. So, funding was provided in the first year of the contract to have four of our key sampling sites mapped in great detail using the C&C Technologies Autonomous Underwater Vehicle (AUV) in preparation for intensive sampling planned for the 2007 field season. The AUV is equipped with instrumentation for collecting high-resolution multibeam bathymetry, chirp sonar subbottom profiles, and side-scan sonar swaths. These data are well constrained with excellent navigation and the data sets are acquired as the AUV travels at a constant height, 40 m, above the seabed. The AUV data sets for AT340, GC852, WR269, and AC601 were acquired in February 2007. Results are being formatted as a database for sampling these four locations during the **JASON ROV** work this summer (June-July, 2007).

Details of the C&C Technologies Autonomous Underwater Vehicle (AUV) are given in the AUV Appendices, as are the results of the AUV imaging.

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APPENDIX A – RECONNAISSANCE CRUISE

Appendix 1 - Cumulative Event Log

PROGRESS REPORT 10 to 24 March 2006

R/V GYRE e-mail: gyre@txcyber.com Nav Room Iridium: 011-881-621-449-529 Bridge Iridium: 011- 881-621-449-967	TDI-Brooks International, Inc e-mail: drjmbrooks@aol.com Phone: 979-696-3634 (Jim Brooks direct) Phone: 979-693-3446 (Texas office)
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TDI-Brooks Job# J06553	Cumulative Report	MMS Chemo III
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MMS CHEMO III PHOTO RECONNAISSANCE GULF OF MEXICO

Event Log for 10-24 March 06 (UTC = Local)

Site	Start	End	Activity	Depth	Comments
<i>Friday 10 Mar</i>					
Mobilize	0800	2,200	Mobilize		Freeport TX
Transit	2230	0000	Transit		In route to Keathly Canyon
<i>Saturday 11 Mar</i>					
Transit	0000	2400	Transit		Slow speed in heavy seas
<i>Sunday 12 Mar</i>					
Transit	0000	0430	Transit		Arrival at Keathley Canyon 243 station
KC243	0430	1600	Preparation		Trouble shooting camera strobe interface
KC243A	1602	1929	Phototransect	1650m	Successful photo-survey of KC243A
Transit	1940	2400	Transit		Transit to KC333
<i>Tuesday 14 Mar</i>					
KC216	0000	0545	Photo survey		KC216 Knoll with flow channels, anomaly on basin flank ENE
Transit	0600	0900	Underway		Transit to KC129
KC129	1025	1338	Photo survey		KC129 Anomalies on E flank of low mound
Transit	1500	1600	Meeting		Science planning meeting
Transit	1600	2100			Transit to GC852
GC852	2,200	0000	Survey	1448	Photo survey GC852
<i>Wednesday 15 March</i>					
GC852	0000	0200	Survey		GC852—Camera turned off on launch. No data
GC852	0300	0800	Survey	1448	Completed photosurvey of GC852
Transit	0830	1130	Underway		Transit to GC767
GC767	1200	1400	Survey	1,586	Completed survey of GC767
Transit	1430	1600	Underway		Transit to GC812
GC812	1700	2000	Survey	1802	Completed survey of GC812
Transit	2000	0000	Underway		Transit to GC817
<i>Thursday 16 March</i>					
Transit	0000	0030	Underway		Transit to GC817
GC817	0120	0730	Survey	1449	Completed survey of GC817
Transit	0800	0930	Underway		Transit to GC600
GC600	0930	1700	Standby		Standby while drift camera battery recharges
GC600	1715	2115	Survey	1187	Completed survey of GC600
Transit	2215	0000	Underway		Transit to GC296

Friday 17 March					
Transit	0000	0230	Underway		Transit to GC296
GC296	0300	0700	Survey	980	Completed survey of GC296
Transit	0730	1400	Underway		Transit to MC981
MC981	1400	0715	Survey	1300	Completed survey of MC981
Transit	1730	0000	Underway		Transit to Venice LA
Saturday 18 March					
Transit	0000	0700	Underway		Transit to Venice LA arrive 0700
Venice	0700	1630	Crew change		Crew change & reprovision
Transit	1630	0000	Underway		Transit to MC462
Sunday 19 March					
Transit	0000	0130	Underway		Transit to MC462
MC462	0200	0600	Survey	960	Completed survey of MC462
Transit	0700	0900	Underway		Transit to MC548
MC548	0900	1300	Standby		Rigging trawl, trawling at wrong depth, fixing A-frame
MC548	1330	1600	Trawling	1,000	Completed trawl station 1 at MC548
Transit	1700	1800	Underway		Transit to MC685
MC685	1815	2145	Trawling	1500	Attempting trawl at MC685
Transit	2,200	0000	Underway		Transit to MC640
Monday 20 March					
MC640	0015	0445	Survey	1404	Completed survey of MC640
Transit	0500	1,000	Underway		Underway to MC908 trawl site
Transit	1,000	1200	Underway		Transit to AT340 photosurvey site. Wait on weather/battery charge
AT340	1330	1740	Survey	2242	Completed survey of AT340 site
MC908	1800	2,200	Box core	2000	Attempt box core at MC908
Tuesday 21 March					
AT342	0045	0430	Survey	1404	Completed survey of AT342
Transit	0500	1,000	Underway		Transit to trawl station
AT209	1030	1400	Trawling	2500	Completed trawl of AT209 station
Transit	1400	0000	Underway		Transit to GC868 photo station ETA 3/22 10:00
Wednesday 22 March					
Transit	0000	1,000	Underway		Transit to GC868
GC868	1115	1514	Survey	1360-1460	Photosurvey GC868—camera malfunction, no images, repair and repeat
GC868	1800	2115	Survey	1360-1460	Completed photosurvey of GC868
Transit	2130	0000	Underway		Transit to WR269
Thursday 23 March					
Transit	0000	0900	Underway		Transit to WR269
WR269/270	1,000	1400	Survey	1925	Completed survey of WR269/270 combined site
Transit	1400	1445	Underway		Transit to WR265 box core site
WR265	1500	2100	Sampling	1820	Took two box cores
Transit	2100	2130	Underway		Transit to WR268
WR268	2,200	0000	Survey	1860	Photosurvey of WR268
Friday 24 March					
WR268	0000	0150	Survey	1860	Completed survey of WR268
Transit	0230	0000	Underway		Return to Freeport TX

Appendix 2 - Site Occupation Log

Stations occupied, station adjustments, comments

Name	Latitude	Longitude	Depth	Preliminary comments
<i>12 March</i>				
KC243	N26° 45 01	W92° 49 45	1610	Designated station offset from amplitude anomaly
KC243A	N26° 43 50.23	W92° 49 52.00	1656	Repositioned station to conform to amplitude—offset ~2km south. 747 survey photos
<i>13 March</i>				
KC333	N26° 45' 01"	W92° 49' 45"	1610	Mussel bed, bacterial mats & discolored sediments
KC514	N26° 43' 50.23"	W92° 49' 52.00"	1656	Small brine channels, isolated shells
<i>14 March</i>				
KC216	N26° 42.01'	W92° 00.02'	1754	Brine pools & brine channels, bacterial mats, solitary shells
KC129	N26° 51.28'	W92° 54.78'	1691	Small brine channels, isolated shells, no significant chemo fauna in preliminary review of photos
<i>15 March</i>				
GC852	N27° 06.75'	W91° 09.85'	1448	Abundant tubeworms and mussels amid large carbonate boulders with soft corals. Lush site.
GC767	N27° 12.27'	W91° 00.51'	1,586	Bacterial mats, brine stained sediments, solitary shells
GC812	N2708° 08.69'	W90° 58.05	1802	Brine stained depressions, bacterial mats, solitary tube worms, carbonates.
<i>16 March</i>				
GC817	N27° 08.96'	W90° 43.36'	1423	Dense mussel bed, carbonates, bacteria
GC600	N27° 21.98	W90° 33.85	1249	Carbonates, living & dead clams, mussel shells, solitary tubeworms
<i>17 March</i>				
GC296	N27°40.28'	W90°21.67'	994	Well site where blow out occurred. Brine-stained sediments, large mud pool at well site, sparse bacteria
MC981	N27°58.43'	W89°17.70'	1300	Anomalies along terrace. Large mud volcano—mud pool and mud flows. Brine-stained sediments bacteria mats, solitary mussel shells.
<i>19 March</i>				
MC462	N28°29.80	W88°53.03'	983	Anomalies with bacterial mat, occasional small carbonates, sparse bacterial mats
MC548	N28°24.29'	W88°58.05'	1,000	Good recovery of assorted benthic organisms
MC685	N28°17.25'	W88°44.35'	1500	Aborted due to bottom obstruction, sparse recovery of organisms
<i>20 March</i>				
MC640	N28°21.35'	W88°47.58'	1404	Collected ~1100 bottom in view photos. Abundant mussels, extensive brine flows with bacteria mats, carbonates, small cluster of tube worms.
AT340	N27°38.78'	W88°21.95'	2242	About 800 BIV photos showed abundant mussels, carbonates, and clusters of tube worms. Observed numerous burrowing echinoids, which

MC908	N28°0395'	W88°34.96'	2000	make trails through bacteria mats. Attempted box core. Reached bottom, but core did not trigger.
21 March				
AT342	N27°40.00'	W88°16.18	2375	This was a mud volcano with a 300 m wide crater surrounded by steeply sloping sides particularly in the S. We collected about 700 BIV photos, but surveying was challenging because the bottom gave very poor returns for the altimeters. Observed widespread mud flows and a crater filled with muddy fluid. SE side of crater had abundant clam shell fields. Observed an area of brine-stained sediments with bacterial mats and a cluster of mussels.
AT209	N27°46.73'	W88°19.30'	2500	Good collection of assorted deep-sea fauna. Abundant ophiuroids and holothuroids. Several fish and crustaceans.
22 March				
GC868	N27°06.26'	W90°22.59'	1360-1460	This station was a series of anomalies on a steep slope and top of escarpment. Scant indicators of seepage and solitary bivalve shells.
23 March				
WR269/270	N26°40.59'	W91°40.56'	1952	This site comprise a series of anomalies and topographic highs at the border between WR269 and WR270 lease blocks. Survey retraced the 3D seismic lines to the extent possible under challenging sea conditions. One small cluster of bivalves and one patch of brine & bacteria mats was observed.
WR265	N26°40.95'	W91°53.14'	1820	This was a non-seep site chosen for box coring to collect background tissue samples of benthic fauna. Two 30x30cm box cores were successfully collected at this site.
WR268	N26°41.17'	W91°45.76'	1862	This site was a series of high amplitude anomalies in a small area at the crest a mound. With good coverage of this area no chemosynthetic megafauna were observed and only scant bacterial mats or other indicators of seepage

APPENDIX B – DCCC CRUISE

Appendix 1. Navigation Target Positions

AT340

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N27 38.50000	W088 22.20000	0	0	
1-Launch BM	N27 38.67600	W088 21.90200	494	320	2,182
2-Mussels-BeerCan	N27 38.84577	W088 21.72023	796	630	2,216
3-Lo_Amp	N27 38.91826	W088 21.77264	711	765	2,213
4-Hi_Amp_Rim	N27 38.95293	W088 21.84751	589	830	2,218
5-Lo_Amp	N27 38.91962	W088 21.98060	369	771	2,207
6-Mussels-Mats	N27 38.82016	W088 21.99486	344	587	2,207
7-Topo_High	N27 38.63063	W088 21.90074	495	236	2,192
8-Hi_Amp	N27 38.68041	W088 21.81164	642	326	2,204
9-Geo_Focal_Point	N27 38.84309	W088 22.17553	47	633	2,213
10-Hi_Amp	N27 38.66138	W088 22.11501	143	296	2,192
11-West_Topo_Hi	N27 38.84205	W088 22.41383	-345	635	2,182
12-Tubies-Mussels	N27 38.67360	W088 21.89610	503	315	2,195
13-Orange_Mat	N27 38.74590	W088 22.02100	299	451	2,201
14-Heart_Urchins	N27 38.84020	W088 22.11320	150	627	2,200
WGS84 UTM16					
Central Meridian		W087 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-3,058,258.71	
False Easting			135,152.20		
Local Origin					
N3058258.71m					
E364847.80m					

GC600

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N27 21.9	W090 34.7	0	0	
1	N27 22.38960	W090 34.52590	270	910	
2	N27 22.35650	W090 34.50360	307	849	
3	N27 22.16180	W090 34.28370	677	497	
4	N27 22.13070	W090 34.06731	1,035	446	
5	N27 22.29970	W090 34.33556	587	750	
6	N27 22.15775	W090 33.92080	1,276	501	
7	N27 22.12116	W090 33.94481	1,237	433	
8	N27 22.38280	W090 34.43158	425	900	
9	N27 22.46869	W090 34.51759	280	1,056	
10	N27 22.44819	W090 34.36051	540	1,023	
11	N27 22.01970	W090 33.84760	1,401	249	
12	N27 21.98000	W090 33.81300	1,460	176	
WGS84 UTM15					
Central Meridian		W093 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-3,029,191.05	
False Easting			-239,526.99		
Local Origin					
N3029191.05m					
E739526.99m					

WR269

Target	Latitude	Longitude	X (m)	Y (m)	Depth (m)
Local_Origin	N26 40.50000	W091 40.50000	0	0	
1	N26 41.14132	W091 39.56046	1,546	1,200	
2	N26 41.14446	W091 39.74229	1,244	1,203	
3	N26 41.21387	W091 39.96005	882	1,327	
4	N26 40.99515	W091 40.17158	535	920	
5	N26 41.01827	W091 40.34520	247	960	
6	N26 40.72553	W091 40.30552	318	420	
WGS84 UTM15					
Central Meridian		W093 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-2,951,123.79	
False Easting			-131,843.00		
Local Origin					
N2951123.79m					
E631843.00m					

KC243

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local Origin	N26 43.7	W092 50.0	0	0	1,672
1-mussels	N26 43.81200	W092 49.83500	273	207	1,656
2-tubeworms	N26 43.83600	W092 49.86600	222	251	1,656
3-geo	N26 43.87339	W092 49.78109	362	321	1,650
WGS84 UTM15					
Central Meridian		W093 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-2,956,357.08	
False Easting			-16,575.43		
Local Origin					
N2956357.08m					
E516575.43m					

GC852

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N27 06.1	W091 10.2	0	0	
1-tubes_mussels	N27 06.320	W091 09.962	387	412	
2-mussels_tubes	N27 06.378	W091 09.959	391	519	
3-soft_corals	N27 06.586	W091 09.927	438	904	
4-red_soft_coral	N27 06.626	W091 09.975	358	977	
5-soft_reflector	N27 06.20083	W091 09.93492	435	193	
6-high_reflector	N27 06.49466	W091 10.09557	162	731	
7-topo_high	N27 06.60334	W091 10.01904	286	934	
8-geo_reflector	N27 06.72,200	W091 09.86759	533	1,157	
9-topo_high_reflector	N27 06.87347	W091 09.79281	652	1,438	
10-Jason_geoA	N27 07.09276	W091 09.95591	377	1,839	
11-Jason_geoB	N27 07.21342	W091 09.95762	371	2,062	
12-Jason_geoC	N27 07.14364	W091 09.82149	597	1,936	
WGS84 UTM15					
Central Meridian		W093 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-2,999,016.02	
False Easting			-181,418.40		
Local Origin					
N2999016.02m					
E681418.40m					

MC853

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N28 07.0000	W089 08.7000	0	0	
1-lanA	N28 07.64310	W089 08.46960	398	1,181	
2-lanB	N28 07.64610	W089 08.60440	178	1,191	
3-topo_high	N28 07.38005	W089 08.38549	527	693	
4-geoA	N28 07.31668	W089 08.54517	264	580	
5-geoB	N28 07.12567	W089 08.26496	716	220	
6-geoC	N28 07.23794	W089 08.15560	899	424	
new_mussel_bed	N28 07.61990	W089 08.47970	381	1,139	
Previous_Marker_C 3	N28 07.60411	W089 08.53554	289	1,111	
WGS84 UTM16					
Central Meridian		W087 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-3,111,985.51	
False Easting			210,701.78		
Local Origin					
N3111985.51m					
E289298.22m					

MC640

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N28 21.2	W088 47.7	0	0	
1-Bio	N28 21.4147	W088 47.5508	250	393	
2-Bio	N28 21.3885	W088 47.5411	265	344	
3-Bio	N28 21.4436	W088 47.6221	134	448	
4-Bio	N28 21.2580	W088 47.5443	256	103	
4-hi_amp	N28 21.25792	W088 47.57867	200	104	
5-topo_high	N28 21.31234	W088 47.57106	214	204	
6-hi_amp	N28 21.36221	W088 47.56422	226	296	
7-hi_amp	N28 21.39477	W088 47.61252	148	358	
8-edge_amp	N28 21.44488	W088 47.64491	97	451	
9-hi_amp	N28 21.35398	W088 47.67408	47	284	
10-flow?	N28 21.28187	W088 47.70783	-11	151	
WGS84 UTM16					
Central Meridian		W087 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-3,137,652.93	
False Easting			175,925.82		
Local Origin					
N3137652.93m					
E324074.18m					

AC818

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N26 10.3	W094 37.7	0	0	
3-geo	N26 10.87071	W094 37.35272	592	1,046	
7-geo	N26 10.39953	W094 37.61391	146	182	
2-geo	N26 10.99434	W094 37.36435	575	1,275	
1-geo	N26 11.10067	W094 37.32450	644	1,470	
5-geo	N26 10.73630	W094 37.37069	559	799	
WELLHEAD	N26 10.78663	W094 37.37362	555	892	
6-geo	N26 10.60057	W094 37.50598	330	551	
ROV chemo	N26 10.80933	W094 37.38367	539	934	
WGS84 UTM15					
Central Meridian		W093 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-2,895,715.18	
False Easting			162,735.70		
Local Origin					
N2895715.18m					
E337264.30m					

AC601

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N26 23.3	W094 31.0	0	0	
2-topo_high	N26 23.43701	W094 30.80559	326	249	
1-southern_amp	N26 23.35948	W094 30.87494	209	107	
3-hi_amp_NE	N26 23.50382	W094 30.76258	399	372	
4-lo_amp	N26 23.54766	W094 30.84760	259	454	
5-hi_amp_NW	N26 23.52115	W094 30.95653	77	407	
6-hi_amp_W	N26 23.43895	W094 30.90413	162	255	
WGS84 UTM15					
Central Meridian		W093 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-2,919,580.57	
False Easting			151,292.71		
Local Origin					
N2919580.57m					
E348707.29m					

AC645

Target	Latitude	Longitude	Local X (m)	Local Y (m)	Depth (m)
Local_Origin	N26 21.1	W094 30.1	0	0	
1-hi_amp_crest	N26 21.22265	W094 29.82120	466	221	
2-mod_amp_NW	N26 21.32091	W094 29.89063	353	404	
3-mod_amp_W	N26 21.18310	W094 30.00991	152	152	
4-lo_amp_W	N26 21.16761	W094 30.43800	-561	131	
WGS84 UTM15					
Central Meridian		W093 00.0000			
Latitude of Origin	N00 00.0000				
Scale Factor	0.999600				
False Northing				-2,915,501.39	
False Easting			149,843.49		
Local Origin					
N2915501.39m					
E350156.51m					

Appendix 2. Niskin Log

Site	Dive #	Niskin #	Collection Date	Collection Time	Used for	By	Processed
MC853	4178	1	5/14/2006	not fired	--	--	--
MC853	4178	2	5/14/2006	19:01	gas analysis	Joye	5/14/2006
MC853	4178	3	5/14/2006	19:01	gas analysis	Joye	5/14/2006
MC853	4178	4	5/14/2006	16:45	gas analysis	Joye	5/14/2006
MC853	4178	5	5/14/2006	16:45	gas analysis	Joye	5/14/2006
AT340	4179	1	5/15/2006	not fired	--	--	--
AT340	4179	2	5/15/2006	not fired	--	--	--
AT340	4179	3	5/15/2006	not fired	--	--	--
AT340	4179	4	5/15/2006	not fired	--	--	--
AT340	4179	5	5/15/2006	16:27	gas analysis	Joye	5/15/2006
AT340	4180	1	5/16/2006	not fired	--	--	--
AT340	4180	2	5/16/2006	18:56	gas analysis	Joye	5/16/2006
AT340	4180	3	5/16/2006	18:32	gas analysis	Joye	5/16/2006
AT340	4180	4	5/16/2006	17:42	gas analysis	Joye	5/16/2006
AT340	4180	5	5/16/2006	17:17	gas analysis	Joye	5/16/2006
AT340	4181	1	5/17/2006	16:22	gas analysis	Joye	5/17/2006
AT340	4181	2	5/17/2006	not fired	--	--	--
AT340	4181	3	5/17/2006	19:39	gas analysis	Joye	5/17/2006
AT340	4181	4	5/17/2006	not fired	--	--	--
AT340	4181	5	5/17/2006	not fired	--	--	--
GC600	4182	1	5/18/2006	15:37	gas analysis	Joye	5/18/2006
GC600	4182	2	5/18/2006	15:37	gas analysis	Joye	5/18/2006
GC600	4182	3	5/18/2006	16:25	gas analysis	Joye	5/18/2006
GC600	4182	4	5/18/2006	16:25	gas analysis	Joye	5/18/2006
GC600	4182	5	5/18/2006	17:42	gas analysis	Joye	5/18/2006

Site	Dive #	Niskin #	Collection Date	Collection Time	Used for	By	Processed
GC852	4189	1	5/24/2006	17:09	gas analysis	Joye	5/24/2006
GC852	4189	2	5/24/2006	17:09	gas analysis	Joye	5/24/2006
GC852	4189	3	5/24/2006	17:09	gas analysis	Joye	5/24/2006
GC852	4189	4	5/24/2006	18:03	gas analysis	Joye	5/24/2006
GC852	4189	5	5/24/2006	18:03	gas analysis	Joye	5/24/2006
WR269	4190	1	5/25/2006	18:13	gas analysis	Joye	5/25/2006
WR269	4190	2	5/25/2006	18:13	gas analysis	Joye	5/25/2006
WR269	4190	3	5/25/2006	18:13	gas analysis	Joye	5/25/2006
WR269	4190	4	5/25/2006	18:13	gas analysis	Joye	5/25/2006
WR269	4190	5	5/25/2006	18:13	gas analysis	Joye	5/25/2006
AC818	4191	1	5/26/2006	16:13	gas analysis	Joye	5/26/2006
AC818	4191	2	5/26/2006	17:13	gas analysis	Joye	5/26/2006
AC818	4191	3	5/26/2006	18:02	gas analysis	Joye	5/26/2006
AC818	4191	4	5/26/2006	18:02	gas analysis	Joye	5/26/2006
AC818	4191	5	5/26/2006	18:41	gas analysis	Joye	5/26/2006
AC601	4193	1	5/28/2006	17:08	gas analysis	Joye	5/28/2006
AC601	4193	2	5/28/2006	17:08	gas analysis	Joye	5/28/2006
AC601	4193	3	5/28/2006	17:08	gas analysis	Joye	5/28/2006
AC601	4193	4	5/28/2006	17:08	gas analysis	Joye	5/28/2006
AC601	4193	5	5/28/2006	17:08	gas analysis	Joye	5/28/2006
AC645	4194	1	5/29/2006	17:07	gas analysis	Joye	5/29/2006
AC645	4194	2	5/29/2006	17:07	gas analysis	Joye	5/29/2006
AC645	4194	3	5/29/2006	17:07	gas analysis	Joye	5/29/2006
AC645	4194	4	5/29/2006	18:41	gas analysis	Joye	5/29/2006
AC645	4194	5	5/29/2006	18:41	gas analysis	Joye	5/29/2006

Appendix 3. CTD Log

Date	Site	CTD Cast #	# bottles tripped
5/15/2006	AT340	1	23
5/17/2006	AT340	2	20
5/20/2006	GC852	3	18
5/22/2006	GC852	4	20
5/22/2006	GC852	5	21
5/29/2006	AC601	6	23
5/31/2006	AC601	7	23

Appendix 4. Hard Corals

Dive Number	Date	Sample Description
4190	25-May-2006	One hard coral sample, tentative identification, <i>Solenosmilia variabilis</i>

Appendix 5. Hydrocarbon Analysis Samples

Site	Crude Oil Samples (Jars)		Site	Gas Samples (Cans)
AT340	4173-Y2			Blank
	4173-R3		AT340	4173-Y6
GC600	4174-Pot		GC600	4174-Y5
	4174-Y2			4174-Y6
	4174-Y4		KC243	4176-R1
	4174-R1		GC852	4177-R4
WR269	4175-Y5			4177-R3
KC243	4176-Rk/Sed		MC853	4178-Y1
	4176-R1			4178-R5
GC852	4177-R4			4178-Y6
MC853	4178-Y2			4178-R3
	4178-R4		MC640	4182-R6
MC640	4182-R2		AT340	4183-R4
	4182-R6			4183-Y3
AT340	4183-R5		GC600	4184-Y3
	4183-R4			4184-Y6
	4183-R5		GC852	4189-R6
GC600	4184-Y4		WR269	4191-R6
	4184-R5		AC818	4192-Y1
GC852	4189-R6		AC601	4193-R2
WR269	4191-R6		AC601	4196-Y4
AC818	4192-Y1			
AC601	4193-Y2			
AC818	4195-Y2 (small sample)			
AC601	4196-Y4			

Appendix 6. Authigenic Carbonate Samples

Dive Number	Dive Site	Date	Comments
4173	AT340	5/9/2006	4 samples (3 mussel grab, 1 tube worms)
4174	GC600	5/10/2006	3 samples
4175	WR269	5/11/2006	No sample
4176	KC243	5/12/2006	2 samples (mussel scoop)
4177	GC852	5/13/2006	2 samples (mussel scoop)
4178	MC853	5/14/2006	2 samples (carb. slab, barite)
4179	AT340	5/15/2006	1 sample
4180	AT340	5/16/2006	1 sample (large block)
4181	AT340	5/17/2006	1 sample (small sample-mussel pot #2)
4182	MC640	5/18/2006	2 samples (large slab, frags mussel scoop,aft)
4183	AT340	5/19/2006	2 small samples (bushmaster, baby tubies)
4184	GC600	5/20/2006	4 samples (2 slabs clam site#1, 2 bags frags clam site #2)
4185	GC852	5/21/2006	3 rock samples (near benchmark)
4186	GC852	5/22/2006	2 samples (TW site/bushmaster bag)
Trawl AT-6	GC852	5/22/2006	3 samples (scale and carbonates)
4187	GC852	5/23/2006	2 samples (top mound/mussel pot)
4188	GC852	5/24/2006	Lost dive-sub power problems
4190	GC852	5/25/2006	Hard coral sample
4191	WR269	5/26/2006	1 rock sample
4192	AC818	5/27/2006	1 small bag rocks (mussel pot), 1 small rock from biobox
4193	AC601	5/28/2006	1 large rock sample (ridge crest), 1 small rock sample (scoop net)
4194	AC645	5/29/2006	2 large rock samples(bottom and top of mound)
4195	AC818	5/30/2006	2 large rock samples, 1 bag of small rocks-mussel scoop, 1 bag of small rocks-bushmaster
4196	AC601	5/31/2006	2 rock samples, 1 group of rock samples, bushmaster
4197	AC645	6/1/2006	2 large samples (top mound), 1 sample (base of mound)

Appendix 7. Core Log

Site	Dive #	Core #	Collected	Used for	By	Processed
AT340	4173	Y1	5/9/2006	porewater	Joye	5/9/2006
AT340	4173	Y2	5/9/2006	microbiol	Joye/Bright	5/9/2006
AT340	4173	Y3	5/9/2006	animals	Bright	5/10/2006
AT340	4173	Y4	5/9/2006	rates	Joye	5/10/2006
AT340	4173	Y5	5/9/2006	animals	Bright	5/10/2006
AT340	4173	Y6	5/9/2006	hydrocarb	Bernard	5/10/2006
AT340	4173	R1	5/9/2006	porewater	Joye	5/9/2006
AT340	4173	R2	5/9/2006	??	??	??
AT340	4173	R3	5/9/2006	hydrocarb	Bernard	5/10/2006
AT340	4173	R4	5/9/2006	rates	Joye	5/10/2006
AT340	4173	R5	5/9/2006	microbiol	Joye/Bright	5/10/2006
AT340	4173	R6	5/9/2006	microbiol	Joye/Bright	5/10/2006
GC600	4174	Y1	5/10/2006	animals	Bright	5/11/2006
GC600	4174	Y2	5/10/2006	porewater	Joye	5/10/2006
GC600	4174	Y3	5/10/2006	NO CORE	--	--
GC600	4174	Y4	5/10/2006	microbiol	Joye/Bright	5/11/2006
GC600	4174	Y5	5/10/2006	hydrocarb	Bernard	5/11/2006
GC600	4174	Y6	5/10/2006	NO CORE	--	--
GC600	4174	R1	5/10/2006	rates	Joye	5/11/2006
GC600	4174	R2	5/10/2006	animals	Bright	5/11/2006
GC600	4174	R3	5/10/2006	animals	Bright	5/11/2006
GC600	4174	R4	5/10/2006	rates	Joye	5/11/2006
GC600	4174	R5	5/10/2006	microbiol	Joye/Bright	5/11/2006
GC600	4174	R6	5/10/2006	porewater	Joye	5/10/2006
GC852	4177	R1	5/13/2006	porewater	Joye	5/13/2006
GC852	4177	R2	5/13/2006	microbiol	Joye/Bright	5/14/2006
GC852	4177	R3	5/13/2006	??	??	??
GC852	4177	R4	5/13/2006	??	??	??
GC852	4177	R5	5/13/2006	rates	Joye	5/14/2006
GC852	4177	R6	5/13/2006	rates	Joye	5/14/2006
MC853	4178	Y1	5/14/2006	animals	Bright	5/15/2006
MC853	4178	Y2	5/14/2006	porewater	Joye	5/14/2006

Site	Dive #	Core #	Collected	Used for	By	Processed
MC853	4178	Y3	5/14/2006	microbiol	Joye/Bright	5/15/2006
MC853	4178	Y4	5/14/2006	rates	Joye	5/15/2006
MC853	4178	Y5	5/14/2006	rates	Joye	5/15/2006
MC853	4178	Y6	5/14/2006	anim/hyd	Bright/Bernard	5/15/2006
MC853	4178	R1	5/14/2006	rates	Joye	5/15/2006
MC853	4178	R2	5/14/2006	microbiol	Joye/Bright	5/15/2006
MC853	4178	R3	5/14/2006	animals	Bright	5/15/2006
MC853	4178	R4	5/14/2006	porewater	Joye	5/14/2006
MC853	4178	R5	5/14/2006	anim/hyd	Bright/Bernard	5/15/2006
MC853	4178	R6	5/14/2006	rates	Joye	5/15/2006
AT340	4181	R3	5/17/2006	Rates	Niemann	5/17/2006
AT340	4181	R4	5/17/2006	Rates	Niemann	5/17/2006
AT340	4181	R5	5/17/2006	Squeeze	Joye	5/17/2006
MC640	4182	Y1	5/18/2006	NO CORE	--	--
MC640	4182	Y2	5/18/2006	NO CORE	--	--
MC640	4182	Y3	5/18/2006	Squeeze	Joye	5/18/2006
MC640	4182	Y4	5/18/2006	Squeeze	Joye	5/18/2006
MC640	4182	Y5	5/18/2006	rates	Joye	5/19/2006
MC640	4182	Y6	5/18/2006	microbiol	Joye	5/19/2006
MC640	4182	R1	5/18/2006	NO CORE	--	--
MC640	4182	R2	5/18/2006	Squeeze	Joye	5/18/2006
MC640	4182	R3	5/18/2006	rates	Joye	5/19/2006
MC640	4182	R4	5/18/2006	rates	Joye	5/19/2006
MC640	4182	R5	5/18/2006	micro/hydro	Joye/Bernard	5/19/2006
MC640	4182	R6	5/18/2006	microbiol	Joye/Bernard	5/19/2006
AT340	4183	Y1	5/19/2006	rates	Niemann	5/19/2006
AT340	4183	Y2	5/19/2006	Squeeze	Joye	5/19/2006
AT340	4183	Y3	5/19/2006	Squeeze	Joye	5/19/2006
AT340	4183	Y4	5/19/2006	macrofau	Cordez	5/18/2006
AT340	4183	Y5	5/19/2006	overfull	--	--
AT340	4183	Y6	5/19/2006	macrofau	Cordez	5/19/2006
AT340	4183	R1	5/19/2006	macrofau	Cordez	5/19/2006
AT340	4183	R2	5/19/2006	Squeeze	Joye	5/19/2006
AT340	4183	R3	5/19/2006	Trode	Joye	5/20/2006

Site	Dive #	Core #	Collected	Used for	By	Processed
AT340	4183	R4	5/19/2006	rates	Joye	5/20/2006
AT340	4183	R5	5/19/2006	rates	Joye	5/20/2006
AT340	4183	R6	5/19/2006	overflow	--	--
GC600	4184	R1	5/20/2006	macrofau	Bright	5/20/2006
GC600	4184	R2	5/20/2006	macrofau	Bright	5/20/2006
GC600	4184	R3	5/20/2006	macrofau	Bright	5/20/2006
GC600	4184	R4	5/20/2006	rocks	--	--
GC600	4184	R5	5/20/2006	rocks	--	--
GC600	4184	R6	5/20/2006	rocky	Bernard?	--
GC600	4184	Y1	5/20/2006	rates	Joye	5/20/2006
GC600	4184	Y2	5/20/2006	trode/micro	Joye	5/20/2006
GC600	4184	Y3	5/20/2006	rates	Joye	5/20/2006
GC600	4184	Y4	5/20/2006	take home	Joye	5/20/2006
GC600	4184	Y5	5/20/2006	rates	Joye	5/20/2006
GC600	4184	Y6	5/20/2006	squeeze	Joye	5/20/2006
GC852	4189	R1	5/24/2006	Trode	Joye	5/24/2006
GC852	4189	R2	5/24/2006	rates	Joye	5/24/2006
GC852	4189	R3	5/24/2006	Squeeze	Joye	5/24/2006
GC852	4189	R4	5/24/2006	trode/micro	Joye	5/24/2006
GC852	4189	R5	5/24/2006	take home	Joye	5/24/2006
GC852	4189	R6	5/24/2006	hydrocarb	Bernard	5/24/2006
GC852	4189	Y1	5/24/2006	trode/sque	Joye	5/24/2006
GC852	4189	Y2	5/24/2006	lost	--	--
GC852	4189	Y3	5/24/2006	lost	--	--
GC852	4189	Y4	5/24/2006	NO CORE	--	--
GC852	4189	Y5	5/24/2006	tubeworm	Niemann	5/24/2006
GC852	4189	Y6	5/24/2006	tubeworm	Niemann	5/24/2006
WR269	4191	R1	5/26/2006	macrofau	Bright	5/26/2006
WR269	4191	R2	5/26/2006	rates	Joye	5/26/2006
WR269	4191	R3	5/26/2006	rates	Joye	5/26/2006
WR269	4191	R4	5/26/2006	macrofau	Bright	5/26/2006
WR269	4191	R5	5/26/2006	macrofau	Bright	5/26/2006
WR269	4191	R6	5/26/2006	hydrocarb	Bernard	5/26/2006
WR269	4191	Y1	5/26/2006	trode/faun	Joye/Bright	5/26/2006

Site	Dive #	Core #	Collected	Used for	By	Processed
WR269	4191	Y2	5/26/2006	rates (MOG)	Joye	5/26/2006
WR269	4191	Y3	5/26/2006	take home	Joye	5/26/2006
WR269	4191	Y4	5/26/2006	trode/micro	Joye	5/26/2006
WR269	4191	Y5	5/26/2006	squeeze	Joye	5/26/2006
WR269	4191	Y6	5/26/2006	NO CORE	--	--
AC818	4192	R1	5/27/2006	??	??	
AC818	4192	R2	5/27/2006	??	??	
AC818	4192	R3	5/27/2006	??	??	
AC818	4192	R4	5/27/2006	??	??	
AC818	4192	R5	5/27/2006	??	??	
AC818	4192	R6	5/27/2006	rates	Joye	5/27/2006
AC818	4192	Y1	5/27/2006	hydrocarb	Bern	5/27/2006
AC818	4192	Y2	5/27/2006	trodes	Joye	5/27/2006
AC818	4192	Y3	5/27/2006	microbiol	Joye	5/27/2006
AC818	4192	Y4	5/27/2006	molecular	Joye	5/27/2006
AC818	4192	Y5	5/27/2006	rates	Joye	5/27/2006
AC818	4192	Y6	5/27/2006	rates (MOG)	Joye	5/27/2006
AC601	4193	R1	5/28/2006	??	??	5/29/2006
AC601	4193	R2	5/28/2006	squeeze	Joye	5/29/2006
AC601	4193	R3	5/28/2006	geol	Roberts	5/28/2006
AC601	4193	R4	5/28/2006	geol	Roberts	5/28/2006
AC601	4193	R5	5/28/2006	trode/micro	Joye	5/29/2006
AC601	4193	R6	5/28/2006	rates	Joye	5/23/2006
AC601	4193	Y1	5/28/2006	squeeze	Joye	5/28/2006
AC601	4193	Y2	5/28/2006	rates	Joye	5/29/2006
AC601	4193	Y3	5/28/2006	tubeworm	Niemann	5/28/2006
AC601	4193	Y4	5/28/2006	tubeworm	Niemann	5/28/2006
AC601	4193	Y5	5/28/2006	rates	Joye	5/29/2006
AC601	4193	Y6	5/28/2006	squeeze	Joye	5/29/2006
AC645	4194	R1	5/29/2006	Girguis	Cordes	5/29/2006
AC645	4194	R2	5/29/2006	microbiol	Joye	5/29/2006
AC645	4194	R3	5/29/2006	hydrocarb	Roberts	5/30/2006
AC645	4194	R4	5/29/2006	geol	Roberts	5/30/2006
AC645	4194	R5	5/29/2006	take home	Joye	5/29/2006

Site	Dive #	Core #	Collected	Used for	By	Processed
AC645	4194	R6	5/29/2006	take home	Joye	5/29/2006
AC645	4194	Y1	5/29/2006	microbiol	Joye	5/29/2006
AC645	4194	Y2	5/29/2006	rates	Joye	5/29/2006
AC645	4194	Y3	5/29/2006	molecular	Joye	5/29/2006
AC645	4194	Y4	5/29/2006	NO CORE	--	--
AC645	4194	Y5	5/29/2006	rates (MOG)	Joye/Bernard	5/30/2006
AC645	4194	Y6	5/29/2006	squeeze	Joye	5/29/2006
AC601	4196	R1	5/31/2006	rates	Joye	5/31/2006
AC601	4196	R2	5/31/2006	rates (MOG)	Joye	5/31/2006
AC601	4196	R3	5/31/2006	microbiol	Joye	5/31/2006
AC601	4196	R4	5/31/2006	rates	Joye	5/31/2006
AC601	4196	R5	5/31/2006	Squeeze	Joye	5/31/2006
AC601	4196	R6	5/31/2006	Geochem	Roberts	5/31/2006
AC601	4196	Y1	5/31/2006	rates	Joye	5/31/2006
AC601	4196	Y2	5/31/2006	rates	Joye	5/31/2006
AC601	4196	Y3	5/31/2006	rate	Joye	5/31/2006
AC601	4196	Y4	5/31/2006	Geochem	Roberts	5/31/2006
AC601	4196	Y5	5/31/2006	microbiol	Joye	5/31/2006
AC601	4196	Y6	5/31/2006	Squeeze	Joye	5/31/2006

Appendix 8. Trawl Log

Trawl # 1	Inventory ID AT-1					
Site:	Atwater Valley 340	2276m depth				
Pos:	27 30.00N 88 22.00W	to	27 42.00N	88 26.00W		
Date:	9 May, 2006					
Time:	Start - 11:45pm	On Bottom- 13:50	Off Bottom 15:25			
Notes: Trawl hung on bottom at 14:40, ship's position 27 39.9375. Pulled free at 7000lbs tension. Wood, iron scale, clinkers, and coal suggest remote possibility of shipwreck. Trawl with ~ 20L mud. Good catch, see inventory. Typical holothuroid/sponge collection for this depth.						
Trawl # 2	Inventory ID AT-2					
Site:	Walker Ridge 269	2000m depth				
Date:	11 May, 2006					
Pos:	26 40.00N 91 34.00W	to 26 44.00N 91 38.00W				
Time:	Start - 15:37		On Bottom - 16:58	Off Bottom 18:00		
Notes: Trawl with ~ 10L mud						
Trawl # 3	Inventory ID AT-3					
Site:	Atwater Valley 340	2,200m depth				
Date:	14 May, 2006					
Pos:	27 37.00N 88 24.00W	to 27 37.00N 88 18.00W				
Time:	Start - 23:15		On Bottom - 00:55	Off Bottom 02:05		
Notes: Good sample with minimal mud and numerous holothuroids						
Trawl # 4	Inventory ID AT-4					
Site:	Atwater Valley 340	2372m depth				
Date:	16 May, 2006					

Pos:		27 37.00N	88 17.00W	to	27 41.00N	88 21.00W	
Time:		Start - 18:15	On Bottom - 19:50	Off Bottom -20:50			
Notes: Small sample similar in content to other AT340 trawls. Minimal mud.							
Trawl #5	Inventory ID AT-5						
Site:	Green Canyon 852						
Date:	21 May, 2006						
Pos:	27 0.45N 91 08.5W	to	27 08.0N	91 08.5W			
Time:	Start - 16:10	On Bottom - 17:15	Off Bottom -	18:15			
Notes: Apparently near-bottom water tow with ~ 6 shrimp. Strong surface current made speed during lowering greater than 3 knots.							
Trawl #6	Inventory ID AT-6						
Site:	Green Canyon 852						
Date:	23-May-10						
Pos:	27 08.0N	91 11.5W	to	27 04.0N	91 11.5W		
Time:	Start - 16:30	On Bottom - 17:33	Off Bottom - 18:35				
Notes: Small sample size.							
Trawl #7	Inventory ID AT-7						
Site:	Green Canyon 852						
Date:	23 May, 2006						
Pos:	27 09.9N	91 11.5W	to	27 04.0	91 11.5W		
Time:	Start - 17:15	On Bottom - 18:35	Off Bottom 13:35				
Notes: Net inverted. Few specimens.							
Trawl #8	Inventory ID AT-8						

Site:		Green Canyon 852					
Date:	25 May, 2006						
Pos:	26 09.00N	91 11.5W	to	27 04.00	91 11.5W		
Time:	Start -16:45	On Bottom - 18:30	Off Bottom - 19:30				
Notes: Strong and opposing surface versus bottom currents make trawling difficult. Added 5lb weight to cod end. Small catch, Umbellula, holothuroids, etc							
Trawl #9	Inventory ID AT-9						
Site:		Alaminos Canyon 818					
Date:		27 May, 2006					
Pos:		08.0N	94 36.6W	to	26 12.0N	94 36.6W	
Time:	Start - 18:20	On Bottom - 20:30	Off Bottom - 21:30				
Notes: Modest catch Holothurians, sponges, ophiuroids.							
Trawl #10	Inventory ID AT-10						
Site:		Alaminos Canyon 818					
Date:		31-May-10					
Pos:		26 05.0N	94 36.5W	to	26 11.0N	94 36.5W	
Time:	Start - 17:35	On Bottom - 19:20	Off Bottom - 20:55				
Notes: Slow recovery due to washing of cable and frequent adjustment of level wind. Modest catch with good variety, octopus, squid, fish, ophiuroids, holothuroids, and many sponges.							

Appendix 9. Samples Collected ATLANTIS/ALVIN

Dive	Site	Lab	Sample Type	tubeworm grab	mussel scoop	mussel scoop 2	biobox	rock grab	slurp	mussel pot 1	mussel pot 2	bushmaster	core R4	core Y4	core R1	clam scoop	crab grab	coral grab	push cores	mussel pot A	mussel pot D	mussel pot B
4173	AT340	PSU	tubeworm genetics	x																		
4173	AT340	PSU	tubeworm stable isotopes	x																		
4173	AT340	PSU	tubeworm morphology	x																		
4173	AT340	U. Austria	tubeworm symbionts	x																		
4173	AT340	PSU	mussel genetics		x																	
4173	AT340	PSU	mussel stable isotopes		x																	
4173	AT340	PSU	mussel morphology		x																	
4173	AT340	MPI Bremen	mussel symbionts		x																	
4173	AT340	PSU	clam genetics																			
4173	AT340	PSU	clam stable isotopes																			
4173	AT340	PSU	clam morphology																			
4173	AT340	MPI Bremen	clam symbionts																			
4173	AT340	PSU	macrofauna genetics																			

Dive	Site	Lab	Sample Type	tubeworm grab	mussel scoop	mussel scoop 2	biobox	rock grab	slurp	mussel pot 1	mussel pot 2	bushmaster	core R4	core Y4	core R1	clam scoop	crab grab	coral grab	push cores	mussel pot A	mussel pot D	mussel pot B
4194	AC645	PSU	tubeworm stable isotopes	x																		
4194	AC645	PSU	tubeworm morphology	x																		
4194	AC645	U. Austria	tubeworm symbionts																			
4194	AC645	PSU	mussel genetics																		x	
4194	AC645	PSU	mussel stable isotopes																		x	
4194	AC645	PSU	mussel morphology																		x	
4194	AC645	MPI Bremen	mussel symbionts																			
4194	AC645	PSU	clam genetics																			
4194	AC645	PSU	clam stable isotopes																			
4194	AC645	PSU	clam morphology																			
4194	AC645	MPI Bremen	clam symbionts																			
4194	AC645	PSU	coral preserved																			
4194	AC645	PSU	coral stable isotope																			
4194	AC645	USGS	coral genetics																			
4194	AC645	PSU	macrofauna genetics	x				x												x	x	

Dive	Site	Lab	Sample Type	tubeworm grab	mussel scoop	mussel scoop 2	biobox	rock grab	slurp	mussel pot 1	mussel pot 2	bushmaster	core R4	core Y4	core R1	clam scoop	crab grab	coral grab	push cores	mussel pot A	mussel pot D	mussel pot B
4197	AC645	U. Austria	tubeworm symbionts																			
4197	AC645	PSU	mussel genetics		x															x		x
4197	AC645	PSU	mussel stable isotopes		x															x		x
4197	AC645	PSU	mussel morphology		x															x		x
4197	AC645	MPI Bremen	mussel symbionts		x																	x
4197	AC645	PSU	clam genetics																			
4197	AC645	PSU	clam stable isotopes																			
4197	AC645	PSU	clam morphology																			
4197	AC645	MPI Bremen	clam symbionts																			
4197	AC645	PSU	coral preserved																			
4197	AC645	PSU	coral stable isotope																			
4197	AC645	USGS	coral genetics																			
4197	AC645	PSU	macrofauna genetics		x															x		x
4197	AC645	PSU	macrofauna stable isotopes		x															x		x
4197	AC645	PSU	macrofauna preserved		x			x												x		x
4197	AC645	U. Austria	meiofauna																	x		x

Appendix 10. Record of Dive Activities

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4173	AT340	2216	5/9/2006	14:59	27.64780486	-88.36231220	Mark Spear	Erik Cordes	Bernie Bernard	Nav set 5462 7065
4173	AT340	2216	5/9/2006	16:08	27.64552701	-88.36329334	Mark Spear	Erik Cordes	Bernie Bernard	1 rock sample
4173	AT340	2216	5/9/2006	16:20	27.64550965	-88.36328493	Mark Spear	Erik Cordes	Bernie Bernard	Yellow cores near mussels and tubeworms
4173	AT340	2216	5/9/2006	16:31	27.64551074	-88.36328422	Mark Spear	Erik Cordes	Bernie Bernard	Mussel scoop
4173	AT340	2216	5/9/2006	16:37	27.64552198	-88.36328749	Mark Spear	Erik Cordes	Bernie Bernard	3 rock samples
4173	AT340	2216	5/9/2006	16:37	27.64552198	-88.36328749	Mark Spear	Erik Cordes	Bernie Bernard	Grab of mussels
4173	AT340	2216	5/9/2006	18:39	27.64463321	-88.36499541	Mark Spear	Erik Cordes	Bernie Bernard	Red cores near tubeworms
4173	AT340	2216	5/9/2006	18:55	27.64463424	-88.36499630	Mark Spear	Erik Cordes	Bernie Bernard	Deployed SEAS experiments
4173	AT340	2216	5/9/2006	18:59	27.64463549	-88.36499424	Mark Spear	Erik Cordes	Bernie Bernard	Collected 1 rock sample
4173	AT340	2216	5/9/2006	18:59	27.64463549	-88.36499424	Mark Spear	Erik Cordes	Bernie Bernard	Collected small clump of tubeworms
4173	AT340	2216	5/9/2006	19:20	27.64460149	-88.36503358	Mark Spear	Erik Cordes	Bernie Bernard	Deployed Marker 1
4174	GC600	1250	5/10/2006	14:04	27.37334615	-90.57041377	Pat Hickey	Bob Carney	Helge Neimann	Surveyed in
4174	GC600	1250	5/10/2006	15:01	27.37323726	-90.57566860	Pat Hickey	Bob Carney	Helge Neimann	Chem sensor deployed, malfunctions
4174	GC600	1250	5/10/2006	15:05	27.37324361	-90.57566171	Pat Hickey	Bob Carney	Helge Neimann	Tubeworm collection
4174	GC600	1250	5/10/2006	15:40	27.37307240	-90.57463477	Pat Hickey	Bob Carney	Helge Neimann	Red pushcores of white bacterial mat
4174	GC600	1250	5/10/2006	17:55	27.36870709	-90.56634925	Pat Hickey	Bob Carney	Helge Neimann	Yellow pushcores of white bacterial mat

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4174	GC600	1250	5/10/2006	18:13	27.36869295	-90.56632326	Pat Hickey	Bob Carney	Helge Neimann	Mussel pot collection-failed
4174	GC600	1250	5/10/2006	18:18	27.36869140	-90.56632375	Pat Hickey	Bob Carney	Helge Neimann	Marker yellow #3 deployed
4174	GC600	1250	5/10/2006	18:20	27.36870575	-90.56633456	Pat Hickey	Bob Carney	Helge Neimann	Large grey carbonate collection- 3 samples
4174	GC600	1250	5/10/2006	18:24	27.36871251	-90.56636470	Pat Hickey	Bob Carney	Helge Neimann	Slurp sample- shrimp and galatheids
4174	GC600	1250	5/10/2006	18:39	27.36797549	-90.56670115	Pat Hickey	Bob Carney	Helge Neimann	Anemone collection
4175	WR269	1950	5/11/2006	16:20	26.68583938	-91.65952070	Bruce Strickrott	Harry Roberts	Vladimir Samarkin	Deployed benchmark #1
4175	WR269	1950	5/11/2006	16:20	26.68583938	-91.65952070	Bruce Strickrott	Harry Roberts	Vladimir Samarkin	Suction sample of tube-like hairy growth and holothurians
4175	WR269	1950	5/11/2006	16:51	26.68626982	-91.66259904	Bruce Strickrott	Harry Roberts	Vladimir Samarkin	Mussel pot collection-failed
4176	KC243	1610	5/12/2006	14:29	26.73097869	-92.83170483	Gavin Eppard	Stephane Hourdez	Mike McCarthy	Deployed benchmarker
4176	KC243	1610	5/12/2006	15:18	26.73073188	-92.83041777	Gavin Eppard	Stephane Hourdez	Mike McCarthy	Deployed ball marker
4176	KC243	1610	5/12/2006	15:29	26.73068558	-92.83045916	Gavin Eppard	Stephane Hourdez	Mike McCarthy	Mussel pot collection
4176	KC243	1610	5/12/2006	16:07	26.73069054	-92.83048721	Gavin Eppard	Stephane Hourdez	Mike McCarthy	2 small rock samples
4176	KC243	1610	5/12/2006	16:07	26.73069054	-92.83048721	Gavin Eppard	Stephane Hourdez	Mike McCarthy	Scooping mussels
4176	KC243	1610	5/12/2006	17:11	26.73073259	-92.83039082	Gavin Eppard	Stephane Hourdez	Mike McCarthy	Mosaic
4177	GC852	1450	5/13/2006	15:27	27.10593737	-91.16603396	Mark Spear	Ian MacDonald	Monika Bright	Deploy rotary camera
4177	GC852	1450	5/13/2006	16:07	27.10635324	-91.16620915	Mark Spear	Ian MacDonald	Monika Bright	Mussel pot collection-failed
4177	GC852	1450	5/13/2006	16:33	27.10635092	-91.16618529	Mark Spear	Ian MacDonald	Monika Bright	SEAS RUST #4 and #5 experiment deployed
4177	GC852	1450	5/13/2006	16:50	27.10633883	-91.16619351	Mark Spear	Ian MacDonald	Monika Bright	Deployed benchmarker #1

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4177	GC852	1450	5/13/2006	16:56	27.10633774	-91.16619309	Mark Spear	Ian MacDonald	Monika Bright	Red pushcores
4177	GC852	1450	5/13/2006	17:10	27.10630550	-91.16618850	Mark Spear	Ian MacDonald	Monika Bright	Rock collection
4177	GC852	1450	5/13/2006	17:40	27.10625979	-91.16607717	Mark Spear	Ian MacDonald	Monika Bright	Tubeworm collection
4177	GC852	1450	5/13/2006	18:29	27.10632465	-91.16590704	Mark Spear	Ian MacDonald	Monika Bright	2 small rock samples
4177	GC852	1450	5/13/2006	18:29	27.10632465	-91.16590704	Mark Spear	Ian MacDonald	Monika Bright	Mussel Scoop
4178	MC853	1070	5/14/2006	14:35	28.12734069	-89.14123695	Pat Hickey	Mandy Joye	Bill Shedd	Deployed marker #1
4178	MC853	1070	5/14/2006	14:55	28.12725063	-89.14149671	Pat Hickey	Mandy Joye	Bill Shedd	Deployed marker #2
4178	MC853	1070	5/14/2006	14:55	28.12725063	-89.14149671	Pat Hickey	Mandy Joye	Bill Shedd	Red cores near bacterial mat
4178	MC853	1070	5/14/2006	15:00	28.12725391	-89.14148473	Pat Hickey	Mandy Joye	Bill Shedd	Slurp surface fauna
4178	MC853	1070	5/14/2006	15:12	28.12726679	-89.14145702	Pat Hickey	Mandy Joye	Bill Shedd	Slurp animals from carbonate
4178	MC853	1070	5/14/2006	15:27	28.12699717	-89.14203478	Pat Hickey	Mandy Joye	Bill Shedd	Slurp large siphonophore
4178	MC853	1070	5/14/2006	15:44	28.12741575	-89.14307532	Pat Hickey	Mandy Joye	Bill Shedd	Mussel pot #1
4178	MC853	1070	5/14/2006	16:11	28.12742335	-89.14307010	Pat Hickey	Mandy Joye	Bill Shedd	Net of mussels
4178	MC853	1070	5/14/2006	16:45	28.12556342	-89.14171007	Pat Hickey	Mandy Joye	Bill Shedd	Fired niskins #4 and 5
4178	MC853	1070	5/14/2006	17:12	28.12383968	-89.14039497	Pat Hickey	Mandy Joye	Bill Shedd	Net of mussels
4178	MC853	1070	5/14/2006	17:29	28.12299006	-89.13980296	Pat Hickey	Mandy Joye	Bill Shedd	Yellow pushcores
4178	MC853	1070	5/14/2006	17:59	28.12303414	-89.13942237	Pat Hickey	Mandy Joye	Bill Shedd	Deployed marker #3
4178	MC853	1070	5/14/2006	18:13	28.12208425	-89.14164213	Pat Hickey	Mandy Joye	Bill Shedd	Clam and mussel scoop

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4178	MC853	1070	5/14/2006	18:31	28.12194479	-89.14206153	Pat Hickey	Mandy Joye	Bill Shedd	Marker deployed
4178	MC853	1070	5/14/2006	18:41	28.12156428	-89.14246169	Pat Hickey	Mandy Joye	Bill Shedd	1 carbonate sample and 1 barite sample
4178	MC853	1070	5/14/2006	19:01	28.12045830	-89.14117104	Pat Hickey	Mandy Joye	Bill Shedd	Niskins 2 and 3
4178	MC853	1070	5/14/2006	19:02	28.12045892	-89.14117084	Pat Hickey	Mandy Joye	Bill Shedd	Mussel pot #2
4179	AT340	2,200	5/15/2006	14:47	27.64468997	-88.36498100	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	On bench marker #1
4179	AT340	2,200	5/15/2006	14:52	27.64455472	-88.36499410	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Deployed fish trap, reset nav
4179	AT340	2,200	5/15/2006	15:17	27.64496778	-88.36451021	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Marker 2 deployed in mussel bed, ball marker deployed
4179	AT340	2,200	5/15/2006	15:39	27.64497002	-88.36446480	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Mosaic in progress
4179	AT340	2,200	5/15/2006	16:27	27.64494116	-88.36459931	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Niskin #5 deployed
4179	AT340	2,200	5/15/2006	16:27	27.64494116	-88.36459931	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Staining tubeworms, marker #3 deployed
4179	AT340	2,200	5/15/2006	17:20	27.64496206	-88.36454942	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Shrimp slurped
4179	AT340	2,200	5/15/2006	17:31	27.64491791	-88.36481012	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Grab of holothurian
4179	AT340	2,200	5/15/2006	18:05	27.64461380	-88.36464289	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Bushmaster sample
4179	AT340	2,200	5/15/2006	18:56	27.64493215	-88.36440101	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	1 carbonate sample

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4179	AT340	2,200	5/15/2006	18:56	27.64493215	-88.36440101	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Staining tubeworms, marker #15 deployed
4179	AT340	2,200	5/15/2006	19:20	27.64491725	-88.36442337	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	More tubeworm staining, deployed marker 6
4179	AT340	2,200	5/15/2006	###	27.64757016	-88.36181058	Bruce Strickrott	Chuck Fisher	Stephanie Lessard-Pilon	Net of mussels
4180	AT340	2,200	5/16/2006	16:45	27.64460498	-88.36502738	Gavin Eppard	Erik Cordes	Jill Petersen	Reset nav, at benchmark
4180	AT340	2,200	5/16/2006	17:03	27.64485193	-88.36464174	Gavin Eppard	Erik Cordes	Jill Petersen	Tubies stained, marker deployed- failed, marker recovered
4180	AT340	2,200	5/16/2006	17:17	27.64485272	-88.36464627	Gavin Eppard	Erik Cordes	Jill Petersen	Niskin #5 fired
4180	AT340	2,200	5/16/2006	17:23	27.64485243	-88.36464715	Gavin Eppard	Erik Cordes	Jill Petersen	1 large carbonate collection
4180	AT340	2,200	5/16/2006	17:42	27.64463373	-88.36475435	Gavin Eppard	Erik Cordes	Jill Petersen	Niskin #4 fired
4180	AT340	2,200	5/16/2006	18:32	27.64463456	-88.36470480	Gavin Eppard	Erik Cordes	Jill Petersen	Niskin #3 fired
4180	AT340	2,200	5/16/2006	18:43	27.64463854	-88.36470252	Gavin Eppard	Erik Cordes	Jill Petersen	Bushmaster collection, deployed marker 10
4180	AT340	2,200	5/16/2006	18:55	27.64487636	-88.36479546	Gavin Eppard	Erik Cordes	Jill Petersen	Deployed marker 11
4180	AT340	2,200	5/16/2006	18:56	27.64487591	-88.36479545	Gavin Eppard	Erik Cordes	Jill Petersen	Fired niskin #2
4180	AT340	2,200	5/16/2006	19:09	27.64487344	-88.36480341	Gavin Eppard	Erik Cordes	Jill Petersen	Mussel scoop
4180	AT340	2,200	5/16/2006	19:09	27.64487344	-88.36480341	Gavin Eppard	Erik Cordes	Jill Petersen	Tubeworm collection
4181	AT340	2,200	5/17/2006	16:22	27.64769809	-88.37371885	Mark Spear	Harry Roberts	Guy Telesnicki	Niskin sample #1
4181	AT340	2,200	5/17/2006	16:38	27.64771148	-88.37372086	Mark Spear	Harry Roberts	Guy Telesnicki	Mussel scoop sample #1

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4181	AT340	2,200	5/17/2006	17:16	27.64724248	-88.37009942	Mark Spear	Harry Roberts	Guy Telesnicki	1 small carbonate sample from mussel pot #2
4181	AT340	2,200	5/17/2006	17:16	27.64724248	-88.37009942	Mark Spear	Harry Roberts	Guy Telesnicki	Deployed marker #4 next to brine lake
4181	AT340	2,200	5/17/2006	17:16	27.64724248	-88.37009942	Mark Spear	Harry Roberts	Guy Telesnicki	Mussel pot collection
4181	AT340	2,200	5/17/2006	17:16	27.64724248	-88.37009942	Mark Spear	Harry Roberts	Guy Telesnicki	Mussel scoop sample #2
4181	AT340	2,200	5/17/2006	17:20	27.64723154	-88.37009544	Mark Spear	Harry Roberts	Guy Telesnicki	Niskin #2
4181	AT340	2,200	5/17/2006	18:57	27.64486525	-88.36546289	Mark Spear	Harry Roberts	Guy Telesnicki	Three red pushcores #1,2,3 near tubie bush
4181	AT340	2,200	5/17/2006	19:36	27.64496980	-88.36487699	Mark Spear	Harry Roberts	Guy Telesnicki	Pick up SEAS experiment
4181	AT340	2,200	5/17/2006	19:39	27.64497012	-88.36487623	Mark Spear	Harry Roberts	Guy Telesnicki	Niskin #3 sample
4181	AT340	2,200	5/17/2006	19:43	27.64494568	-88.36492379	Mark Spear	Harry Roberts	Guy Telesnicki	Retrieve fish trap
4182	MC640	1,410	5/18/2006	15:37	28.35701639	-88.79243328	Pat Hickey	Bob Carney	PIT	Niskins #1,2 fired
4182	MC640	1,410	5/18/2006	15:41	28.35701663	-88.79243354	Pat Hickey	Bob Carney	PIT	Yellow marker #1 deployed
4182	MC640	1,410	5/18/2006	15:45	28.35701595	-88.79243416	Pat Hickey	Bob Carney	PIT	Mussel pot
4182	MC640	1,410	5/18/2006	15:56	28.35701214	-88.79242785	Pat Hickey	Bob Carney	PIT	Yellow pushcores # 1,2,3
4182	MC640	1,410	5/18/2006	16:00	28.35701531	-88.79243203	Pat Hickey	Bob Carney	PIT	Slurp sample, single brachyuran crab
4182	MC640	1,410	5/18/2006	16:08	28.35700960	-88.79242800	Pat Hickey	Bob Carney	PIT	Net scoop, 1 small sample carbonate
4182	MC640	1,410	5/18/2006	16:25	28.35684735	-88.79275408	Pat Hickey	Bob Carney	PIT	Niskin 3 and 4
4182	MC640	1,410	5/18/2006	16:33	28.35682499	-88.79276285	Pat Hickey	Bob Carney	PIT	Pushcores in bacterial mat Yellow # 4, 5, 6 and Red 1, 2, 3

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4182	MC640	1,410	5/18/2006	17:37	28.35638800	-88.79307935	Pat Hickey	Bob Carney	PIT	1 large carbonate slab
4182	MC640	1,410	5/18/2006	17:37	28.35638800	-88.79307935	Pat Hickey	Bob Carney	PIT	Mussel net
4182	MC640	1,410	5/18/2006	17:42	28.35637943	-88.79308487	Pat Hickey	Bob Carney	PIT	Niskin #5
4182	MC640	1,410	5/18/2006	17:43	28.35637711	-88.79308268	Pat Hickey	Bob Carney	PIT	Push cores red #4,5,6
4183	AT340	2175	5/19/2006	14:58	27.64716006	-88.37394226	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Two control push cores
4183	AT340	2175	5/19/2006	16:07	27.64743598	-88.37392894	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Marker #12 deployed, tubies stained
4183	AT340	2175	5/19/2006	16:36	27.64740908	-88.37394170	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Marker #8 deployed, tubies stained
4183	AT340	2175	5/19/2006	16:49	27.64742126	-88.37395479	Bruce Strickrott	Chuck Fisher	Adriana Leiva	More tubies stained close to marker #8
4183	AT340	2175	5/19/2006	17:30	27.64747180	-88.37407465	Bruce Strickrott	Chuck Fisher	Adriana Leiva	1 small sample carbonate
4183	AT340	2175	5/19/2006	17:30	27.64747180	-88.37407465	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Baby tubeworms grabbed
4183	AT340	2175	5/19/2006	17:47	27.64719816	-88.37395332	Bruce Strickrott	Chuck Fisher	Adriana Leiva	1 small sample carbonate
4183	AT340	2175	5/19/2006	17:47	27.64719816	-88.37395332	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Bushmaster collection
4183	AT340	2175	5/19/2006	18:28	27.64566399	-88.37047091	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Coring urchins (10 cores)
4183	AT340	2175	5/19/2006	18:44	27.64566905	-88.37046218	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Collecting net of urchins
4183	AT340	2175	5/19/2006	19:00	27.64567445	-88.37041617	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Slurp of hermit crabs and shrimp
4183	AT340	2175	5/19/2006	19:30	27.64463582	-88.36313513	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Deployed marker 5
4183	AT340	2175	5/19/2006	19:39	27.64449399	-88.36310889	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Mosaic of Mussel brick road
4183	AT340	2175	5/19/2006	19:45	27.64505625	-88.36310903	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Ball marker dropped

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4183	AT340	2175	5/19/2006	19:48	27.64520603	-88.36308171	Bruce Strickrott	Chuck Fisher	Adriana Leiva	Ball marker dropped
4184	GC600	1250	5/20/2006	14:25	27.37323512	-90.57566438	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Dropped benchmarker 2
4184	GC600	1250	5/20/2006	17:12	27.37198656	-90.57340318	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Niskins #1, 2
4184	GC600	1250	5/20/2006	17:23	27.37199002	-90.57340311	Gavin Eppard	Stephane Hourdez	Marshall Bowles	2 small carbonate samples from clam site 1
4184	GC600	1250	5/20/2006	17:23	27.37199002	-90.57340311	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Yellow pushcores by clams
4184	GC600	1250	5/20/2006	17:41	27.37199935	-90.57341006	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Clam collection - 2 carbonate samples
4184	GC600	1250	5/20/2006	17:55	27.37200733	-90.57342351	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Rock collection
4184	GC600	1250	5/20/2006	19:12	27.36650148	-90.56391870	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Niskins #3, 4, 5
4184	GC600	1250	5/20/2006	19:16	27.36651657	-90.56392994	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Dropped Ian marker #5, took red pushcores with rock underneath
4184	GC600	1250	5/20/2006	19:22	27.36650222	-90.56392320	Gavin Eppard	Stephane Hourdez	Marshall Bowles	2 small bags of carbonate from clam site 2
4184	GC600	1250	5/20/2006	19:22	27.36650222	-90.56392320	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Clam scoop
4184	GC600	1250	5/20/2006	19:35	27.36651593	-90.56392333	Gavin Eppard	Stephane Hourdez	Marshall Bowles	Slurping galatheids, crabs and shrimp
4185	GC852	1,410	5/21/2006	14:45	27.10590706	-91.16572768	Mark Spear	Monika Bright	Cheryl Morrison	Deploy camera
4185	GC852	1,410	5/21/2006	14:52	27.10591292	-91.16572970	Mark Spear	Monika Bright	Cheryl Morrison	Set DVL nav
4185	GC852	1,410	5/21/2006	15:05	27.10586444	-91.16601322	Mark Spear	Monika Bright	Cheryl Morrison	Recover crab trap
4185	GC852	1,410	5/21/2006	16:23	27.10968413	-91.16540625	Mark Spear	Monika Bright	Cheryl Morrison	Collect anemones
4185	GC852	1,410	5/21/2006	16:45	27.10959154	-91.16549012	Mark Spear	Monika Bright	Cheryl Morrison	Collect anemones

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4185	GC852	1,410	5/21/2006	17:52	27.11085603	-91.16565289	Mark Spear	Monika Bright	Cheryl Morrison	Collection of 3 rock samples near benchmark
4185	GC852	1,410	5/21/2006	17:52	27.11085603	-91.16565289	Mark Spear	Monika Bright	Cheryl Morrison	Deployed benchmarker #2
4185	GC852	1,410	5/21/2006	17:52	27.11085603	-91.16565289	Mark Spear	Monika Bright	Cheryl Morrison	Sponge collection
4185	GC852	1,410	5/21/2006	18:05	27.11087553	-91.16562954	Mark Spear	Monika Bright	Cheryl Morrison	Crab collection
4185	GC852	1,410	5/21/2006	18:12	27.11088447	-91.16563330	Mark Spear	Monika Bright	Cheryl Morrison	Collect rock
4185	GC852	1,410	5/21/2006	18:20	27.11091394	-91.16561953	Mark Spear	Monika Bright	Cheryl Morrison	Collect crab with manipulator
4185	GC852	1,410	5/21/2006	18:48	27.10995915	-91.16593877	Mark Spear	Monika Bright	Cheryl Morrison	Collect bamboo coral
4186	GC852	1,410	5/22/2006	15:56	27.10635657	-91.16618318	Pat Hickey	Chuck Fisher	Erin Becker	at benchmarker 1
4186	GC852	1,410	5/22/2006	16:08	27.10638635	-91.16612887	Pat Hickey	Chuck Fisher	Erin Becker	Deploy fish trap
4186	GC852	1,410	5/22/2006	16:24	27.10619126	-91.16613587	Pat Hickey	Chuck Fisher	Erin Becker	Mussel pot collection
4186	GC852	1,410	5/22/2006	17:43	27.10619210	-91.16613065	Pat Hickey	Chuck Fisher	Erin Becker	Deployed Ian marker 6 about 2-3 meters from stained tubeworms
4186	GC852	1,410	5/22/2006	18:05	27.10595746	-91.16622784	Pat Hickey	Chuck Fisher	Erin Becker	Bushmaster collection
4186	GC852	1,410	5/22/2006	18:22	27.10595072	-91.16623594	Pat Hickey	Chuck Fisher	Erin Becker	Carbonate collection- 2 rocks
4186	GC852	1,410	5/22/2006	18:22	27.10595072	-91.16623594	Pat Hickey	Chuck Fisher	Erin Becker	Slurp collection
4187	GC852	1,410	5/23/2006	14:19	27.10627679	-91.16612168	Bruce Strickrott	Erik Cordes	PIT Sean	At benchmarker 1, reset nav
4187	GC852	1,410	5/23/2006	16:15	27.11092930	-91.16563683	Bruce Strickrott	Erik Cordes	PIT Sean	Mussel pot- 1 small carbonate sample
4187	GC852	1,410	5/23/2006	16:38	27.11093301	-91.16559239	Bruce Strickrott	Erik Cordes	PIT Sean	Deployed marker #8, staining tubeworms
4187	GC852	1,410	5/23/2006	17:25	27.11126986	-91.16554374	Bruce Strickrott	Erik Cordes	PIT Sean	Bushmaster

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4187	GC852	1,410	5/23/2006	17:55	27.11113716	-91.16543614	Bruce Strickrott	Erik Cordes	PIT Sean	Reset nav again
4187	GC852	1,410	5/23/2006	18:13	27.11109414	-91.16533438	Bruce Strickrott	Erik Cordes	PIT Sean	Deployed marker #5, staining tubeworms
4187	GC852	1,410	5/23/2006	18:38	27.11073273	-91.16558741	Bruce Strickrott	Erik Cordes	PIT Sean	Mussel scoop
4187	GC852	1,410	5/23/2006	19:30	27.10994806	-91.16591835	Bruce Strickrott	Erik Cordes	PIT Sean	Mosaic
4187	GC852	1,410	5/23/2006	20:19	27.11002441	-91.16599061	Bruce Strickrott	Erik Cordes	PIT Sean	Grabbed rock- 1 sample from mound top
4189	GC852	1,410	5/24/2006	16:39	27.10962838	-91.16583993	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Deployed camera
4189	GC852	1,410	5/24/2006	16:56	27.10956311	-91.16596107	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Coral collection
4189	GC852	1,410	5/24/2006	17:09	27.10956207	-91.16596204	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Three niskins # 1,2,3
4189	GC852	1,410	5/24/2006	17:15	27.10956263	-91.16596135	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Carbonate/anemone collection
4189	GC852	1,410	5/24/2006	17:28	27.10954937	-91.16591027	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Sampled corals with manipulator
4189	GC852	1,410	5/24/2006	17:48	27.11073239	-91.16542413	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Reset nav
4189	GC852	1,410	5/24/2006	18:03	27.11082444	-91.16568254	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Fired 2 niskin bottles- #4,5
4189	GC852	1,410	5/24/2006	18:10	27.11082626	-91.16568493	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Red pushcores
4189	GC852	1,410	5/24/2006	18:50	27.11063536	-91.16593047	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Yellow pushcores
4189	GC852	1,410	5/24/2006	19:07	27.10974384	-91.16615795	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Collected camera
4189	GC852	1,410	5/24/2006	19:55	27.10968478	-91.16643060	Gavin Eppard	Ian MacDonald	Cheryl Morrison	Collecting corals
4190	GC852	1,410	5/25/2006	14:33	27.11089199	-91.16556501	Mark Spear	Bob Carney	Meg Bernier	Camera deployed
4190	GC852	1,410	5/25/2006	15:55	27.10988105	-91.16605704	Mark Spear	Bob Carney	Meg Bernier	Corals (hard and soft) collected

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4190	GC852	1,410	5/25/2006	18:13	27.10634876	-91.16662567	Mark Spear	Bob Carney	Meg Bernier	Recover SEAS experiments and fish trap
4190	GC852	1,410	5/25/2006	18:13	27.10634876	-91.16662567	Mark Spear	Bob Carney	Meg Bernier	Trip all 5 Niskins at BM 2
4191	WR269	1950	5/26/2006	15:25	26.68584842	-91.65950000	Pat Hickey	Harry Roberts	Matt Kupchik	Mosaic of pogonopheran field
4191	WR269	1950	5/26/2006	16:13	26.68585277	-91.65943294	Pat Hickey	Harry Roberts	Matt Kupchik	Niskins #1 and #2
4191	WR269	1950	5/26/2006	16:34	26.68585359	-91.65943805	Pat Hickey	Harry Roberts	Matt Kupchik	12 pushcores in pogonopheran field
4191	WR269	1950	5/26/2006	16:45	26.68584936	-91.65943976	Pat Hickey	Harry Roberts	Matt Kupchik	Slurp of pogos and friends
4191	WR269	1950	5/26/2006	17:45	26.68623861	-91.66249239	Pat Hickey	Harry Roberts	Matt Kupchik	Scoop of mussels for biobox with manipulator and scoop
4191	WR269	1950	5/26/2006	18:02	26.68623575	-91.66249352	Pat Hickey	Harry Roberts	Matt Kupchik	Niskins #3 and #4
4191	WR269	1950	5/26/2006	18:08	26.68621371	-91.66252919	Pat Hickey	Harry Roberts	Matt Kupchik	Tubeworm sampling and niskin #5
4191	WR269	1950	5/26/2006	18:25	26.68614540	-91.66273958	Pat Hickey	Harry Roberts	Matt Kupchik	Mussel pot sampling
4191	WR269	1950	5/26/2006	18:41	26.68614449	-91.66273524	Pat Hickey	Harry Roberts	Matt Kupchik	Niskin #5
4191	WR269	1950	5/26/2006	18:41	26.68614449	-91.66273524	Pat Hickey	Harry Roberts	Matt Kupchik	Tubeworm sampling
4191	WR269	1950	5/26/2006	18:43	26.68615072	-91.66268446	Pat Hickey	Harry Roberts	Matt Kupchik	Carbonate sample- 1 rock sample
4192	AC818	2740	5/27/2006	16:34	26.18007124	-94.62332043	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Mussel pot- 1 small carbonate sample from mussel pot
4192	AC818	2740	5/27/2006	16:34	26.18007124	-94.62332043	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Reset nav
4192	AC818	2740	5/27/2006	18:15	26.18031058	-94.62299540	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Deployed benchmarker #1
4192	AC818	2740	5/27/2006	18:25	26.18032212	-94.62299783	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Grab of tubeworms

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4192	AC818	2740	5/27/2006	18:38	26.18033419	-94.62299176	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Red pushcores
4192	AC818	2740	5/27/2006	19:22	26.18033930	-94.62299229	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Mussel scoop
4192	AC818	2740	5/27/2006	19:41	26.18033421	-94.62299557	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Rock collection- 1 small sample of carbonate
4192	AC818	2740	5/27/2006	20:10	26.18063365	-94.62306222	Bruce Strickrott	Stephane Hourdez	Mike McCarthy	Yellow pushcores in urchins
4193	AC601	2340	5/28/2006	14:27	26.39109301	-94.51640515	Gavin Eppard	Harry Roberts	Mandy Joye	Reset nav
4193	AC601	2340	5/28/2006	14:46	26.38917276	-94.51498331	Gavin Eppard	Harry Roberts	Mandy Joye	Two pushcores (Y5 and Y6) and drop marker #8
4193	AC601	2340	5/28/2006	15:06	26.38997174	-94.51398619	Gavin Eppard	Harry Roberts	Mandy Joye	Sample tubeworms
4193	AC601	2340	5/28/2006	15:34	26.39031791	-94.51352748	Gavin Eppard	Harry Roberts	Mandy Joye	Rock sample
4193	AC601	2340	5/28/2006	15:56	26.39001010	-94.51400350	Gavin Eppard	Harry Roberts	Mandy Joye	Slurp sample
4193	AC601	2340	5/28/2006	16:03	26.39001444	-94.51399530	Gavin Eppard	Harry Roberts	Mandy Joye	Pushcore Y3 and Y4 near tubeworm bush
4193	AC601	2340	5/28/2006	17:08	26.39185364	-94.51487329	Gavin Eppard	Harry Roberts	Mandy Joye	Niskins 1-5
4193	AC601	2340	5/28/2006	17:12	26.39181519	-94.51491989	Gavin Eppard	Harry Roberts	Mandy Joye	#1, #2 Yellow cores in brine pool bottom
4193	AC601	2340	5/28/2006	17:30	26.39216157	-94.51492716	Gavin Eppard	Harry Roberts	Mandy Joye	#5,6 Red cores in brine pool bottom
4193	AC601	2340	5/28/2006	17:49	26.39245723	-94.51346072	Gavin Eppard	Harry Roberts	Mandy Joye	#R3,4 edge of brine pool
4193	AC601	2340	5/28/2006	17:59	26.39228399	-94.51343532	Gavin Eppard	Harry Roberts	Mandy Joye	Attempted sample of crystals
4193	AC601	2340	5/28/2006	18:09	26.39200087	-94.51355430	Gavin Eppard	Harry Roberts	Mandy Joye	Carbonate sample- 1 large rock sample from ridge crest
4193	AC601	2340	5/28/2006	18:48	26.39208202	-94.51521337	Gavin Eppard	Harry Roberts	Mandy Joye	Pushcores R1 and R2 by mixed mussel/urchin field

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4193	AC601	2340	5/28/2006	18:51	26.39208131	-94.51521359	Gavin Eppard	Harry Roberts	Mandy Joye	Scoop of mussels/urchins- 1 small carbonate sample
4194	AC645	2240	5/29/2006	14:32	26.35276965	-94.50737606	Mark Spear	Bob Carney	Cindy Petersen	2 red pushcores #1,2
4194	AC645	2240	5/29/2006	14:40	26.35448739	-94.50942685	Mark Spear	Bob Carney	Cindy Petersen	Coral and holothurian collection
4194	AC645	2240	5/29/2006	16:12	26.35433470	-94.49826002	Mark Spear	Bob Carney	Cindy Petersen	Mussel pot A taken
4194	AC645	2240	5/29/2006	16:29	26.35434411	-94.49824978	Mark Spear	Bob Carney	Cindy Petersen	Rock collection- 2 large rock samples from bottom and top of mound
4194	AC645	2240	5/29/2006	16:45	26.35435148	-94.49823508	Mark Spear	Bob Carney	Cindy Petersen	Grab of tubeworm clump
4194	AC645	2240	5/29/2006	16:58	26.35442288	-94.49841938	Mark Spear	Bob Carney	Cindy Petersen	Pushcores #3,4,5
4194	AC645	2240	5/29/2006	17:04	26.35444044	-94.49845174	Mark Spear	Bob Carney	Cindy Petersen	Pushcore #6
4194	AC645	2240	5/29/2006	17:05	26.35444043	-94.49845173	Mark Spear	Bob Carney	Cindy Petersen	Niskins 1,2,3
4194	AC645	2240	5/29/2006	17:13	26.35444820	-94.49834450	Mark Spear	Bob Carney	Cindy Petersen	Marker #1 deployed
4194	AC645	2240	5/29/2006	17:39	26.35434091	-94.49744296	Mark Spear	Bob Carney	Cindy Petersen	Soft and hard coral collection, 1 rock sample from base of soft coral
4194	AC645	2240	5/29/2006	18:22	26.35516997	-94.49865260	Mark Spear	Bob Carney	Cindy Petersen	Second mussel pot B
4194	AC645	2240	5/29/2006	18:30	26.35518301	-94.49865207	Mark Spear	Bob Carney	Cindy Petersen	Pushcores Y1-6 taken in bacterial mat
4194	AC645	2240	5/29/2006	18:41	26.35523857	-94.49863592	Mark Spear	Bob Carney	Cindy Petersen	Niskins #4, 5 fired
4194	AC645	2240	5/29/2006	19:10	26.35480803	-94.49823122	Mark Spear	Bob Carney	Cindy Petersen	Net samples of 3 holothuroids
4195	AC818	2740	5/30/2006	14:42	26.18013755	-94.62276839	Pat Hickey	Erik Cordes	Liz Goehring	Reset nav

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4195	AC818	2740	5/30/2006	14:54	26.18021658	-94.62301668	Pat Hickey	Erik Cordes	Liz Goehring	At benchmark 9
4195	AC818	2740	5/30/2006	16:36	26.18017507	-94.62298908	Pat Hickey	Erik Cordes	Liz Goehring	Bushmaster- 1 bag small rocks from bushmaster
4195	AC818	2740	5/30/2006	17:05	26.18014656	-94.62,300305	Pat Hickey	Erik Cordes	Liz Goehring	Deployed marker #4 by stained tubeworms
4195	AC818	2740	5/30/2006	17:21	26.18021399	-94.62298475	Pat Hickey	Erik Cordes	Liz Goehring	Deployed marker #3 by 2nd stained tubie bush
4195	AC818	2740	5/30/2006	17:29	26.18031411	-94.62301068	Pat Hickey	Erik Cordes	Liz Goehring	3rd bush stained near marker #1
4195	AC818	2740	5/30/2006	18:31	26.18065005	-94.62279433	Pat Hickey	Erik Cordes	Liz Goehring	Slurp of 3 starfish, 1 squid, sea cucumber, galatheid crab and pogonophorans
4195	AC818	2740	5/30/2006	18:45	26.18084772	-94.62289617	Pat Hickey	Erik Cordes	Liz Goehring	Mussel scoop- included 1 back small carbonate rocks
4195	AC818	2740	5/30/2006	18:57	26.17987855	-94.62323654	Pat Hickey	Erik Cordes	Liz Goehring	Slurp of holothurian
4195	AC818	2740	5/30/2006	19:06	26.18013517	-94.62282694	Pat Hickey	Erik Cordes	Liz Goehring	Pushcore #2 and 3 at bushmaster scar
4195	AC818	2740	5/30/2006	19:14	26.18018699	-94.62282498	Pat Hickey	Erik Cordes	Liz Goehring	2 large carbonate collection near marker #3
4196	AC601	2330	5/31/2006	15:11	26.39235023	-94.51421983	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Pelagic pump- yellow chamber
4196	AC601	2330	5/31/2006	15:27	26.39230210	-94.51411562	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Pelagic pump- red chamber
4196	AC601	2330	5/31/2006	17:09	26.39208968	-94.51375551	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Slurp of sargassum
4196	AC601	2330	5/31/2006	17:20	26.39244268	-94.51376537	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Red pushcores of fluff
4196	AC601	2330	5/31/2006	17:31	26.39248183	-94.51380398	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Coconut collection
4196	AC601	2330	5/31/2006	17:37	26.39248196	-94.51380323	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Octopus collection

DIVE NUM	Site	Depth (m)	Date	Time	Lat Mean	Lon Mean	Pilot	Port Observer	STB Observer	Activity
4196	AC601	2330	5/31/2006	17:45	26.39222156	-94.51382848	Bruce Strickrott	Chuck Fisher	Jeremy Potter	6 push cores in brine
4196	AC601	2330	5/31/2006	18:00	26.39186735	-94.51384672	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Carbonate with sponges collection
4196	AC601	2330	5/31/2006	18:42	26.39031060	-94.51437619	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Bushmaster
4196	AC601	2330	5/31/2006	19:32	26.39045026	-94.51382057	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Reset nav
4196	AC601	2330	5/31/2006	19:34	26.39050095	-94.51356327	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Deployed Benchmark #1
4196	AC601	2330	5/31/2006	19:35	26.39047826	-94.51354937	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Carbonate collection
4196	AC601	2330	5/31/2006	20:21	26.39146400	-94.51488008	Bruce Strickrott	Chuck Fisher	Jeremy Potter	Mussel scoop
4197	AC645	2,200	6/1/2006	14:29	26.35388547	-94.49602851	Gavin Eppard	Ian MacDonald	Kazumi Shibata	Mussel pot A near marker 3
4197	AC645	2,200	6/1/2006	14:57	26.35387337	-94.49601058	Gavin Eppard	Ian MacDonald	Kazumi Shibata	Mussel pot B near marker 4
4197	AC645	2,200	6/1/2006	15:16	26.35387452	-94.49601434	Gavin Eppard	Ian MacDonald	Kazumi Shibata	Mussel scoop
4197	AC645	2,200	6/1/2006	15:33	26.35436315	-94.49729308	Gavin Eppard	Ian MacDonald	Kazumi Shibata	Carbonate collection
4197	AC645	2,200	6/1/2006	15:45	26.35411139	-94.49743801	Gavin Eppard	Ian MacDonald	Kazumi Shibata	Medium carbonate from top of hill
4197	AC645	2,200	6/1/2006	15:45	26.35411139	-94.49743801	Gavin Eppard	Ian MacDonald	Kazumi Shibata	Small carbonate collection from top of hill

APPENDIX C - AUV FEBRUARY 2007

I read the pages that you are including in the appendix and you have my permission to use them in the report. If you need anything further please do not hesitate to call.

*Jay G. Northcutt
Geophysical Division Manager
C & C Technologies, Inc.
730 East Kaliste Saloom Road
Lafayette, Louisiana 70508
www.cctechnol.com*

Appendix 1. AUV Specifications and Logs

APPENDIX A

INSTRUMENT SETTINGS
SURVEY CONFIGURATION
EQUIPMENT DESCRIPTIONS

INSTRUMENT SETTINGS

**COASTALSTUDIES INSTITUTE
SITE SURVEY
BLOCK 340, ATWATER VALLEY AREA
BLOCK 852, GREEN CANYON AREA
BLOCK 269, WALKER RIDGE AREA
BLOCK 601, ALAMINOS CANYON AREA**

EDGETECH CHIRPED SUBBOTTOM PROFILER

Acoustic Source Level = 200 dB re 1 μ Pa at one meter
Beam Width = 15° - 25°
Record Length = 100 meters (1,500 meters/second)
Record Divisions = 10 meters
Delay = Variable in meters
Setback = None (acoustically positioned)
Frequency = 2 to 8 kilohertz (Chirped/Frequency Modulated)

EDGETECH DUAL FREQUENCY SIDE SCAN SONAR

Frequency = 120 kilohertz
Acoustic Source Level = 210 dB re 1 μ Pa @ 1 m
Transducer Radiation = 0.8° horizontal composite, 70° vertical
Range = 225 meters per channel
Record Divisions = 50 meters
Pulse Bandwidth = 12 kHz

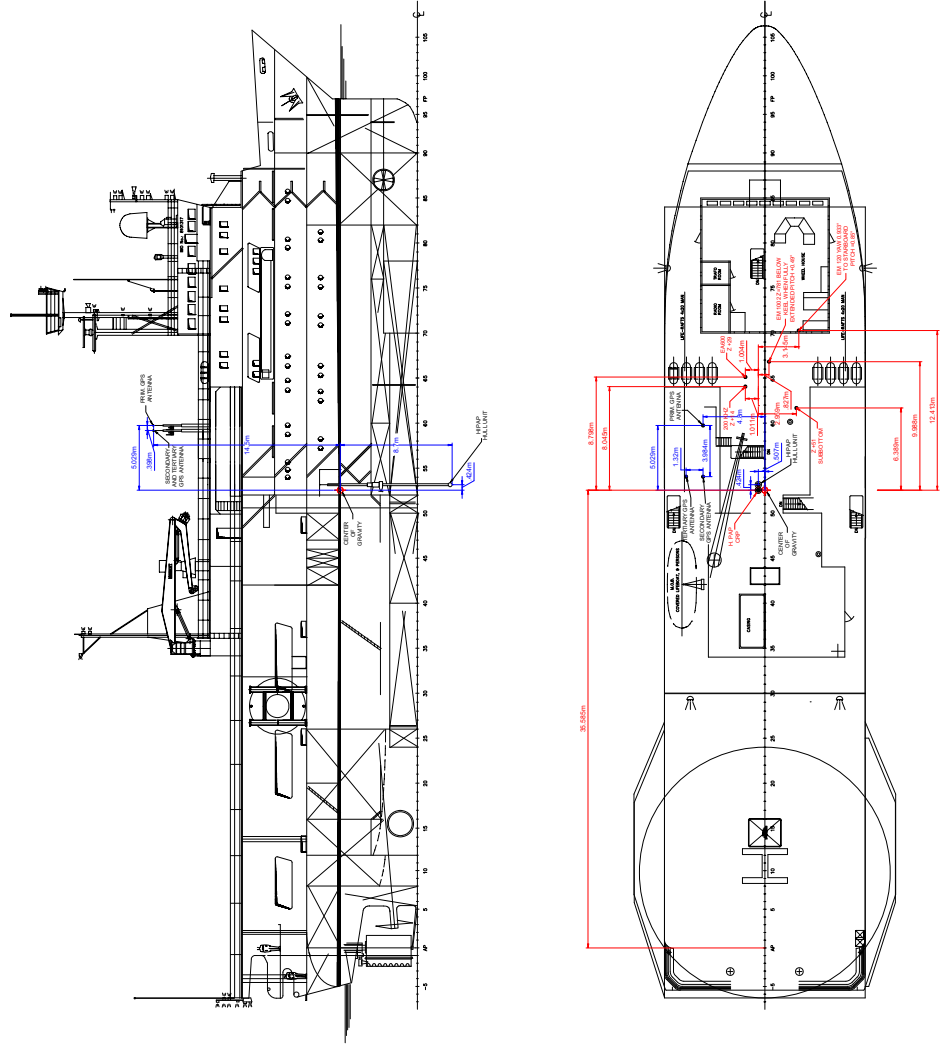
SIMRAD EM-2000 MULTIBEAM ECHOSOUNDER

Frequency = 200 kHz
Ping Rate = 3 times per second
Number of Beams per Ping = 111
Beamwidth = 2° across-track; 1.5° along-track
Pulse Length = 0.05 – 0.25 msec

SURVEY VESSEL

R/V *Northern Resolution*
Average speed during survey = 3.8 knots
Survey sea state = Calm to 6 feet

**GLOBAL POSITIONING SYSTEM
ANTENNA OFFSETS**



C-Surveyor II™ Autonomous Underwater Vehicle (AUV)

The C-Surveyor II™ Autonomous Underwater Vehicle (AUV) is designed to collect deep-water, high-resolution geophysical data for site and route surveys in water depths up to 3,000 meters. C & C Technologies, Inc. worked with Kongsberg Simrad in developing the complex system design in the year 2005. A schematic diagram (Figure 1) of the vehicle and major system components is presented following this text.

Primary survey sensors found in the system payload include a Simrad EM 2000 Swath Bathymetric System, EdgeTech Chirp Side Scan Sonar and an EdgeTech Chirp Subbottom Profiler. An inertial guidance system is used for primary positioning of the underwater vehicle. Ancillary sensors include a precision depth sensor, altimeter, acoustic Doppler log and a salinity/temperature probe for calculating water column sound velocity. Transponders on the system for transmission of data include the HiPAP (High Precision Acoustic Positioning), ACL (Acoustic Command Link) and ADL (Acoustic Data Link). An aluminum/oxygen fuel cell powers the AUV for a period of up to 60 hours. Emergency ascent systems include a drop weight and air bag. A pinger, radio beacon, flashing light and GPS/RF link output visual and remote sensing aids used in locating the AUV should an event occur where communication is lost with the survey ship.

Three industrial strength computers control all the system functions within the C-Surveyor II™. These computers are referred to as the Control Processor, Payload Processor and Navigation Processor. The processors use artificial intelligence algorithms based on feedback returned from the more than 75 sensors to make real-time decisions regarding the system performance. Two titanium spheres, payload and control, house the computers and dual 50-gigabyte data storage drives.

Three topside computers communicate continuously with the vehicle while it is in operation. The C-Surveyor II™ Operator Station is responsible for monitoring all the sensors found in the vehicle and generates warnings to the operator when the values are out of optimal range. The Payload Operator Station computer provides the user with graphical views of the reduced subsets of the subbottom, bathymetry and side scan sonar data. It also allows the user to turn the systems

on or off and adjust instrument settings as needed. The third topside computer is the HiPAP Operator Station. This computer provides a real-time graphic display of the C-Surveyor IITM vehicle subsurface position and the surface position of the mother ship, which travels directly above the AUV while collecting data. C & C's C-NAV[®] Differential GPS provides the mother ship positions while the AUV vehicle positions are calculated using ultra short baseline acoustics (USBL), inertial navigation and Doppler velocity speed log.

Primary positioning of the C-Surveyor IITM is controlled by the inertial navigation system. This system uses precision gyros and accelerometers to maintain the AUV track of the mission plan (trackline running sequence). The mission plan is downloaded to the C-Surveyor IITM system computers before deployment. The HiPAP system and Doppler velocity speed log provide input into the inertial navigation system for guidance system checks. These inputs are weighted and applied to the positioning solution using a Kalman digital filter. Post processing routines can be implemented to further refine the subsea positions.

Simrad's EM 2000 Swath Bathymetry System collects soundings in approximately a 200-meter swath underneath the C-Surveyor IITM vehicle. An onboard velocimeter provides real-time data at the transducer for proper beam forming of the acoustic transmissions. The system is capable of collecting 111 beams or soundings across the swath. A high-precision depth sensor provides the C-Surveyor IITM vehicle depth. The data are processed utilizing C & C's proprietary HydroMap software.

The C-Surveyor IITM is equipped with a dual frequency chirp EdgeTech Side Scan Sonar that uses a calibrated wide band digital frequency modulated (FM) signal to provide high resolution, low-noise images. This sonar simultaneously transmits linearly swept FM pulses centered at two discrete frequencies: 120 kHz and 410 kHz. The raw data files are post-processed and converted to XTF (eXtended Triton Format) for digital interpretation and hardcopy generation.

Seismic profiles are collected with an EdgeTech Chirp Subbottom Profiler. The transmit pulses are generated in the frequency band between 2 and 8 kHz. The system takes advantage of built-in deconvolution of the system response of the output pulse. The sonar's measured system

impulse response is used to design a unique output pulse that will prevent the source from ringing. The raw seismic data can be post processed to create SEG-Y or XTF datasets.

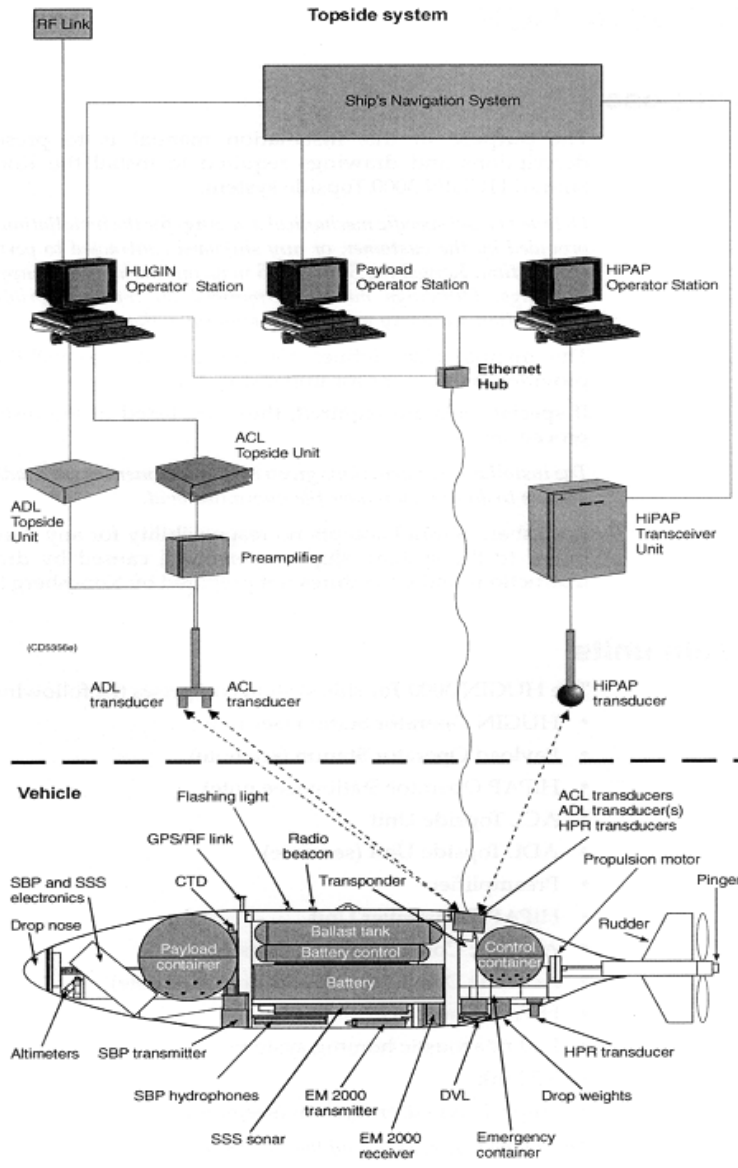


Figure 1 - C-Surveyor II™ (complete system)

Survey Sensors:

Simrad EM 2000 Bathymetry and Imagery (200 kHz, 150°)

Side Scan Sonar: Chirp (120 kHz and/or 410 kHz)

Subbottom Profiler: Chirp (2 –8 kHz)

Ancillary Sensors:

Inertial Navigation

Simrad HiPAP USBL

Doppler Velocity Log

Kalman Filter

Fiber Optic Gyro

Motion Reference Unit

Digiquartz Depth Unit

Single-Beam Altimeter

DGPS

Acoustic Communications

Command and Control (Low Speed Acoustic Modem)

Data Uplink (High Speed Acoustic Modem)

Vessel Specifications:

Depth Rating: 3,000 meters

Length: 6.1 meters

Maximum Diameter: 0.96 meters

Normal Speed: 4 knots

Underwater Endurance @ 4 knots: 60 hours

Power: Aluminum Oxygen Fuel Cell

Survey Equipment Specifications:**Simrad EM 2000 Multibeam Echo Sounder**

Frequency	200 kHz
Maximum Ping Rate	10 times per second
Number of Beams per Ping	111
Beamwidth	2° acrosstrack; 1.5° alongtrack
Beam Spacing	Equiangle or equidistant
Coverage Sector	150°
Depth Resolution	2 cm
Pulse Length	0.05 – 0.25 msec
Range Sampling Rate	10 kHz
Sonar Head Depth Rating	6,000 meters

C-NAV DIFFERENTIAL GPS

C-Nav is a globally corrected differential GPS system owned and operated by C & C Technologies, Inc. The C-Nav GPS Receiver combines a dual-frequency, geodetic grade, GPS Receiver with an integrated L-BAND communication RF detector and decoder all linked by an internal microprocessor. C-Nav uses monitoring stations strategically located around the globe to provide worldwide accuracies in the order of 0.25m (1 sigma)*.



The technique, developed by the Jet Propulsion Lab for the National Aeronautics Space Administration, uses a global network of reference stations to track the entire constellation of GPS satellites. The raw GPS observations are transmitted via the Internet back to the Network Control Center where the GPS constellation satellite orbital corrections and clock-offset values are calculated and modeled in real-time. These corrections are universally valid and can be applied to GPS measurements from any location on earth.

The multi-function antenna assembly is capable of receiving the L1 and L2 GPS frequencies as well as the Inmarsat L-BAND receive frequency band. The gain pattern of this antenna is designed to be relatively constant even at lower elevations. This allows for an efficient link budget when the unit is operated at higher latitudes where the elevation of the geo-stationary communication satellite is low and close to the horizon. Atmospheric delays are eliminated from local measurements by comparing the L1 and L2 frequencies in the internal GPS receiver.

Full Spectrum Chirp Side Scan Sonar

Modulation	Full spectrum chirp frequency modulated pulse with amplitude and phase weighting	
Dual Frequency Combinations	120/410 kHz	

Common

Vertical Beam Width	70°	
Depression Angle	25° from horizontal	
A/D Resolution	16 bits	
Sample Rate	~2,000 samples per channel	

Frequency Specific

Center Frequency	120 kHz	410 kHz
Pulse Bandwidth	12 kHz	41 kHz
Pulse Length	8.3 msec.	2.4 msec.
Range Scale Selection (per side)	25-500 meters	12.5-100 meters
Maximum Ping Rate	30 pps	60 pps
Range Resolution	6.25 cm	1.8 cm
Horizontal 3 dB Beam Width	0.8°	0.5°
Transmit Power	200 Watts	160 Watts
Peak Source Level	210 dB	216 dB
(ref = 1µPa @ 1 m)		
Receiver Sensitivity	-190 dB	-196 dB
(ref = 1 V/µPa @ center frequency)		

Full Spectrum Chirp Subbottom Profiler

Modulation	Full Spectrum Chirp Frequency Modulated Pulse with amplitude and phase weighting
Source Level	200 dB re 1 µPa at one meter
Transmit Power	200 Watts
Receive Sensitivity	-204 dB re 1 µPa at one meter
Receiver Variable Gain	38 – 105 dB, automatic or manual control
Noise Level	70 dB re 1 µPa at one meter over sonar bandwidth (at hydrophone input)
Pulse Repetition Frequency	15 Hz maximum
Calibration	Each system is acoustic tank tested to calibrate for reflection coefficient measurements
Frequency Band	2 – 8 kHz
Number of Hydrophone Arrays	2
Resolution	6 – 10 cm
Beam Width	15° - 25°

Survey Sensors:

Simrad EM 2000 Bathymetry and Imagery (200 kHz, 150°)

Side Scan Sonar: Chirp (120 kHz and/or 410 kHz)

Subbottom Profiler: Chirp (2 –8 kHz)

Ancillary Sensors:

Inertial Navigation

Simrad HiPAP USBL

Doppler Velocity Log

Kalman Filter

Fiber Optic Gyro

Motion Reference Unit

Digiquartz Depth Unit

Single-Beam Altimeter

DGPS

Acoustic Communications

Command and Control (Low Speed Acoustic Modem)

Data Uplink (High Speed Acoustic Modem)

Vessel Specifications:

Depth Rating: 3,000 meters

Length: 6.1 meters

Maximum Diameter: 0.96 meters

Normal Speed: 4 knots

Underwater Endurance @ 4 knots: 60 hours

Power: Aluminum Oxygen Fuel Cell

Survey Equipment Specifications:**Simrad EM 2000 Multibeam Echo Sounder**

Frequency	200 kHz
Maximum Ping Rate	10 times per second
Number of Beams per Ping	111
Beamwidth	2° acrosstrack; 1.5° alongtrack
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Coverage Sector	150°
Depth Resolution	2 cm
Pulse Length	0.05 – 0.25 msec
Range Sampling Rate	10 kHz
Sonar Head Depth Rating	6,000 meters

impulse response is used to design a unique output pulse that will prevent the source from ringing. The raw seismic data can be post processed to create SEG-Y or XTF datasets.

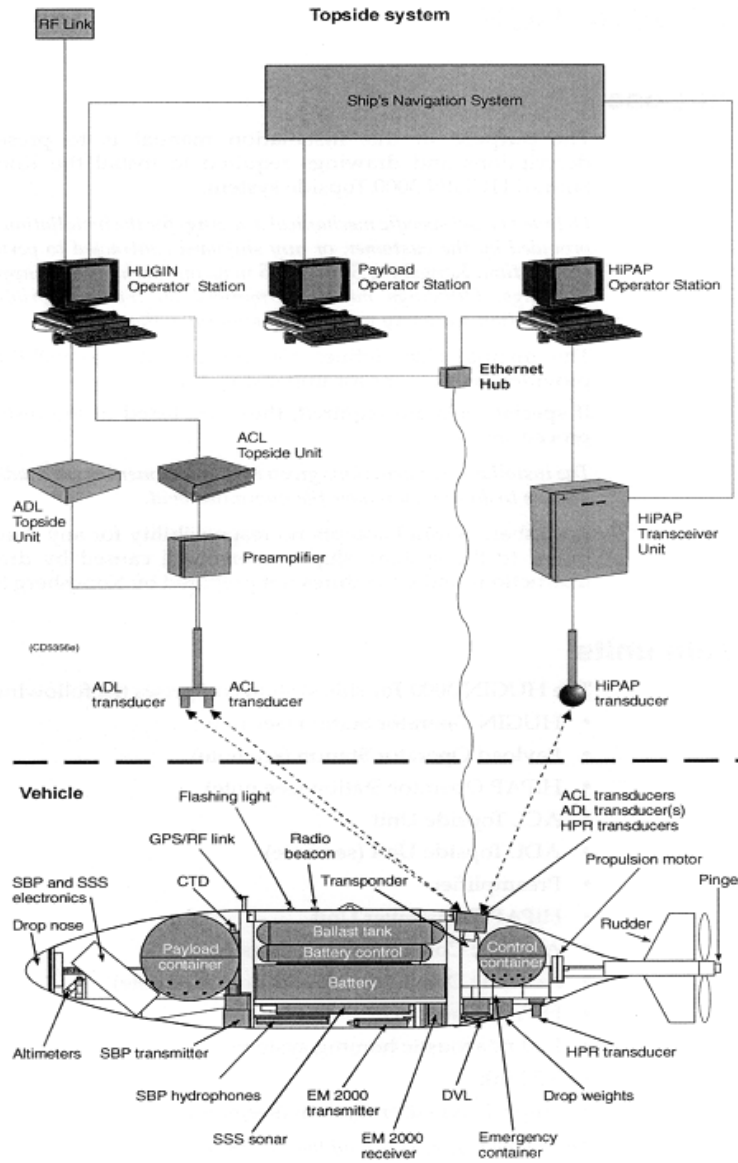


Figure 1 - C-Surveyor II™ (complete system)

C-Surveyor IITM Autonomous Underwater Vehicle (AUV)

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Three topside computers communicate continuously with the vehicle while it is in operation. The C-Surveyor IITM Operator Station is responsible for monitoring all the sensors found in the vehicle and generates warnings to the operator when the values are out of optimal range. The Payload Operator Station computer provides the user with graphical views of the reduced subsets of the subbottom, bathymetry and side scan sonar data. It also allows the user to turn the systems

Specifications:

	Measurement Range	Initial Accuracy	Resolution	Sensor Calibration
Conductivity	0 to 7 S/m	+/- 0.001 S/m	+/- 0.0001 S/m	0 – 7 S/m Physical calibration over the range 1.4 to 6 S/m, plus zero conductivity (air)
Temperature (°C)	-5 to + 35	+/- 0.01	+/-0.001	-1 to +31 (Measurements outside this range may be at slightly reduces accuracy due to extrapolation errors)
Depth	68 to 1000 m	+/- 0.25%	+/- 0.015%	Minimum 5 values between 0 and full scale

APPENDIX B
PROJECT PERSONNEL
DAILY PROGRESS REPORTS
SURVEY LOGS

PROJECT PERSONNEL

FIELD PERSONNEL

R/V *NORTHERN RESOLUTIN*:

Scott McBay – Party Chief
David Aucoin – Shift Leader
Cole Gibbens –COS Operator
Beau Hollie – Shift Leader
Mark Gatch – COS Operator
T.J. Maise – AUV Van Crew Chief
Gerard Lege – AUV Technician
Keith Dominique – AUV Technician
Josh Saran – AUV Technician
Scotty Belaire – Data Processor
Will Harwell – Data Processor
Tim Badeaux – ACAD Operator
Kim Eslinger – Geologist
Eddie Romero – Additional C&C Crew (trainee)
Tom Javins – Medic
Mark Quinney – Cook

OFFICE PERSONNEL

Jay Northcutt – Geophysical Projects Manager
Ralph Coleman – Database Calculations
Jason Duplechin – Data Processor
Tony George – Geosciences Manager
Ave McBride – Cartographer
Nicole Douglas – Geophysical Assistant
Nikki Bono – Geophysical Assistant



Louisiana State University LSU

JOB #	072265	DPR #	1	Mission:	run070207_1		2/7/2007
Client				LSU			
Project Name				AUV Site Survey			
Survey Area				Multiple Areas			
Scope of Work				AUV Site Survey			
Vessel				R/V Northern Resolution			
Midnight Location				Lat:	N28 01.3201	Lon:	W88 08.3575
DPR Distribution List:							
E-mail Address		Name		Company			
Client Representative							
Client Distribution List							
hrober3@lsu.edu		Dr. Harry Roberts					
C&C Technologies:							
smm@cctechnol.com		Scott Melancon		C&C Technologies			
pcm@cctechnol.com		Paige Melancon		C&C Technologies			
jsm@cctechnol.com		Scott McBay		C&C Technologies			
jgn@cctechnol.com		Jay Northcutt		C&C Technologies			
ces@cctechnol.com		Charlie Spann		C&C Technologies			
tdr@cctechnol.com		Tom Richards		C&C Technologies			
tsc@cctechnol.com		Thomas Chance		C&C Technologies			
dja@cctechnol.com		Dave Alleman		C&C Technologies			
jef@cctechnol.com		Jeff Fortenberry		C&C Technologies			
Project Dates/Times							
Note All Times In UTC (GMT)							
				Date:		Time:	
Commenced Mobilization				2/7/2007		0600	
Completed Mobilization				2/7/2007		0800	
Transit to Job Site				2/7/2007		0600	
Arrived at Job Site				2/7/2007		0800	
Commenced Calibrations							
Completed Calibrations							
Commenced Scope of Work				2/7/2007		1000	
Completed Scope of Work							
Commenced Additional Work							
Completed Additional Work							
Commenced Rerun's							
Completed Rerun's							
Commenced Coring							
Completed Coring							
Arrived alongside							
Commenced Demobilization							
Completed Demobilization							

Safety				
	Today	To Date		
Stop Cards	0	0	Safety/Orientation inductions	2
Tailgate Meetings	2	0	Job Kickoff Meeting	2/5/2007
Shift Change Meetings	2	0	Last Safety Meeting	2/7/2007
JSA Review	1	0	Last Safety Committee	2/2/2007
First aid cases	0	0	Last Fire Drill	2/7/2007
Medical treatment cases	0	0	Last Abandon Ship Drill	2/7/2007
Restricted work cases	0	0	Last Man Over Board Drill	2/7/2007
Lost time incidents	0	0	Total Personnel On Board	33
Comments:				
Weather - Last 24 hours				
Time	Wind Direction	Wind Speed Knots	Seas Meters	Swell
0000-0600	ENE	15	2-3	
0600-1200	ENE	15	2-3	
1200-1800	SE	12	1	
1800-2400	NE	12	1	
Forecast Next 48 Hours				
Date	Wind Direction	Wind Speed knots	Seas Meters	Swell
2/8/2007	E	10	1	
2/9/2007	E	10	1	
Daily Chronology Summary				
From Hr:Min	To Hr:Min	Total Hr:Min	Code	Description
0:00	8:00	8:00	MD	Mobilize
8:00	10:00	2:00	AIV	CTD
10:00	11:00	1:00	ALR	Launch AUV
11:00	0:00	13:00	RL	Survey
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
Cumulative Times				
Description	Code	Today	To Date	Cumulative
Mobilization/Demob	MD	8.00	0.00	8.00
Transit	TR	0.00	0.00	0.00
Calibrations	CA	0.00	0.00	0.00
Op(AUV in the Van)	AIV	2.00	0.00	2.00
Op(AUV running lines)	RL	13.00	0.00	13.00
OP(AUV L&R)	ALR	1.00	0.00	1.00
Additional work (Clients request)	AW	0.00	0.00	0.00
Coring	CO	0.00	0.00	0.00
Standby	SB	0.00	0.00	0.00
Equipment Downtime	ED	0.00	0.00	0.00
Vessel Downtime	VD	0.00	0.00	0.00
Re Runs	RR	0.00	0.00	0.00
Weather Downtime	WOW	0.00	0.00	0.00
Other	OTH	0.00	0.00	0.00
Totals		24.00	0.00	24.00
Ops Planned Next 3 Days:				
AUV Survey				

Dive Summary						
Cumulative Dives	Planned Dives Complete	Failed Dives Prior To Start of Mission	Failed Dives During Mission	Dives Aborted		
1	0	0	0	0		
Percentage	0.00%	0.00%	0.00%	0.00%		
Percentages: Survey Operations						
Description			Complete	Remain		
Mob/Demob			50%	50%		
Transit			50%	50%		
Data Acquisition						
Calculations Based On 140 Km in a 24 Hour Period						
Description	Total	Today	To Date	Complete	Remain	Days
Survey Primary	216.00	60.90	60.90	28.19%	71.81%	1.11
Survey Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Primary	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Battery Change + LR	Anode Changes	0	Recovery Fluid Change	0	0.00	0.00
Coring						
Calculations Based on 12 Cores Taken in a 24 Hour Period						
Description	Total	Complete	Remain	Days		
Piston	0	0	0	0.00		
Box	0	0	0	0.00		
Totals				1.11		
Comments						
C&C:						
Client:						
Contact Numbers						
R/V Northern Resolution						
Lab Voice-----Ext. 2911	VSAT	(337) 237-4242 Then Appropriate Ext.				
Bridge Voice-----Ext. 2913	SAT B	001-874-327-302-889				
Party Chief Voice-----Ext. 2912						
C&C TECHNOLOGIES						
Office	337-261-0660					
Office Fax	337-261-0192					
C&C Representative	Client Representative		Client Representative			
AUV Field Project Manager						
Scott McBay						



Louisiana State University
LSU

JOB #	072265	DPR #	2	Mission:	run070207_1		2/8/2007
Client	LSU						
Project Name	AUV Site Survey						
Survey Area	Multiple Areas						
Scope of Work	AUV Site Survey						
Vessel	R/V Northern Resolution						
Midnight Location	Lat:	N28 01.3201	Lon:	W88 08.3575			
DPR Distribution List:							
E-mail Address	Name	Company					
Client Representative							
Client Distribution List							
hrober3@lsu.edu	Dr. Harry Roberts						
C&C Technologies:							
smm@cctechnol.com	Scott Melancon	C&C Technologies					
pcm@cctechnol.com	Paige Melancon	C&C Technologies					
jsm@cctechnol.com	Scott McBay	C&C Technologies					
jgn@cctechnol.com	Jay Northcutt	C&C Technologies					
ces@cctechnol.com	Charlie Spann	C&C Technologies					
tdr@cctechnol.com	Tom Richards	C&C Technologies					
tsc@cctechnol.com	Thomas Chance	C&C Technologies					
dja@cctechnol.com	Dave Alleman	C&C Technologies					
jef@cctechnol.com	Jeff Fortenberry	C&C Technologies					
Project Dates/Times							
Note All Times In UTC (GMT)							
	Date:	Time:					
Commenced Mobilization	2/7/2007	0600					
Completed Mobilization	2/7/2007	0800					
Transit to Job Site	2/7/2007	0600					
Arrived at Job Site	2/7/2007	0800					
Commenced Calibrations							
Completed Calibrations							
Commenced Scope of Work	2/7/2007	1000					
Completed Scope of Work							
Commenced Additional Work							
Completed Additional Work							
Commenced Rerun's							
Completed Rerun's							
Commenced Coring							
Completed Coring							
Arrived alongside							
Commenced Demobilization							
Completed Demobilization							

Safety				
	Today	To Date		
Stop Cards	0	0	Safety/Orientation inductions	2
Tailgate Meetings	2	0	Job Kickoff Meeting	2/5/2007
Shift Change Meetings	2	0	Last Safety Meeting	2/8/2007
JSA Review	1	0	Last Safety Committee	2/2/2007
First aid cases	0	0	Last Fire Drill	2/7/2007
Medical treatment cases	0	0	Last Abandon Ship Drill	2/7/2007
Restricted work cases	0	0	Last Man Over Board Drill	2/7/2007
Lost time incidents	0	0	Total Personnel On Board	33
Comments:				
Weather - Last 24 hours				
Time	Wind Direction	Wind Speed Knots	Seas Meters	Swell
0000-0600	ENE	15	2-3	
0600-1200	ENE	15	2-3	
1200-1800	SE	12	1	
1800-2400	NE	12	1	
Forecast Next 48 Hours				
Date	Wind Direction	Wind Speed knots	Seas Meters	Swell
2/8/2007	E	10	1	
2/9/2007	E	10	1	
Daily Chronology Summary				
From Hr:Min	To Hr:Min	Total Hr:Min	Code	Description
0:00	3:30	3:30	RL	Survey AT340
3:30	4:30	1:00	ALR	Recover CSII
4:30	19:00	14:30	TR	Transit to GC852
19:00	22:30	3:30	AIV	CTD 070807a
22:30	23:30	1:00	ALR	Launch AUV
23:30	0:00	0:30	RL	Survey GC852
		0		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
Cumulative Times				
Description	Code	Today	To Date	Cumulative
Mobilization/Demob	MD	0.00	8.00	8.00
Transit	TR	14.50	0.00	14.50
Calibrations	CA	0.00	0.00	0.00
Op(AUV in the Van)	AIV	3.50	2.00	5.50
Op(AUV running lines)	RL	4.00	13.00	17.00
OP(AUV L&R)	ALR	2.00	1.00	3.00
Additional work (Clients request)	AW	0.00	0.00	0.00
Coring	CO	0.00	0.00	0.00
Standby	SB	0.00	0.00	0.00
Equipment Downtime	ED	0.00	0.00	0.00
Vessel Downtime	VD	0.00	0.00	0.00
Re Runs	RR	0.00	0.00	0.00
Weather Downtime	WOW	0.00	0.00	0.00
Other	OTH	0.00	0.00	0.00
Totals		24.00	24.00	48.00
Ops Planned Next 3 Days:				
AUV Survey				

Dive Summary						
Cumulative Dives	Planned Dives Complete	Failed Dives Prior To Start of Mission	Failed Dives During Mission	Dives Aborted		
1	0	0	0	0		
Percentage	0.00%	0.00%	0.00%	0.00%		
Percentages: Survey Operations						
Description				Complete	Remain	
Mob/Demob				50%	50%	
Transit				50%	50%	
Data Acquisition						
Calculations Based On 140 Km in a 24 Hour Period						
Description	Total	Today	To Date	Complete	Remain	Days
Survey Primary	216.00	18.00	78.90	36.53%	63.47%	0.98
Survey Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Primary	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Battery Change + LR	Anode Changes	0	Recovery Fluid Change	0	0.00	
Coring						
Calculations Based on 12 Cores Taken in a 24 Hour Period						
Description	Total	Complete	Remain	Days		
Piston	0	0	0	0.00		
Box	0	0	0	0.00		
Totals						0.98
Comments						
C&C:						
Client:						
Contact Numbers						
R/V Northern Resolution						
Lab Voice-----Ext. 2911	VSAT	(337) 237-4242 Then Appropriate Ext.				
Bridge Voice-----Ext. 2913	SAT B	001-874-327-302-889				
Party Chief Voice-----Ext. 2912						
C&C TECHNOLOGIES						
Office	337-261-0660					
Office Fax	337-261-0192					
C&C Representative		Client Representative		Client Representative		
AUV Field Project Manager						
Scott McBay						



Louisiana State University LSU

JOB #	072265	DPR #	3	Mission:	run070208_1		2/9/2007
Client	LSU						
Project Name	AUV Site Survey						
Survey Area	Multiple Areas						
Scope of Work	AUV Site Survey						
Vessel	R/V Northern Resolution						
Midnight Location	Lat:	N26 41.2369	Lon:	W91 40.2744			
DPR Distribution List:							
E-mail Address	Name		Company				
Client Representative							
Client Distribution List							
hrober3@lsu.edu	Dr. Harry Roberts						
C&C Technologies:							
smm@cctechnol.com	Scott Melancon		C&C Technologies				
pcm@cctechnol.com	Paige Melancon		C&C Technologies				
jsm@cctechnol.com	Scott McBay		C&C Technologies				
jgn@cctechnol.com	Jay Northcutt		C&C Technologies				
ces@cctechnol.com	Charlie Spann		C&C Technologies				
tdr@cctechnol.com	Tom Richards		C&C Technologies				
tsc@cctechnol.com	Thomas Chance		C&C Technologies				
dja@cctechnol.com	Dave Alleman		C&C Technologies				
jef@cctechnol.com	Jeff Fortenberry		C&C Technologies				
Project Dates/Times							
Note All Times In UTC (GMT)							
	Date:		Time:				
Commenced Mobilization	2/7/2007		0600				
Completed Mobilization	2/7/2007		0800				
Transit to Job Site	2/7/2007		0600				
Arrived at Job Site	2/7/2007		0800				
Commenced Calibrations							
Completed Calibrations							
Commenced Scope of Work	2/7/2007		1000				
Completed Scope of Work							
Commenced Additional Work							
Completed Additional Work							
Commenced Rerun's							
Completed Rerun's							
Commenced Coring							
Completed Coring							
Arrived alongside							
Commenced Demobilization							
Completed Demobilization							

Safety				
	Today	To Date		
Stop Cards	1	0	Safety/Orientation inductions	2
Tailgate Meetings	2	2	Job Kickoff Meeting	2/5/2007
Shift Change Meetings	2	2	Last Safety Meeting	2/9/2007
JSA Review	1	1	Last Safety Committee	2/2/2007
First aid cases	0	0	Last Fire Drill	2/7/2007
Medical treatment cases	0	0	Last Abandon Ship Drill	2/7/2007
Restricted work cases	0	0	Last Man Over Board Drill	2/7/2007
Lost time incidents	0	0	Total Personnel On Board	33
Comments:				
Weather - Last 24 hours				
Time	Wind Direction	Wind Speed Knots	Seas Meters	Swell
0000-0600	N	10	1	
0600-1200	E	7	0	
1200-1800	E	3	.5	
1800-2400	NE	4	1	
Forecast Next 48 Hours				
Date	Wind Direction	Wind Speed knots	Seas Meters	Swell
2/10/2007	ENE	5-10	1	
2/11/2007	ESE	10	1	
Daily Chronology Summary				
From Hr:Min	To Hr:Min	Total Hr:Min	Code	Description
0:00	12:00	12:00	RL	Survey GC852
12:00	13:30	1:30	ALR	Recover CSII
13:30	17:00	3:30	TR	Transit to WR269
17:00	18:30	1:30	AIV	CTD 070209a
18:30	20:00	1:30	ALR	Launch CSII
20:00	0:00	4:00	RL	Survey WR269
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
Cumulative Times				
Description	Code	Today	To Date	Cumulative
Mobilization/Demob	MD	0.00	8.00	8.00
Transit	TR	3.50	14.50	18.00
Calibrations	CA	0.00	0.00	0.00
Op(AUV in the Van)	AIV	1.50	5.50	7.00
Op(AUV running lines)	RL	16.00	17.00	33.00
OP(AUV L&R)	ALR	3.00	3.00	6.00
Additional work (Clients request)	AW	0.00	0.00	0.00
Coring	CO	0.00	0.00	0.00
Standby	SB	0.00	0.00	0.00
Equipment Downtime	ED	0.00	0.00	0.00
Vessel Downtime	VD	0.00	0.00	0.00
Re Runs	RR	0.00	0.00	0.00
Weather Downtime	WOW	0.00	0.00	0.00
Other	OTH	0.00	0.00	0.00
Totals		24.00	48.00	72.00
Ops Planned Next 3 Days:				
AUV Survey				

Dive Summary						
Cumulative Dives	Planned Dives Complete	Failed Dives Prior To Start of Mission	Failed Dives During Mission	Dives Aborted		
3	2	0	0	0		
Percentage	66.67%	0.00%	0.00%	0.00%		
Percentages: Survey Operations						
Description			Complete	Remain		
Mob/Demob			50%	50%		
Transit			50%	50%		
Data Acquisition						
Calculations Based On 140 Km in a 24 Hour Period						
Description	Total	Today	To Date	Complete	Remain	Days
Survey Primary	216.00	88.05	166.95	77.29%	22.71%	0.35
Survey Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Primary	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Battery Change + LR	Anode Changes	0	Recovery Fluid Change	0	0.00	0.00
Coring						
Calculations Based on 12 Cores Taken in a 24 Hour Period						
Description	Total	Complete	Remain	Days		
Piston	0	0	0	0.00		
Box	0	0	0	0.00		
Totals				0.35		
Comments						
C&C:						
Client:						
Contact Numbers						
R/V Northern Resolution						
Lab Voice-----Ext. 2911	VSAT	(337) 237-4242 Then Appropriate Ext.				
Bridge Voice-----Ext. 2913	SAT B	001-874-327-302-889				
Party Chief Voice-----Ext. 2912						
C&C TECHNOLOGIES						
Office	337-261-0660					
Office Fax	337-261-0192					
C&C Representative	Client Representative		Client Representative			
AUV Field Project Manager						
Scott McBay						



Louisiana State University
LSU

JOB #	072265	DPR #	4	Mission:	run070210_1		2/10/2007
Client	LSU						
Project Name	AUV Site Survey						
Survey Area	Multiple Areas						
Scope of Work	AUV Site Survey						
Vessel	R/V Northern Resolution						
Midnight Location	Lat:	N26 21.7806	Lon:	W94 31.3067			
DPR Distribution List:							
E-mail Address	Name		Company				
Client Representative							
Client Distribution List							
hrober3@lsu.edu	Dr. Harry Roberts						
C&C Technologies:							
smm@cctechnol.com	Scott Melancon		C&C Technologies				
pcm@cctechnol.com	Paige Melancon		C&C Technologies				
jsm@cctechnol.com	Scott McBay		C&C Technologies				
jgn@cctechnol.com	Jay Northcutt		C&C Technologies				
ces@cctechnol.com	Charlie Spann		C&C Technologies				
tdr@cctechnol.com	Tom Richards		C&C Technologies				
tsc@cctechnol.com	Thomas Chance		C&C Technologies				
dja@cctechnol.com	Dave Alleman		C&C Technologies				
jef@cctechnol.com	Jeff Fortenberry		C&C Technologies				
Project Dates/Times							
Note All Times In UTC (GMT)							
	Date:		Time:				
Commenced Mobilization	2/7/2007		0600				
Completed Mobilization	2/7/2007		0800				
Transit to Job Site	2/7/2007		0600				
Arrived at Job Site	2/7/2007		0800				
Commenced Calibrations							
Completed Calibrations							
Commenced Scope of Work	2/7/2007		1000				
Completed Scope of Work							
Commenced Additional Work							
Completed Additional Work							
Commenced Rerun's							
Completed Rerun's							
Commenced Coring							
Completed Coring							
Arrived alongside							
Commenced Demobilization							
Completed Demobilization							

Safety				
	Today	To Date		
Stop Cards	0	1	Safety/Orientation inductions	2
Tailgate Meetings	2	4	Job Kickoff Meeting	2/5/2007
Shift Change Meetings	2	4	Last Safety Meeting	2/10/2007
JSA Review	2	2	Last Safety Committee	2/10/2007
First aid cases	0	0	Last Fire Drill	2/7/2007
Medical treatment cases	0	0	Last Abandon Ship Drill	2/7/2007
Restricted work cases	0	0	Last Man Over Board Drill	2/7/2007
Lost time incidents	0	0	Total Personnel On Board	33
Comments:				
Weather - Last 24 hours				
Time	Wind Direction	Wind Speed Knots	Seas Meters	Swell
0000-0600	N	2	.5	
0600-1200	E	7	1	
1200-1800	E	3	1	
1800-2400	NE	4	1	
Forecast Next 48 Hours				
Date	Wind Direction	Wind Speed knots	Seas Meters	Swell
2/11/2007	E	15	2	
2/12/2007	SE	15	2	
Daily Chronology Summary				
From Hr:Min	To Hr:Min	Total Hr:Min	Code	Description
0:00	2:30	2:30	RL	Survey WR269
2:30	4:00	1:30	ALR	Recover CSII
4:00	18:00	14:00	TR	Transit to AC601
18:00	20:00	2:00	AIV	CTD 070210a
20:00	21:00	1:00	ALR	Launch CSII
21:00	0:00	3:00	RL	Survey AC601
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
Cumulative Times				
Description	Code	Today	To Date	Cumulative
Mobilization/Demob	MD	0.00	8.00	8.00
Transit	TR	14.00	18.00	32.00
Calibrations	CA	0.00	0.00	0.00
Op(AUV in the Van)	AIV	2.00	7.00	9.00
Op(AUV running lines)	RL	5.50	33.00	38.50
OP(AUV L&R)	ALR	2.50	6.00	8.50
Additional work (Clients request)	AW	0.00	0.00	0.00
Coring	CO	0.00	0.00	0.00
Standby	SB	0.00	0.00	0.00
Equipment Downtime	ED	0.00	0.00	0.00
Vessel Downtime	VD	0.00	0.00	0.00
Re Runs	RR	0.00	0.00	0.00
Weather Downtime	WOW	0.00	0.00	0.00
Other	OTH	0.00	0.00	0.00
Totals		24.00	72.00	96.00
Ops Planned Next 3 Days:				
AUV Survey				

Dive Summary						
Cumulative Dives	Planned Dives Complete	Failed Dives Prior To Start of Mission	Failed Dives During Mission	Dives Aborted		
4	3	0	0	0		
Percentage	75.00%	0.00%	0.00%	0.00%		
Percentages: Survey Operations						
Description			Complete	Remain		
Mob/Demob			50%	50%		
Transit			50%	50%		
Data Acquisition						
Calculations Based On 140 Km in a 24 Hour Period						
Description	Total	Today	To Date	Complete	Remain	Days
Survey Primary	216.00	21.15	188.10	87.08%	12.92%	0.20
Survey Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Primary	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Battery Change + LR	Anode Changes	0	Recovery Fluid Change	0	0.00	0.00
Coring						
Calculations Based on 12 Cores Taken in a 24 Hour Period						
Description	Total	Complete	Remain	Days		
Piston	0	0	0	0.00		
Box	0	0	0	0.00		
Totals				0.20		
Comments						
C&C:						
Client:						
Contact Numbers						
R/V Northern Resolution						
Lab Voice-----Ext. 2911		VSAT	(337) 237-4242 Then Appropriate Ext.			
Bridge Voice-----Ext. 2913		SAT B	001-874-327-302-889			
Party Chief Voice-----Ext. 2912						
C&C TECHNOLOGIES						
Office	337-261-0660					
Office Fax	337-261-0192					
C&C Representative		Client Representative		Client Representative		
AUV Field Project Manager						
Scott McBay						



Louisiana State University LSU

JOB #	072265	DPR #	5	Mission:	run070210_1		2/11/2007
Client	LSU						
Project Name	AUV Site Survey						
Survey Area	Multiple Areas						
Scope of Work	AUV Site Survey						
Vessel	R/V Northern Resolution						
Midnight Location	Lat:	N26 21.7806	Lon:	W94 31.3067			
DPR Distribution List:							
E-mail Address	Name		Company				
Client Representative							
Client Distribution List							
hrober3@lsu.edu	Dr. Harry Roberts						
C&C Technologies:							
smm@cctechnol.com	Scott Melancon		C&C Technologies				
pcm@cctechnol.com	Paige Melancon		C&C Technologies				
jsm@cctechnol.com	Scott McBay		C&C Technologies				
jgn@cctechnol.com	Jay Northcutt		C&C Technologies				
ces@cctechnol.com	Charlie Spann		C&C Technologies				
tdr@cctechnol.com	Tom Richards		C&C Technologies				
tsc@cctechnol.com	Thomas Chance		C&C Technologies				
dja@cctechnol.com	Dave Alleman		C&C Technologies				
jef@cctechnol.com	Jeff Fortenberry		C&C Technologies				
Project Dates/Times							
Note All Times In UTC (GMT)							
	Date:		Time:				
Commenced Mobilization	2/7/2007		0600				
Completed Mobilization	2/7/2007		0800				
Transit to Job Site	2/7/2007		0600				
Arrived at Job Site	2/7/2007		0800				
Commenced Calibrations							
Completed Calibrations							
Commenced Scope of Work	2/7/2007		1000				
Completed Scope of Work	2/11/2007		0700				
Commenced Additional Work							
Completed Additional Work							
Commenced Rerun's							
Completed Rerun's							
Commenced Coring							
Completed Coring							
Arrived alongside							
Commenced Demobilization							
Completed Demobilization							

Safety				
	Today	To Date		
Stop Cards	0	1	Safety/Orientation inductions	2
Tailgate Meetings	2	4	Job Kickoff Meeting	2/5/2007
Shift Change Meetings	2	4	Last Safety Meeting	2/10/2007
JSA Review	2	2	Last Safety Committee	2/10/2007
First aid cases	0	0	Last Fire Drill	2/7/2007
Medical treatment cases	0	0	Last Abandon Ship Drill	2/7/2007
Restricted work cases	0	0	Last Man Over Board Drill	2/7/2007
Lost time incidents	0	0	Total Personnel On Board	33
Comments:				
Weather - Last 24 hours				
Time	Wind Direction	Wind Speed Knots	Seas Meters	Swell
0000-0600	N	2	.5	
0600-1200	E	7	1	
1200-1800	E	3	1	
1800-2400	NE	4	1	
Forecast Next 48 Hours				
Date	Wind Direction	Wind Speed knots	Seas Meters	Swell
2/11/2007	E	15	2	
2/12/2007	SE	15	2	
Daily Chronology Summary				
From Hr:Min	To Hr:Min	Total Hr:Min	Code	Description
0:00	5:00	5:00	RL	Survey AC601
5:00	7:00	2:00	ALR	Recover CSII
7:00	0:00	17:00	TR	Transit to GC237
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
		0:00		
Cumulative Times				
Description	Code	Today	To Date	Cumulative
Mobilization/Demob	MD	0.00	8.00	8.00
Transit	TR	17.00	32.00	49.00
Calibrations	CA	0.00	0.00	0.00
Op(AUV in the Van)	AIV	0.00	9.00	9.00
Op(AUV running lines)	RL	5.00	38.50	43.50
OP(AUV L&R)	ALR	2.00	8.50	10.50
Additional work (Clients request)	AW	0.00	0.00	0.00
Coring	CO	0.00	0.00	0.00
Standby	SB	0.00	0.00	0.00
Equipment Downtime	ED	0.00	0.00	0.00
Vessel Downtime	VD	0.00	0.00	0.00
Re Runs	RR	0.00	0.00	0.00
Weather Downtime	WOW	0.00	0.00	0.00
Other	OTH	0.00	0.00	0.00
Totals		24.00	96.00	120.00
Ops Planned Next 3 Days:				
AUV Survey				

Dive Summary						
Cumulative Dives	Planned Dives Complete	Failed Dives Prior To Start of Mission	Failed Dives During Mission	Dives Aborted		
4	4	0	0	0		
Percentage	100.00%	0.00%	0.00%	0.00%		
Percentages: Survey Operations						
Description			Complete	Remain		
Mob/Demob			50%	50%		
Transit			50%	50%		
Data Acquisition						
Calculations Based On 140 Km in a 24 Hour Period						
Description	Total	Today	To Date	Complete	Remain	Days
Survey Primary	216.00	27.90	216.00	100.00%	0.00%	0.00
Survey Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Primary	0.00	0.00	0.00	0.00	100.00%	0.00
Rerun's Additional	0.00	0.00	0.00	0.00	100.00%	0.00
Battery Change + LR	Anode Changes	0	Recovery Fluid Change	0	0.00	0.00
Coring						
Calculations Based on 12 Cores Taken in a 24 Hour Period						
Description	Total	Complete	Remain	Days		
Piston	0	0	0	0.00		
Box	0	0	0	0.00		
Totals				0.00		
Comments						
C&C:						
Client:						
Contact Numbers						
R/V Northern Resolution						
Lab Voice-----Ext. 2911		VSAT	(337) 237-4242 Then Appropriate Ext.			
Bridge Voice-----Ext. 2913		SAT B	001-874-327-302-889			
Party Chief Voice-----Ext. 2912						
C&C TECHNOLOGIES						
Office	337-261-0660					
Office Fax	337-261-0192					
C&C Representative		Client Representative		Client Representative		
AUV Field Project Manager						
Scott McBay						

C & C TECHNOLOGIES SURVEY LOG (Hydro-station)						Page No. 1
JobNo.:	Client: Louisiana State University		Vessel: R/V Northern Resolution Remote Vessel: C-Surveyor II™		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log	
Date: (UTC)	Areas: AT Valley Blocks: 340 Units: Meters		Mission:	Datum: NAD27 Projection: UTM Zone: 16N		Geophysical Equipment:
072265			run070207_1	Edgetech 216 FSSB Profiler (2-10 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 (200 kHz)		
Time (UTC) (-6 to Local)	Heading	Water Depth	Fix No.	Line Name	Remarks	
0550					Transit to job site	
0600				Shift Change	B.Hollie, M.Gatch	
				WX	Winds: S 9 knots Seas: 1.0m	
0754					On location for CTD 070207a	
					lowering HiPAP ram	
0801					CTD in water	
0854					CTD on bottom Y:3060090.36 X:365507.37 WD:2318	
0934					CTD on deck CTD 070207a	
0948					Start prediver 070207_1	
1006					Prediver complete	
1019.12					Pin Pulled	
1020					AUV in water	
1118					AUV in external guidance	
1130	180	2243	1	301	SOL	
1153	180	2209	16	301	EOL	
1158	360	2209	16	302	SOL	
1200				WX	Winds: N 7 knots Seas: 1.0m	
1219	360	2243	1	302	EOL	
1223	180	2244	1	303	SOL	
1246	180	2214	16	303	EOL	
1250	360	2216	16	304	SOL	
1311	360	2242	1	304	EOL	
1315	180	2243	1	305	SOL	
1338	180	2217	16	305	EOL	
1343	360	2216	16	306	SOL	
1403	360	2240	1	306	EOL	
1408	180	2242	1	307	SOL	
1431	180	2218	16	307	EOL	
1435	360	2222	16	308	SOL	
1456	360	2245	1	308	EOL	
1500	180	2258	1	309	SOL	
1523	180	2227	16	309	EOL	

C & C TECHNOLOGIES SURVEY LOG (Hydro-station)						Page No. 2
JobNo.:	Client: Louisiana State University		Vessel: R/V <i>Northern Resolution</i> Remote Vessel: C-Surveyor II™		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log	
Date: (UTC)	Areas: AT Valley Blocks: 340 Units: Meters		Mission:	Datum: NAD27 Projection: UTM Zone: 16N		Geophysical Equipment:
072265			run070207_1	Edgetech 216 FSSB Profiler (2-10 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 (200 kHz)		
Time (UTC) (-6 to Local)	Heading	Water Depth	Fix No.	Line Name	Remarks	
1527	360	2232	16	310	SOL; GPS went out for a few seconds b/w SP:	
					7-5	
1548	360	2271	1	310	EOL	
1552	180	2279	1	311	SOL	
1615	180	2238	16	311	EOL	
1619	360	2241	16	312	SOL	
1641	360	2286	1	312	EOL	
1645	180	2295	1	313	SOL	
1708	180	2246	16	313	EOL	
1716	270	2251	1	403	SOL	
1739	270	2207	16	403	EOL	
1750	090	2211	16	402	SOL	
1800				WX	Winds NE 11 Kts. Seas 4'	
					Shift Change D. Aucoin C. Gibbens	
1811	090	2254	1	402	EOL	
1822	270	2294	1	401	SOL	
1845	270	2233	16	401	EOL	
1856	270	2256	12	512	SOL	
1913	270	2251	1	512	EOL	
1918	090	2246	1	513	SOL	
1933	090	2248	12	513	EOL	
1938	270	2242	12	514	SOL	
1954	270	2242	1	514	EOL	
2000	090	2238	1	515	SOL	
2015	090	2237	12	515	EOL	
2020	270	2233	12	516	SOL	
2036	270	2233	1	516	EOL	
2041	090	2227	1	517	SOL	
2057	090	2230	12	517	EOL	
2102	270	2225	12	518	SOL	
2118	270	2221	1	518	EOL	
2123	090	2213	1	519	SOL	

C & C TECHNOLOGIES SURVEY LOG (Hydro-station)						Page No. 3
JobNo.:	Client: Louisiana State University		Vessel: R/V Northern Resolution Remote Vessel: C-Surveyor II™		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log	
Date: (UTC)	Areas:	Mission:	Datum:	Geophysical Equipment:		
02/07/2007	AT Valley Blocks: 340 Units: Meters	run070207_1	NAD27 Projection: UTM Zone: 16N	Edgetech 216 FSSB Profiler (2-10 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 (200 kHz)		
Time (UTC) (-6 to Local)	Heading	Water Depth	Fix No.	Line Name	Remarks	
2139	090	2223	12	519	EOL	
2144	270	2222	12	520	SOL	
2200	270	2209	1	520	EOL	
2205	090	2207	1	521	SOL	
2221	090	2221	12	521	EOL	
2225	270	2222	12	522	SOL	
2242	270	2204	1	522	EOL	
2249	000	2210	16	501	SOL	
2312	000	2252	1	501	EOL	
2316	180	2254	1	502	SOL	
2337	180	2211	16	502	EOL	
2341	000	2212	16	503	SOL	
0000				New Day	02/08/2007 Lat. 27 39.3102 Lon. 88 24.1975	
				WX	Winds NE 10 Kts. Seas 2-3'	
0003	000	2253	1	503	EOL	
0007	180	2255	1	504	SOL	
0028	180	2213	16	504	EOL	
0031	000	2214	16	505	SOL	
0054	000	2254	1	505	EOL	
0057	180	2256	1	506	SOL Reboot ts workstation	
0119	180	2215	16	506	EOL	
0122	000	2215	16	507	SOL	
0145	000	2255	1	507	EOL	
0149	180	2254	1	508	SOL	
0209	180	2217	16	508	EOL	
0213	000	2218	16	509	SOL	
0235	000	2255	1	509	EOL	
0239	180	2256	1	510	SOL	
0301	180	2219	16	510	EOL	
0304	000	2219	16	511	SOL	
0326	000	2255	1	511	EOL Begin ascent procedures	
0440					AUV on surface	

C & C TECHNOLOGIES SURVEY LOG (Hydro-station)						Page No. 1
JobNo.:	Client: Louisiana State University		Vessel: R/V <i>Northern Resolution</i> Remote Vessel: C-Surveyor II™		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log	
Date: (UTC)	Areas: Green Canyon Blocks: 852 Units: Meters		Mission:	Datum: NAD27 Projection: UTM Zone: 15N		Geophysical Equipment:
072265			run070208_1			Edgetech 216 FSSB Profiler (2-10 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 (200 kHz)
Time (UTC) (-6 to Local)	Heading	Water Depth	Fix No.	Line Name	Remarks	
					Transit to job location	
1910					Arrive @ CTD location 070208a	
1946					CTD on bottom Y=3003199.01 X=682108.95 WD=1738m	
2016					CTD on deck heading to AUV drop point	
2057					Retake CTD 070208b	
2122					CTD on bottom Y=3005440.99 X=682914.15 WD=1791m	
2152					CTD on deck	
2200					Start prediver	
2235					Prediver complete	
2242					AUV in water	
2336					External Guidance	
2343	180	1700	1	601	SOL	
0000				New Day	02/09/2007 Lat. 27 06.7524 Lon. 91 10.7112	
				WX	Winds N 10 Kts. Seas 2-3'	
0018	180	1650	24	601	EOL	
0023	000	1642	24	602	SOL	
0055	000	1671	1	602	EOL	
0059	180	1642	1	603	SOL	
0134	180	1632	24	603	EOL	
0138	000	1620	24	604	SOL	
0212	000	1609	1	604	EOL	
0216	180	1581	1	605	SOL	
0250	180	1610	24	605	EOL	
0255	000	1592	24	606	SOL	
0328	000	1573	1	606	EOL	
0333	180	1555	1	607	SOL	
0407	180	1576	24	607	EOL	
0411	000	1557	24	608	SOL	
0445	000	1537	1	608	EOL	
0449	180	1526	1	609	SOL	
0523	180	1535	24	609	EOL	



C & C TECHNOLOGIES SURVEY LOG (Hydro-station)						Page No. 2
JobNo.:	Client: Louisiana State University		Vessel: R/V Northern Resolution Remote Vessel: C-Surveyor II™		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log	
Date: (UTC)	Areas: Green Canyon Blocks: 852 Units: Meters		Mission:	Datum: NAD27 Projection: UTM Zone: 15N	Geophysical Equipment: Edgetech 216 FSSB Profiler (2-10 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 (200 kHz)	
Time (UTC) (-6 to Local)	Heading	Water Depth	Fix No.	Line Name	Remarks	
0527	000	1552	24	610	SOL	
0600				Shift Change	B.Hollie, M.Gatch	
				WX	Winds: E 7 knots Seas: Calm	
0602	000	1535	1	610	EOL	
0605	180	1526	1	611	SOL	
0639	180	1575	24	611	EOL	
0643	000	1595	24	612	SOL	
0717	000	1546	1	612	EOL	
0721	180	1569	1	613	SOL	
0755	180	1599	24	613	EOL	
0758	000	1625	24	614	SOL	
0832	000	1578	1	614	EOL	
0836	180	1586	1	615	SOL	
0910	180	1618	24	615	EOL	
0914	000	1608	24	616	SOL	
0948	000	1603	1	616	EOL	
0956	270	1600	1	701	SOL	
1018					AUV kicked out of external guidance	
					NAV P restarted	
1022	270	1700	19	701	EOL	
1024					AUV back in external guidance; heading to line	
1035	090	1680	19	702	SOL	
1102	090	1590	1	702	EOL	
1113	270	1606	1	703	SOL	
1140	270	1693	19	703	EOL	
1152	090	1669	19	704	SOL	
1200				WX	Winds: E 3 knots Seas: .5m	
1218	090	1602	1	704	EOL; job complete; starting ascent procedures	
1219					AUV stopped external guidance	
1340					AUV in van	

C & C TECHNOLOGIES SURVEY LOG (Hydro-station)						Page No. 1
JobNo.:	Client: Louisiana State University		Vessel: R/V <i>Northern Resolution</i> Remote Vessel: C-Surveyor II™		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log	
Date: (UTC)	Areas: Walker Ridge Blocks: 269 Units: Meters		Mission:	Datum: NAD27 Projection: UTM Zone: 15N		Geophysical Equipment:
2-9-07			run070209_1			Edgetech 216 FSSB Profiler (2-10 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 (200 kHz)
Time (UTC) (-6 to Local)	Heading	Water Depth	Fix No.	Line Name	Remarks	
1350					transit to job site	
1716					On location; preparing CTD cast 070209a	
1803					CTD on bottom Y=2950608.54 X=630655.54 Z=2034m	
1837					CTD on deck – Start Prediver	
1909					Prediver Complete	
1915					AUV in water	
2009					External Guidance	
2018	067	1994	22	808	SOL	
2048	067	1944	1	808	EOL	
2052	247	1948	1	807	SOL	
2123	247	1997	22	807	EOL	
2127	067	2018	22	806	SOL	
2157	067	1967	1	806	EOL	
2202	247	1961	1	805	SOL	
2233	247	2018	22	805	EOL	
2237	067	2019	22	804	SOL	
2308	067	1974	1	804	EOL	
2312	247	1975	1	803	SOL	
2343	247	2011	22	803	EOL	
2347	067	2023	22	802	SOL	
0000				New Day	02/10/2007 Lat. 26 41.2369 Lon. 91 40.2744	
				WX	Winds N 2 Kts Seas Calm	
0018	067	1977	1	802	EOL	
0022	247	1978	1	801	SOL	
0052	247	2013	22	801	EOL	
0100	157	2001	1	904	SOL	
0114	157	1961	10	904	EOL	
0125	337	1956	10	903	SOL	
0138	337	1964	1	903	EOL	
0150	157	1997	1	902	SOL	
0203	157	1967	10	902	EOL	
0214	337	1937	10	901	SOL	

C & C TECHNOLOGIES SURVEY LOG (Hydro-station)						Page No. 1
JobNo.:	Client: Louisiana State University		Vessel: R/V Northern Resolution Remote Vessel: C-Surveyor II™		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log	
Date: (UTC)	Areas: Alam Canyon Blocks: 601 Units: Meters		Mission:	Datum: NAD27 Projection: UTM Zone: 15N		Geophysical Equipment:
2-10-07			run070210_1	Edgetech 216 FSSB Profiler (2-10 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 (200 kHz)		
Time (UTC) (-6 to Local)	Heading	Water Depth	Fix No.	Line Name	Remarks	
0420					Transit to job site	
1748					On location for CTD 070210a; lowering HiPAP & getting CTD ready for deployment	
1837					CTD on bottom Y=347560.87 X=347560.87 WD=2359m	
1920					CTD on deck Begin pre-dive	
1950					Pre-dive complete	
1955					AUV in water	
2057					Activate external guidance	
2107	010	2327	29	101	SOL	
2149	010	2327	1	101	EOL	
2153	190	2337	1	102	SOL	
2233	190	2313	29	102	EOL	
2237	010	2320	29	103	SOL	
2319	010	2342	1	103	EOL	
2323	190	2342	1	104	SOL	
0000				New Day	02/11/2007 Lat. 26 21.7806 Lon. 94 31.3067	
				WX	Winds NE 22 Kts. Seas 2m	
0003	190	2310	29	104	EOL	
0007	010	2298	28	105	SOL	
0048	010	2350	1	105	EOL	
0053	190	2356	1	106	SOL	
0131	190	2269	28	106	EOL	
0135	010	2282	28	107	SOL	
0216	010	2362	1	107	EOL	
0220	190	2361	1	108	SOL	
0258	190	2283	28	108	EOL	
0305	280	2263	11	205	SOL	
0320	280	2327	1	205	EOL	
0331	100	2332	1	204	SOL	
0347	100	2255	11	204	EOL	
0358	280	2308	11	203	SOL	
0413	280	2291	1	203	EOL	

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 1
Job No: 072265		Client: Louisiana State University			Vessel: R/V Northern Resolution			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Survey Units: Meters			Datum: WGS84			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date: 2/7/2007		Area: AT Valley Block: 340			Projection: UTM			Zone: 16N		
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
09:48					Start Previde					
10:06					Previde Complete					
10:19					Pin Pulled					
10:20					Aquatic Fish in Water					
10:20					AUV in Water					
10:28					AUV at 300 Pitch Roll -0.1					
10:34					AUV at 600 Pitch 3.4 Roll -0.1					
10:41					AUV at 900 Pitch -2.8 Roll -0.1					
10:49					AUV at 1200 Pitch -2.3 Roll -0.2					
10:56					AUV at 1500 Pitch 3.8 Roll -0.1					
11:03					AUV at 1800 Pitch 3.6 Roll 0.1					
11:10					AUV at 2100 Pitch 3.3 Roll -0.2					
11:13					AUV at 2180 Pitch 3.3 Roll -0.2					
11:18					AUV on External Guidance					
11:30	180	2243	1	301	SOL					
11:53	180	2209	16	301	EOL					
11:58	360	2209	16	302	SOL					
12:19	360	2243	1	302	EOL					
12:23	180	2244	1	303	SOL					
12:46	180	2214	16	303	EOL					
12:50	360	2216	16	304	SOL					

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 2
Job No: 072265		Client: Louisiana State University			Vessel: R/V Northern Resolution			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Survey Units: Meters			Datum: WGS84			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date: 2/7/2007		Area: AT Valley Block: 340			Projection: UTM			Zone: 16N		
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
13:11	360	2242	1	304	EOL					
13:15	180	2243	1	305	SOL					
13:38	180	2217	16	305	EOL					
13:43	360	2216	16	306	SOL					
14:03	360	2240	1	306	EOL					
14:08	180	2242	1	307	SOL					
14:31	180	2218	16	307	EOL					
14:35	360	2222	16	308	SOL					
14:56	360	2245	1	308	EOL					
15:00	180	2258	1	309	SOL					
15:23	180	2227	16	309	EOL					
15:27	360	2232	16	310	SOL					
15:48	360	2271	1	310	EOL					
15:52	180	2279	1	311	SOL					
16:15	180	2238	16	311	EOL					
16:19	360	2241	16	312	SOL					
16:41	360	2286	1	312	EOL					
16:45	180	2295	1	313	SOL					
17:08	180	2246	16	313	EOL					
17:16	270	2251	1	403	SOL					
17:39	270	2207	16	403	EOL					

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 3
Job No: 072265		Client: Louisiana State University			Vessel: R/V <i>Northern Resolution</i>			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Area: AT Valley			Datum: WGS84			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date: 2/7/2007		Block: 340			Projection: UTM			Zone: 16N		
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
1750	090	2211	16	402	SOL					
1800					Shif Change D. Aucoin C. Gibbens					
1811	090	2254	1	402	EOL					
1822	270	2294	1	401	SOL					
1845	270	2233	16	401	EOL					
1856	270	2256	12	512	SOL					
1913	270	2251	1	512	EOL					
1918	090	2246	1	513	SOL					
1933	090	2248	12	513	EOL					
1938	270	2242	12	514	SOL					
1954	270	2242	1	514	EOL					
2000	090	2238	1	515	SOL					
2015	090	2237	12	515	EOL					
2020	270	2233	12	516	SOL					
2036	270	2233	1	516	EOL					
2041	090	2227	1	517	SOL					
2057	090	2230	12	517	EOL					
2102	270	2225	12	518	SOL					
2118	270	2221	1	518	EOL					
2123	090	2213	1	519	SOL					

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 4
Job No: 072265		Client: Louisiana State University			Vessel: R/V Northern Resolution			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Area: AT Valley Block: 340			Survey Units: Meters			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date:		Block: 340			Datum: WGS84			Projection: UTM		
Time (UTC (-6 to Local))		Heading	Water Depth	Fix No.	Line Name	Remarks				
2139		090	2223	12	519	EOL				
2144		270	2222	12	520	SOL				
2200		270	2209	1	520	EOL				
2205		090	2207	1	521	SOL				
2221		090	2221	12	521	EOL				
2225		270	2222	12	522	SOL				
2242		270	2205	1	522	EOL				
2249		000	2210	16	501	SOL				
2312		000	2252	1	501	EOL				
2316		180	2254	1	502	SOL				
2337		180	2211	16	502	EOL				
2341		000	2212	16	503	SOL				
0003		000	2253	1	503	EOL				
0007		180	2255	1	504	SOL				
0028		180	2213	16	504	EOL				
0031		000	2214	16	505	SOL				
0054		000	2257	1	505	EOL				
0057		180	2256	1	506	SOL				
0119		180	2215	16	506	EOL				
0122		000	2215	16	507	SOL				
0144		000	2255	1	507	EOL				

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 1
Job No: 072265		Client: HYDRO Gulf of Mexico, LLC		Vessel: R/V <i>Northern Resolution</i>		Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log				
Mission Name:		Area: Green Canyon		Survey Units: Meters		Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)				
Date: 2 / 8 / 07		Block: 852		Datum: WGS84						
				Projection: UTM						
				Zone: 15N						
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
2215					Start Previde					
2235					Previde Complete					
2241					Pin Pulled					
2243					AUV In Water					
2247					Aquatic Fish In Water					
2252					AUV At 300	Pitch 3.1	Roll .2			
2259					AUV At 600	Pitch 3.6	Roll 0.2			
2305					AUV At 900	Pitch 3.3	Roll 0.3			
2312					AUV At 1200	Pitch 4.0	Roll 0.2			
2316					AUV At 1400	Pitch 3.6	Roll 0.1			
2319					AUV At 1500	Pitch 4.4	Roll 0.1			
2322					AUV At 1600	Pitch 2.8	Roll 0.0			
2328					AUV At 1700	Pitch 2.5	Roll 0.1			
2336					AUV On External Guidance					
2343	180	1700	1	601	SOL					
0018	180	1650	24	601	EOL					
0023	000	1642	24	602	SOL					
0055	000	1671	1	602	EOL					
0059	180	1642	1	603	SOL					
0134	180	1632	24	603	EOL					
0138	000	1620	24	604	SOL					

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 2
Job No: 072265		Client: HYDRO Gulf of Mexico, LLC			Vessel: R/V Northern Resolution			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Area: Green Canyon Block: 852			Survey Units: Meters			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date: 2/8/2007		Datum: WGS84			Projection: UTM			Zone: 15N		
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
0212	000	1609	1	604	EOL					
0216	180	1581	1	605	SOL					
0250	180	1610	24	605	EOL					
0255	000	1592	24	606	SOL					
0328	000	1573	1	606	EOL					
0333	180	1555	1	607	SOL					
0407	180	1576	24	607	EOL					
0411	000	1557	24	608	SOL					
0445	000	1537	1	608	EOL					
0449	180	1526	1	609	SOL					
0523	180	1535	24	609	EOL					
0527	000	1552	24	610	SOL					
0602	000	1535	1	610	EOL					
0605	180	1526	1	611	SOL					
0639	180	1575	24	611	EOL					
0643	000	1595	24	612	SOL					
0717	000	1546	1	612	EOL					
0721	180	1569	1	613	SOL					
0755	180	1599	24	613	EOL					
0758	000	1625	24	614	SOL					
0832	000	1578	1	614	EOL					

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 3
Job No: 072265		Client: HYDRO Gulf of Mexico, LLC		Vessel: R/V Northern Resolution		Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log				
Mission Name:		Area: Green Canyon Block: 852		Survey Units: Meters		Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)				
Date: 2/8/07		Datum: WGS84		Projection: UTM						
		Zone: 15N								
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
0836	180	1586	1	615	SOL					
0910	180	1618	24	615	EOL					
0914	000	1608	24	616	SOL					
0948	000	1603	1	616	EOL					
0956	270	1600	1	701	SOL					
1022	270	1700	19	701	EOL					
1035	090	1680	19	702	SOL					
1102	090	1590	1	702	EOL					
1113	270	1606	1	703	SOL					
1140	270	1693	19	703	EOL					
1152	090	1669	19	704	SOL					
1218	090	1602	1	704	EOL					
1219					Stop External Guidance					
1225					Set depth @ 1530					
1229					Set depth @ 1500					
1238					Set depth @ 1200					
1248					Set depth @ 900					
1251					Set depth @ 600					
1303					AUV Enter Line 24					
1325					AUV on Surface					
1338					AUV on Deck					

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 1
Job No: 072265		Client: Louisiana State University			Vessel: R/V <i>Northern Resolution</i>			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Survey Units: Meters			Datum: WGS84 Projection: UTM Zone: 15N			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date: 2/9/2007	Area: Walker Ridge Block: 269		Line Name		Remarks					
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
1900					Start Previde					
1913					Previde Complete					
1914					Pin Pulled					
1915					AUV In Water					
1919					Aquatic Fish In Water					
1925					AUV @ 300 Pitch 3.3 Roll 0.3					
1930					AUV @ 600 Pitch 4.0 Roll 0.3					
1937					AUV @ 900 Pitch 3.4 Roll 0.3					
1944					AUV @ 1200 Pitch 3.5 Roll 0.1					
1951					AUV @ 1500 Pitch 1.9 Roll 0.1					
2000					AUV @ 1800 Pitch 3.3 Roll 0.0					
2000					AUV @ 1900 Pitch 3.4 Roll 0.1					
2006					AUV @ 1965 Pitch 3.3 Roll 0.0					
2010					AUV On External Guidance					
2018	067	1994	22	808	SOL					
2048	067	1944	1	808	EOL					
2052	247	1948	1	807	SOL					
2123	247	1997	22	807	EOL					
2127	067	2016	22	806	SOL					
2157	067	1967	1	806	EOL					
2202	247	1961	1	805	SOL					

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 2
Job No: 072265		Client: Louisiana State University			Vessel: R/V Northern Resolution			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Survey Units: Meters			Datum: WGS84			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date: 2/9/2007		Area: Walker Ridge Block: 269			Projection: UTM			Zone: 15N		
Time (UTC (-6 to Local))	Heading	Water Depth	Fix No.	Line Name	Remarks					
2233	247	2018	22	805	EOL					
2237	067	2019	22	804	SOL					
2308	067	1974	1	804	EOL					
2312	247	1975	1	803	SOL					
2343	247	2011	22	803	EOL					
2347	067	2023	22	802	SOL					
0018	067	1977	1	802	EOL					
0022	247	1978	1	801	SOL					
0052	247	2013	22	801	EOL					
0100	157	2001	1	904	SOL					
0114	157	1961	10	904	EOL					
0125	337	1956	10	903	SOL					
0138	337	1964	1	903	EOL					
0150	157	1997	1	902	SOL					
0203	157	1967	10	902	EOL					
0214	337	1937	10	901	SOL					
0228	337	1982	1	901	EOL					
0230					Starting Ascent Procedures, Job Complete					
0232					Stop External Guidance					
0346					AUV on surface					
0358					Pin In					

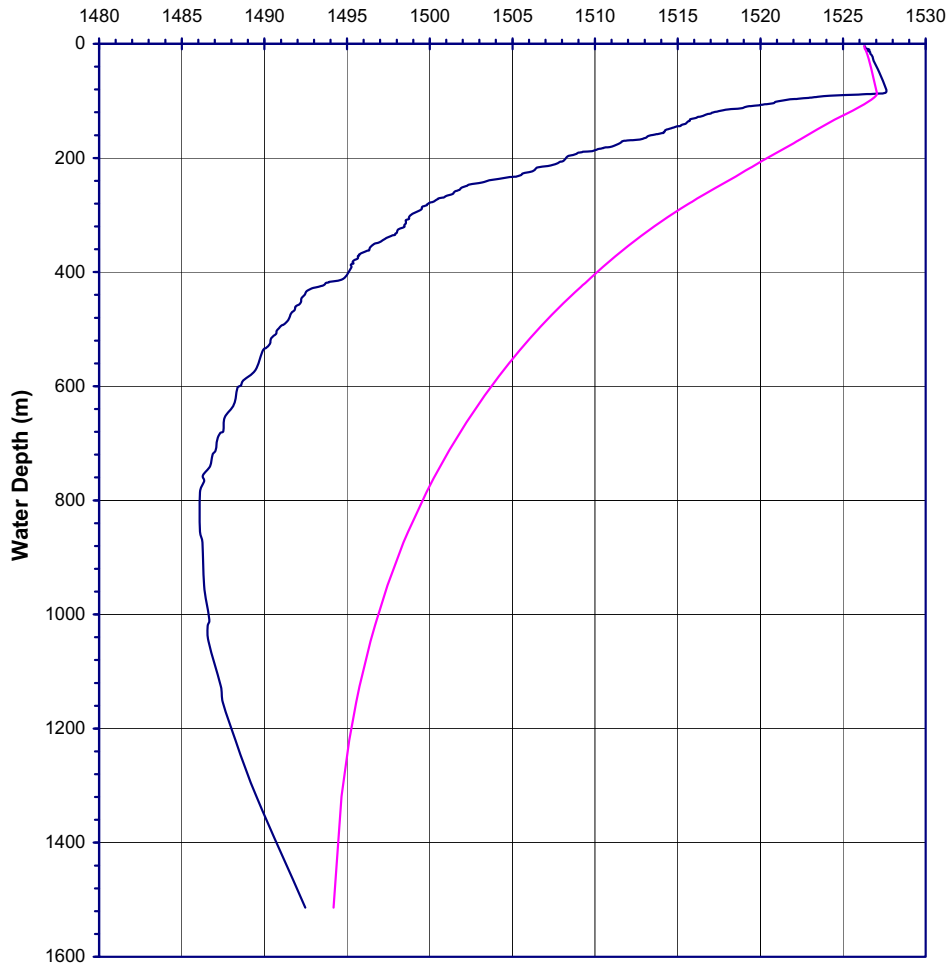
C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 1
Job No: 072265		Client: Louisiana State University			Vessel: R/V <i>Northern Resolution</i>			Survey Equipment: DGPS, Inertial Navigation, HIPAP, Doppler Speed Log		
Mission Name:		Area: Alam Canyon			Survey Units: Meters			Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (120 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)		
Date:		Block: 601			Datum: WGS84			Projection: UTM		
Time (UTC (-6 to Local))		Heading	Water Depth	Fix No.	Line Name	Remarks				
1935						Start Previde				
1945						Previde Complete				
1954						Pin Pulled				
1955						AUV In Water				
1958						Aquatic Fish In Water				
2003						AUV @ 300 Pitch 3.6 Roll -0.3				
2010						AUV @ 600 Pitch 3.7 Roll -0.5				
2016						AUV @ 900 Pitch 3.3 Roll -0.4				
2023						AUV @ 1200 Pitch 3.7 Roll -0.2				
2029						AUV @ 1500 Pitch 3.1 Roll -0.2				
2036						AUV @ 1800 Pitch 3.7 Roll -0.2				
2042						AUV @ 2100 Pitch 3.8 Roll 0.0				
2046						AUV @ 2200 Pitch 3.0 Roll -0.2				
2050						AUV @ 2300 Pitch 1.9 Roll 1.8				
2053						AUV @ 2360 Pitch 3.0 Roll -0.1				
2057						AUV On External Guidance				
2107	010	2327	29		101	SOL				
2149	010	2327	1		101	EOL				
2153	190	2337	1		102	SOL				
2233	190	2323	29		102	EOL				
2237	010	2320	29		103	SOL				

C & C TECHNOLOGIES AUV COS SURVEY LOG										Page No. 2
Job No: 072265		Client: Louisiana State University			Vessel: R/V Northern Revolution		Survey Equipment: DGPS, Inertial Navigation, HiPAP, Doppler Speed Log			Remarks
Mission Name:		Area: Alam Canyon Block: 601			Datum: WGS84 Projection: UTM Zone: 15N		Geophysical Equipment: Edgetech 216 FSSB Profiler (2-6 kHz), Edgetech Dual Frequency SSS (1.20 & 410 kHz), Simrad EM 2000 Multibeam (200 kHz)			
Date:	Heading	Water Depth	Fix No.	Line Name	Survey Units: Meters					
Time (UTC (-6 to Local))	010	010	010	010	010					
2319	010	2342	1	103	EOL					
2323	190	2342	1	104	SOL					
0003	190	2310	29	104	EOL					
0007	010	2298	28	105	SOL					
0048	010	2350	1	105	EOL					
0053	190	2356	1	106	SOL					
0131	190	2269	28	106	EOL					
0135	010	2283	28	107	SOL					
0216	010	2362	1	107	EOL					
0220	190	2361	1	108	SOL					
0258	190	2283	28	108	EOL					
0305	280	2263	11	205	SOL					
0320	280	2327	1	205	EOL					
0331	100	2332	1	204	SOL					
0347	100	2255	11	204	EOL					
0358	280	2308	11	203	SOL					
0413	280	2291	1	203	EOL					
0424	100	2309	1	202	SOL					
0439	100	2351	11	202	EOL					
0451	280	2362	11	201	SOL					
0505	280	2333	1	201	EOL					

APPENDIX C

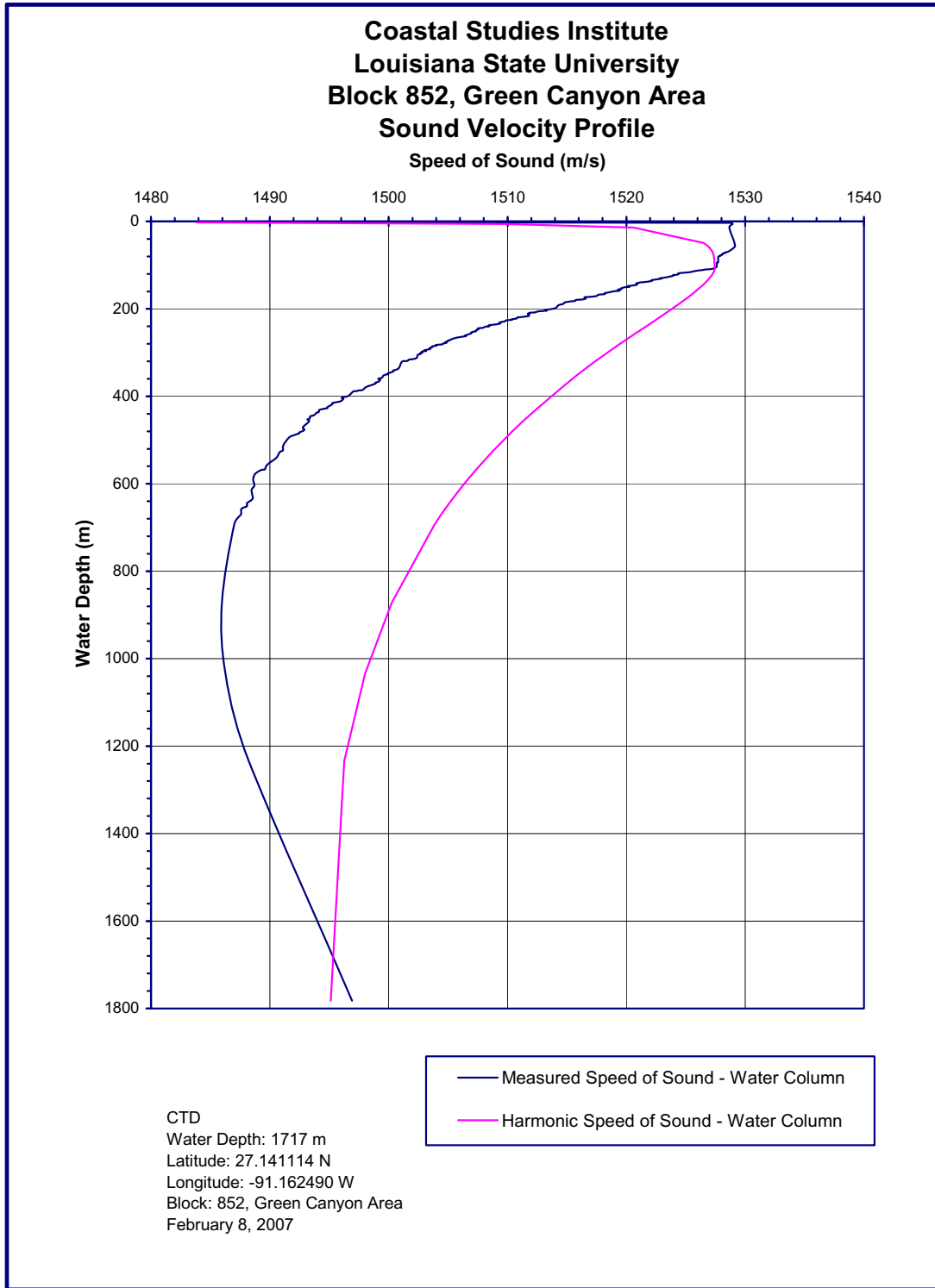
WATER COLUMN SOUND VELOCITY PROFILES

Coastal Studies Institute
Louisiana State University
Block 340, Atwater Valley Area
Sound Velocity Profile
Speed of Sound (m/s)

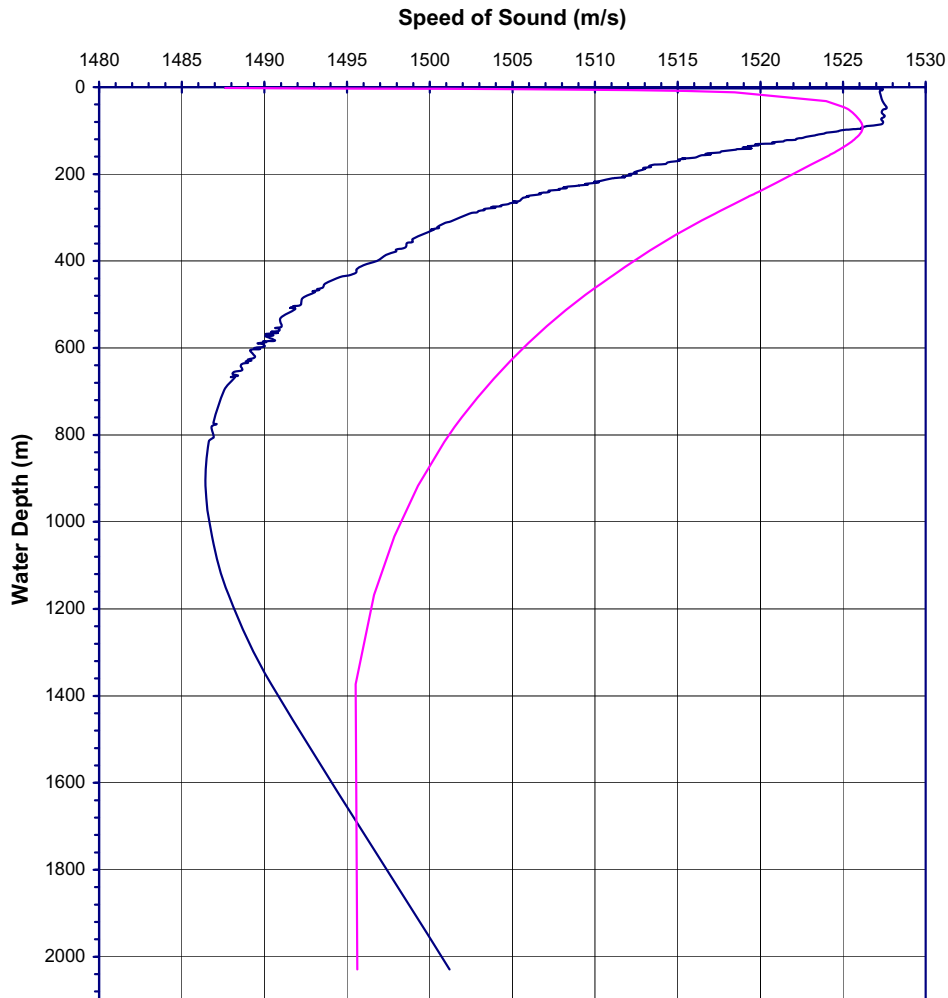


CTD
Water Depth: 2340m
Latitude: 27.660069 N
Longitude: -88.363499 W
Blocks: 340
February 7, 2007

— Measured Speed of Sound - Water Column
— Harmonic Speed of Sound - Water Column

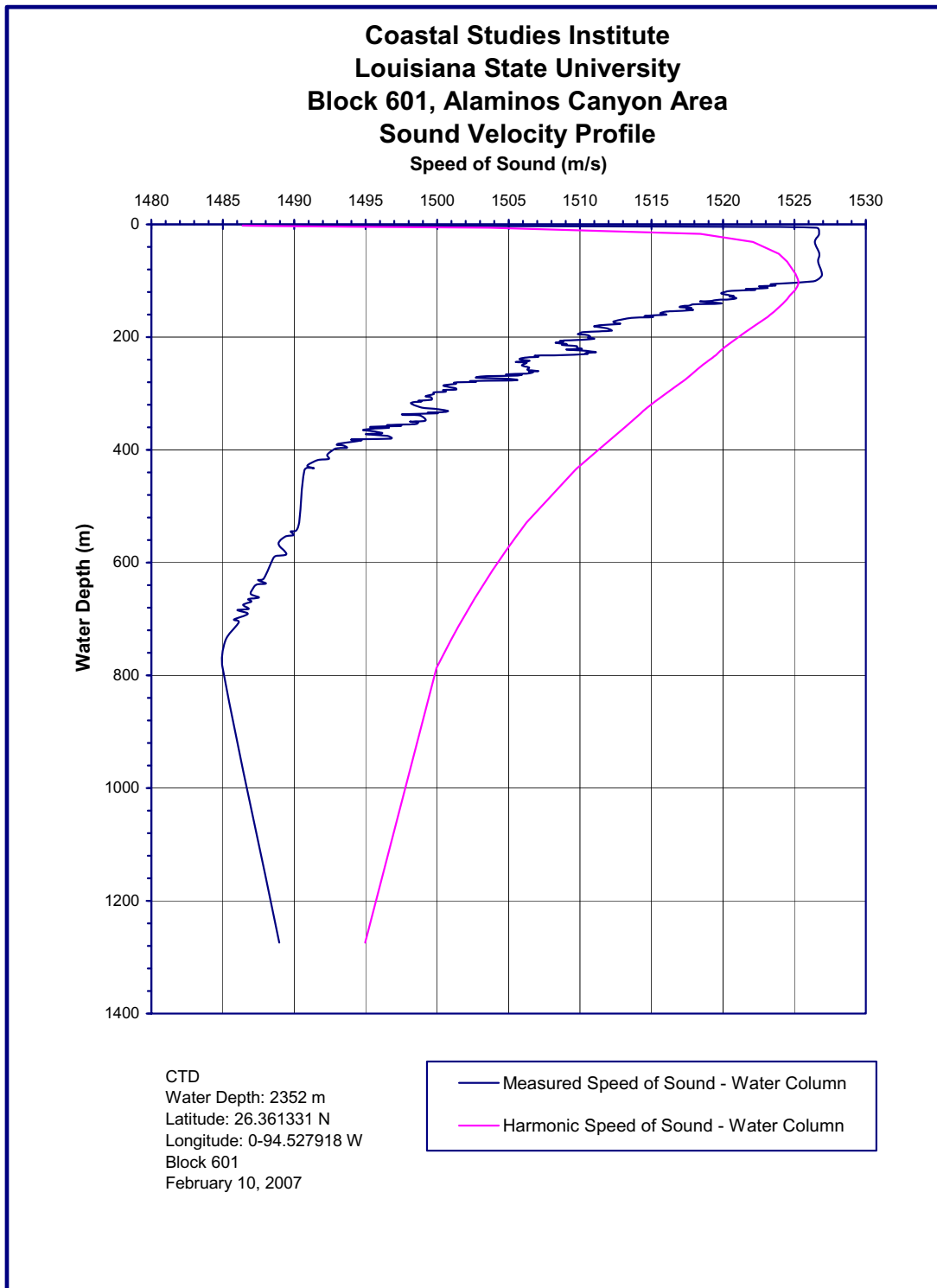


**Coastal Studies Institute
Louisiana State University
Block 269, Walker Ridge Area
Sound Velocity Profile**



CTD
Water Depth: 2029 m
Latitude: 26.672246 N
Longitude: -91.687049 W
Block: 269
February 9, 2007

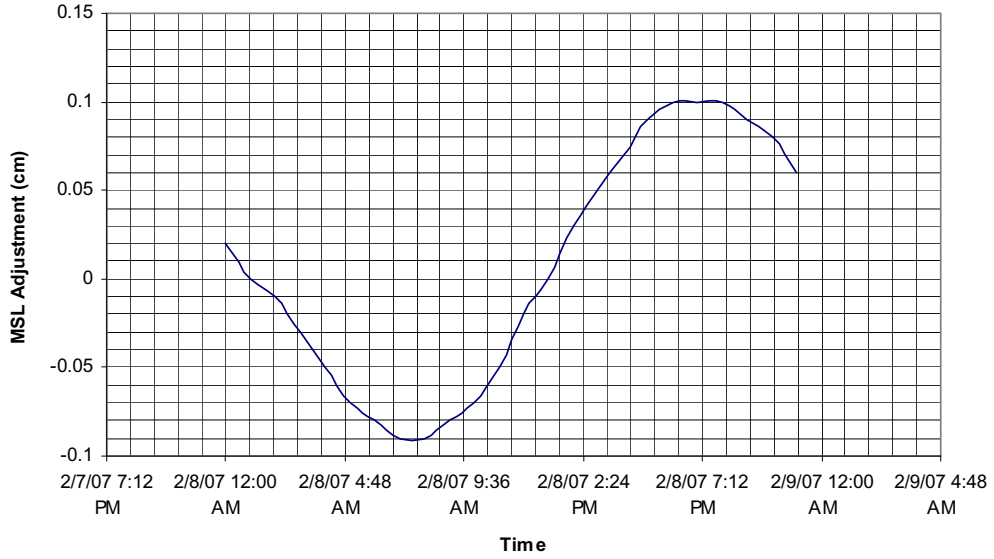
— Measured Speed of Sound - Water Column
— Harmonic Speed of Sound - Water Column



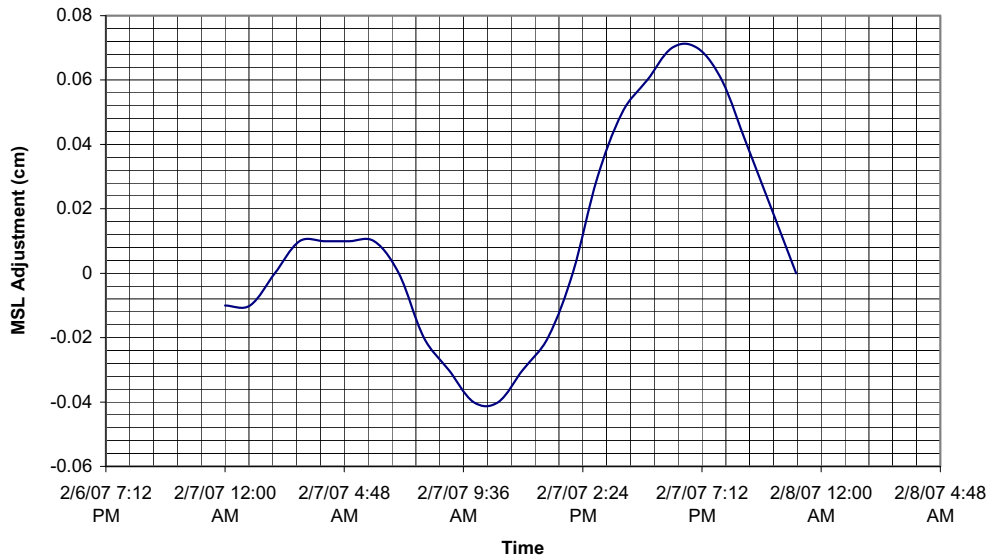
APPENDIX D

TIDE CURVES

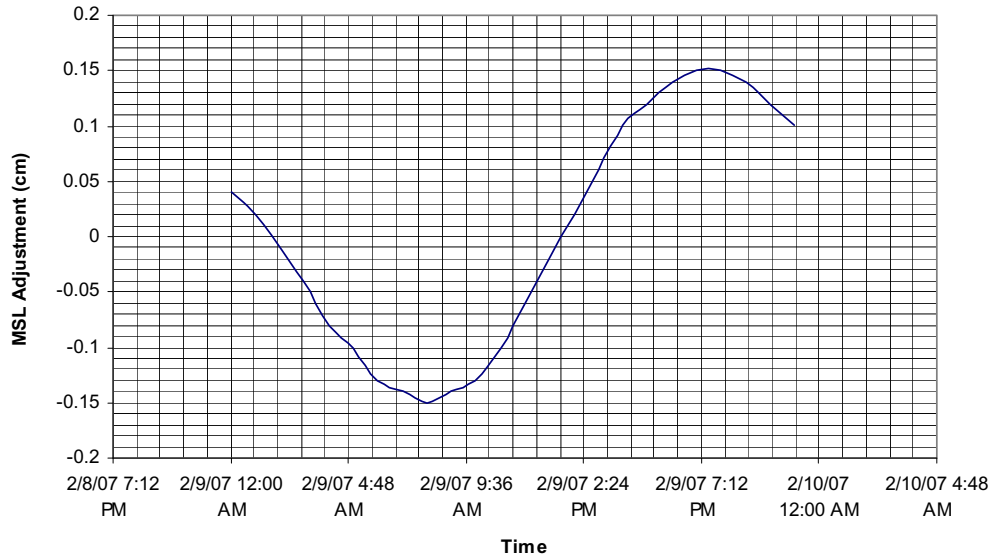
**Goddard Global Ocean Tide Model
 ARCHAEOLOGICAL ASSESSMENT STUDY
 BLOCK 852, GREEN CANYON AREA**



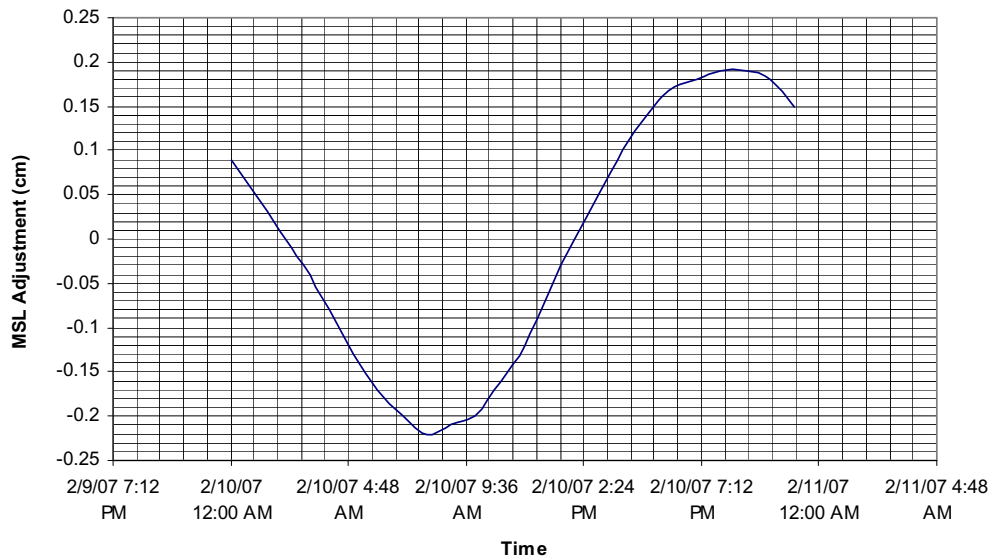
**Goddard Global Ocean Tide Model
 ARCHAEOLOGICAL ASSESSMENT STUDY
 BLOCK 340, ATWATER VALLEY AREA**



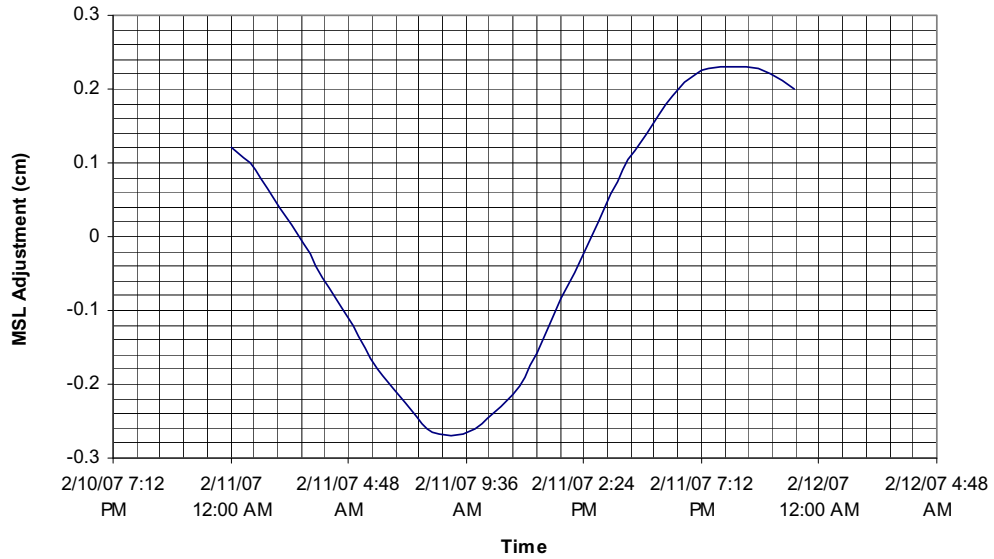
**Goddard Global Ocean Tide Model
ARCHAEOLOGICAL ASSESSMENT STUDY
BLOCK 269, WALKER RIDGE AREA**



**Goddard Global Ocean Tide Model
ARCHAEOLOGICAL ASSESSMENT STUDY
BLOCK 601, ALAMINOS CANYON AREA**



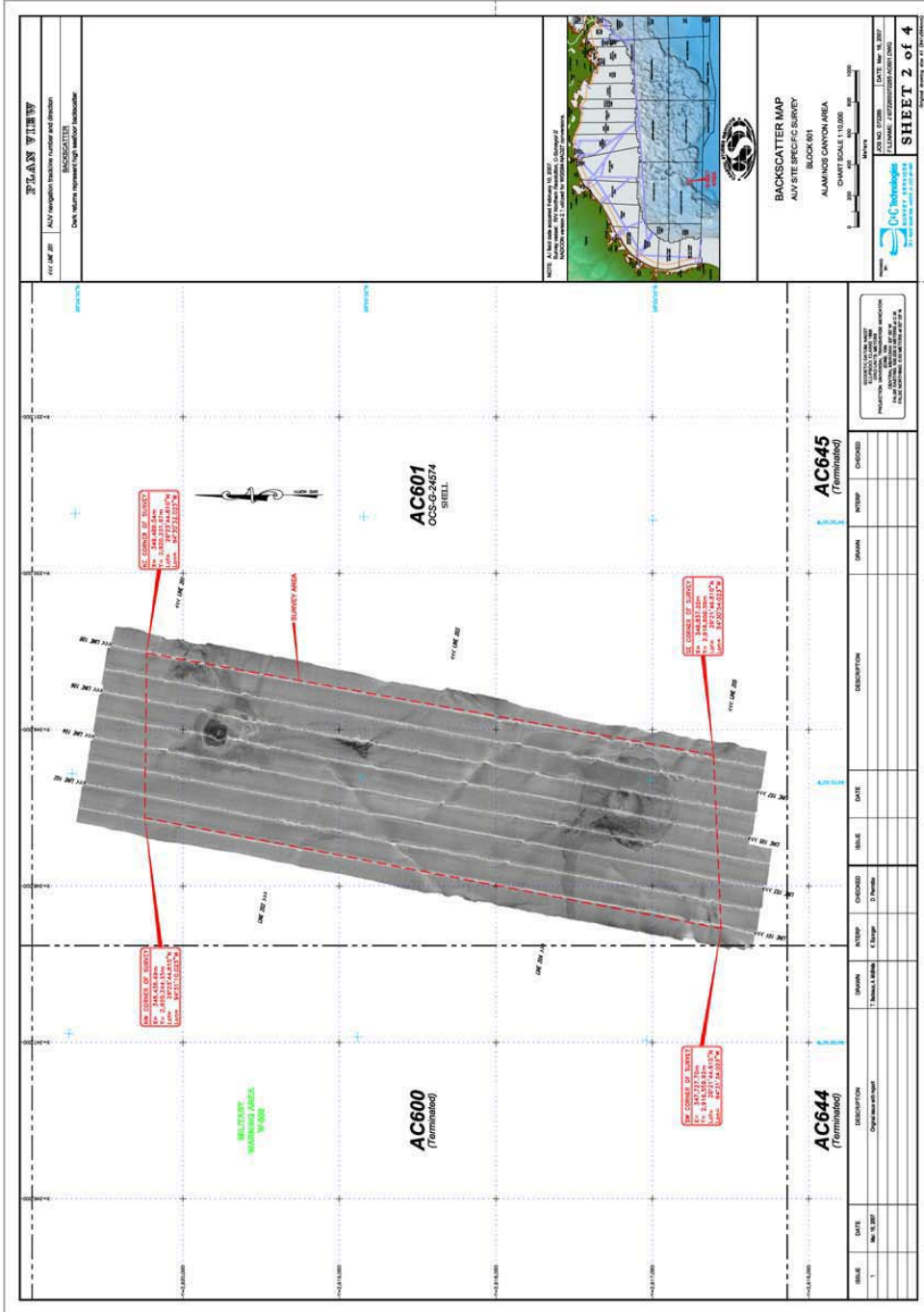
Goddard Global Ocean Tide Model
ARCHAEOLOGICAL ASSESSMENT STUDY
BLOCK 601, ALAMINOS CANYON AREA

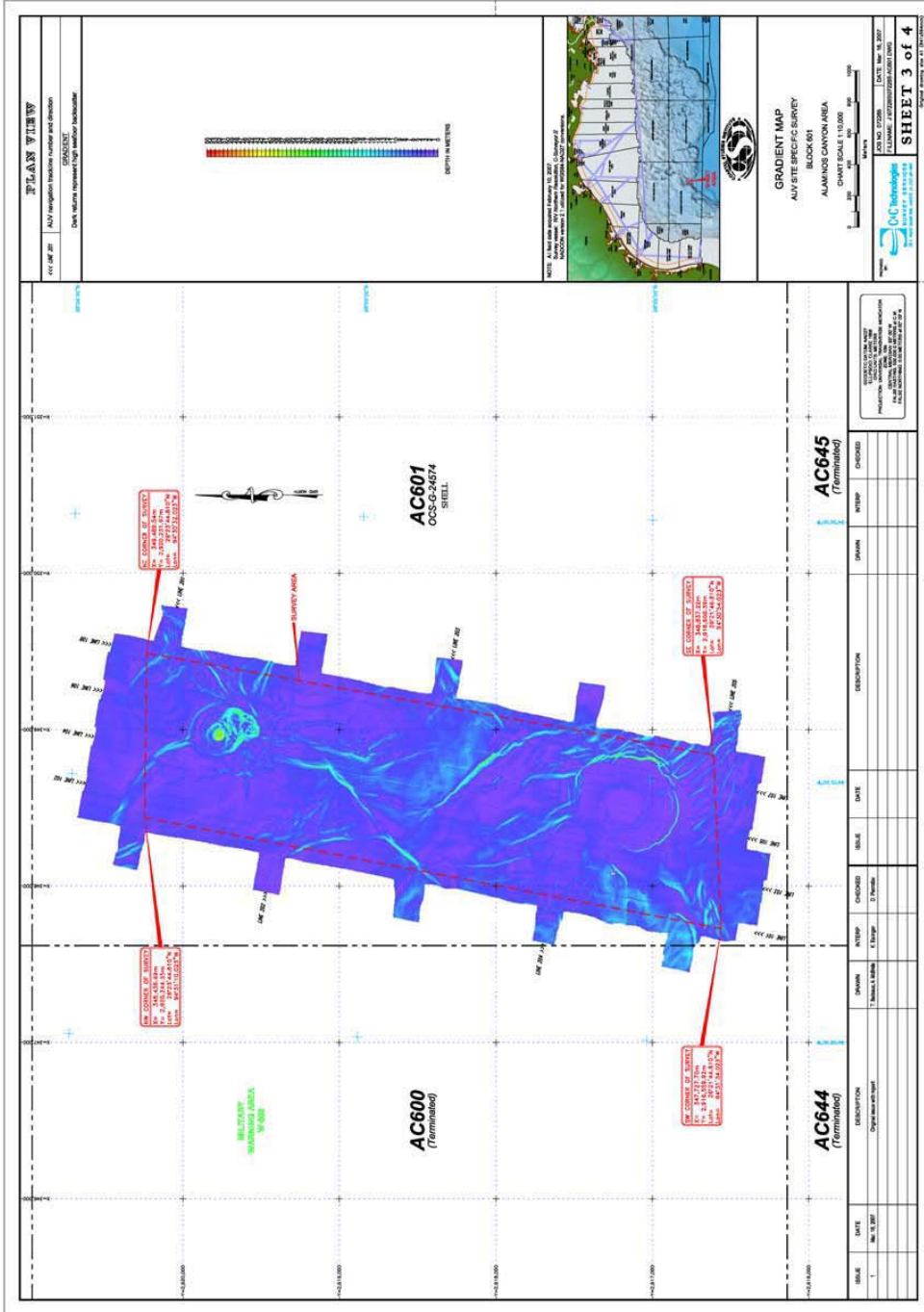


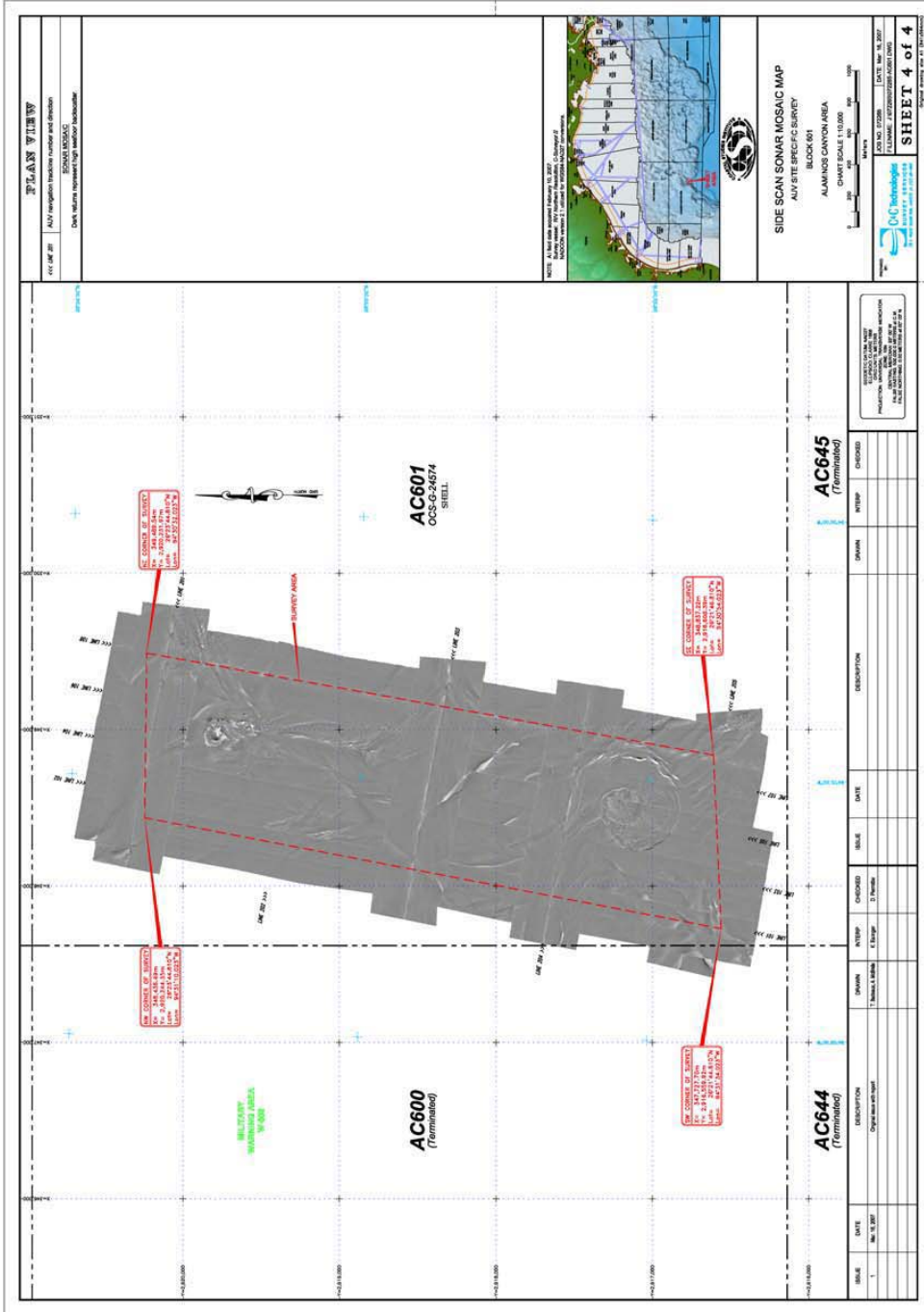
APPENDIX 2

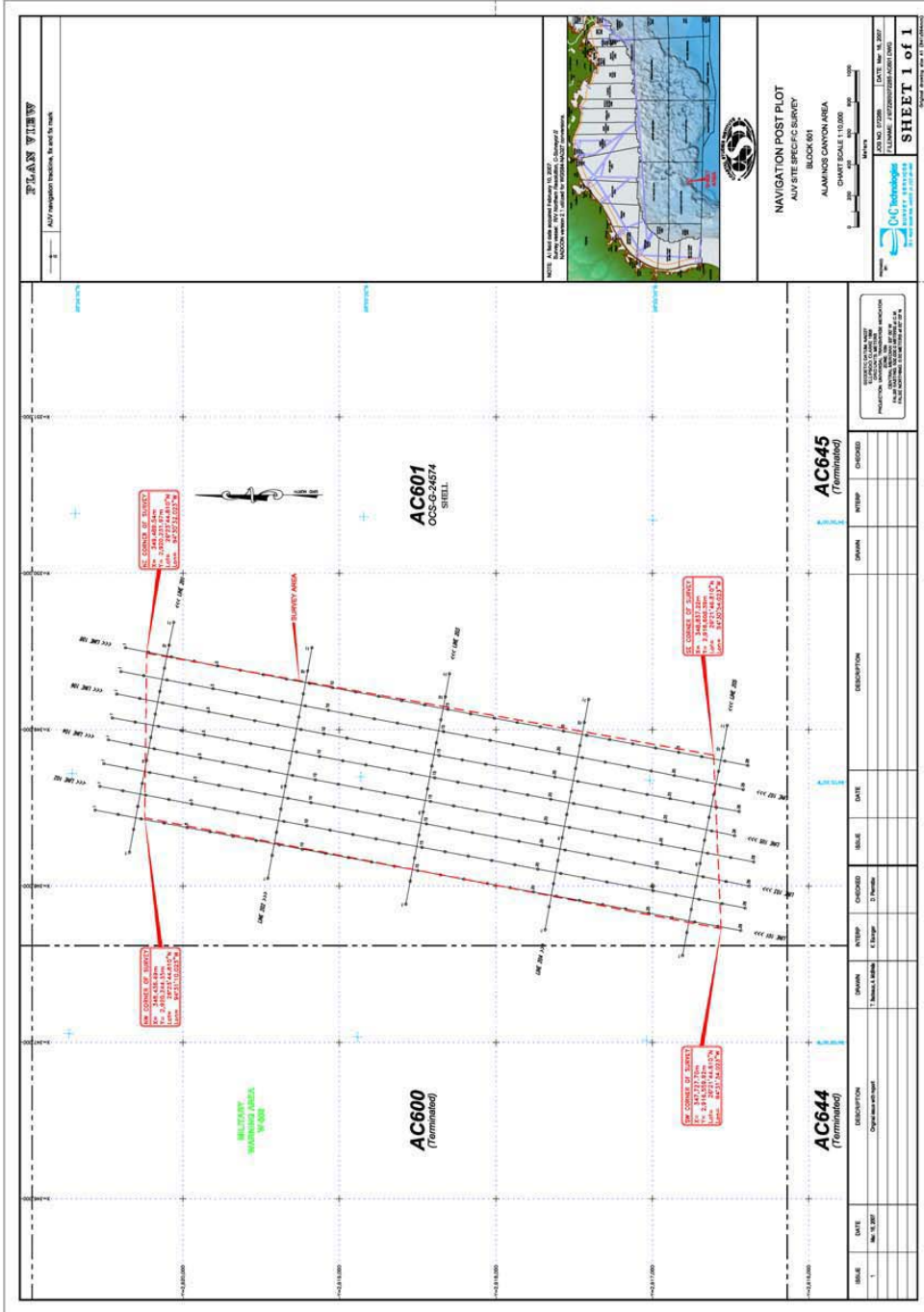
AUV MAPS

AC601

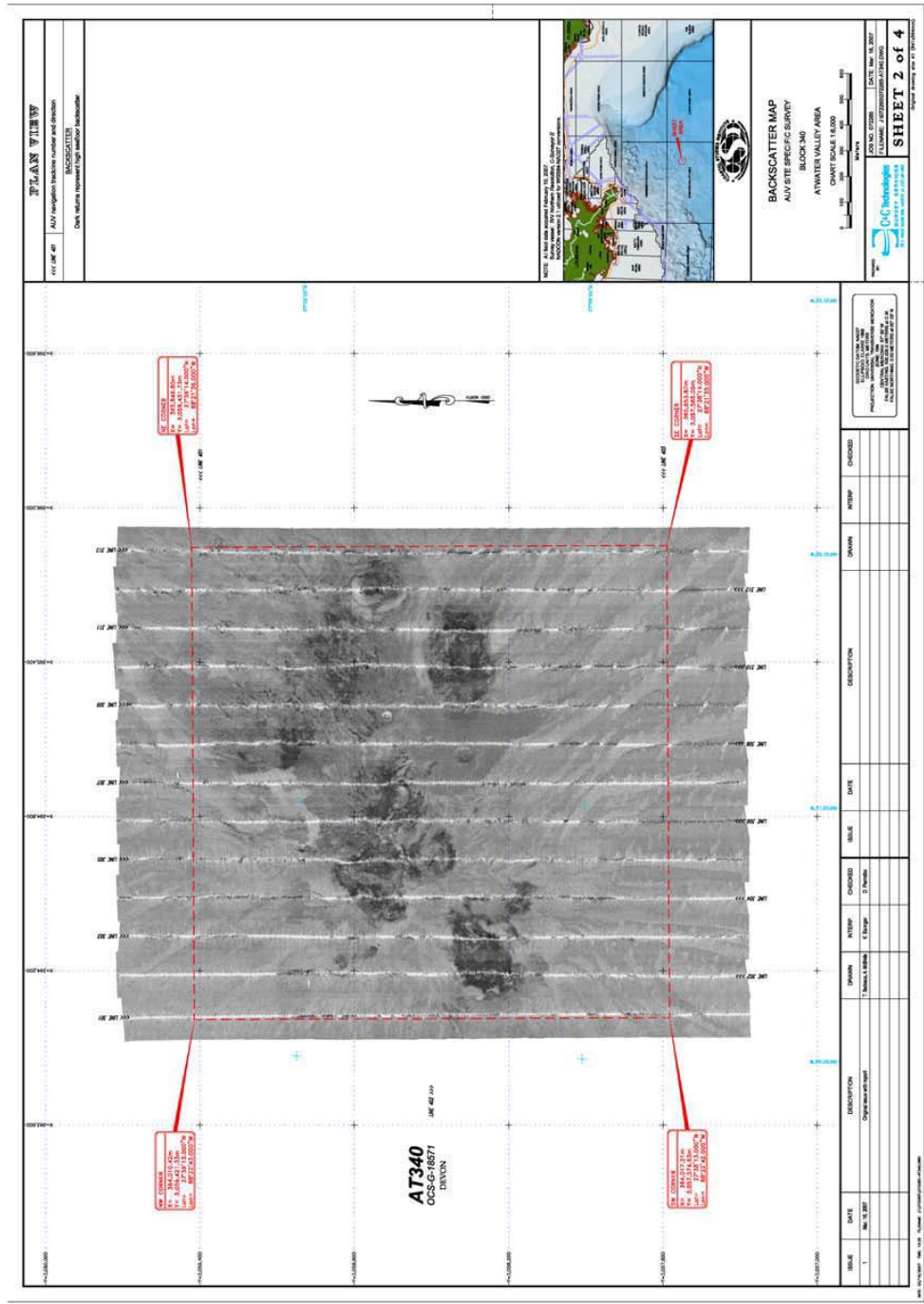




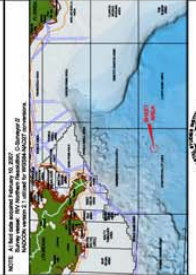




AT340



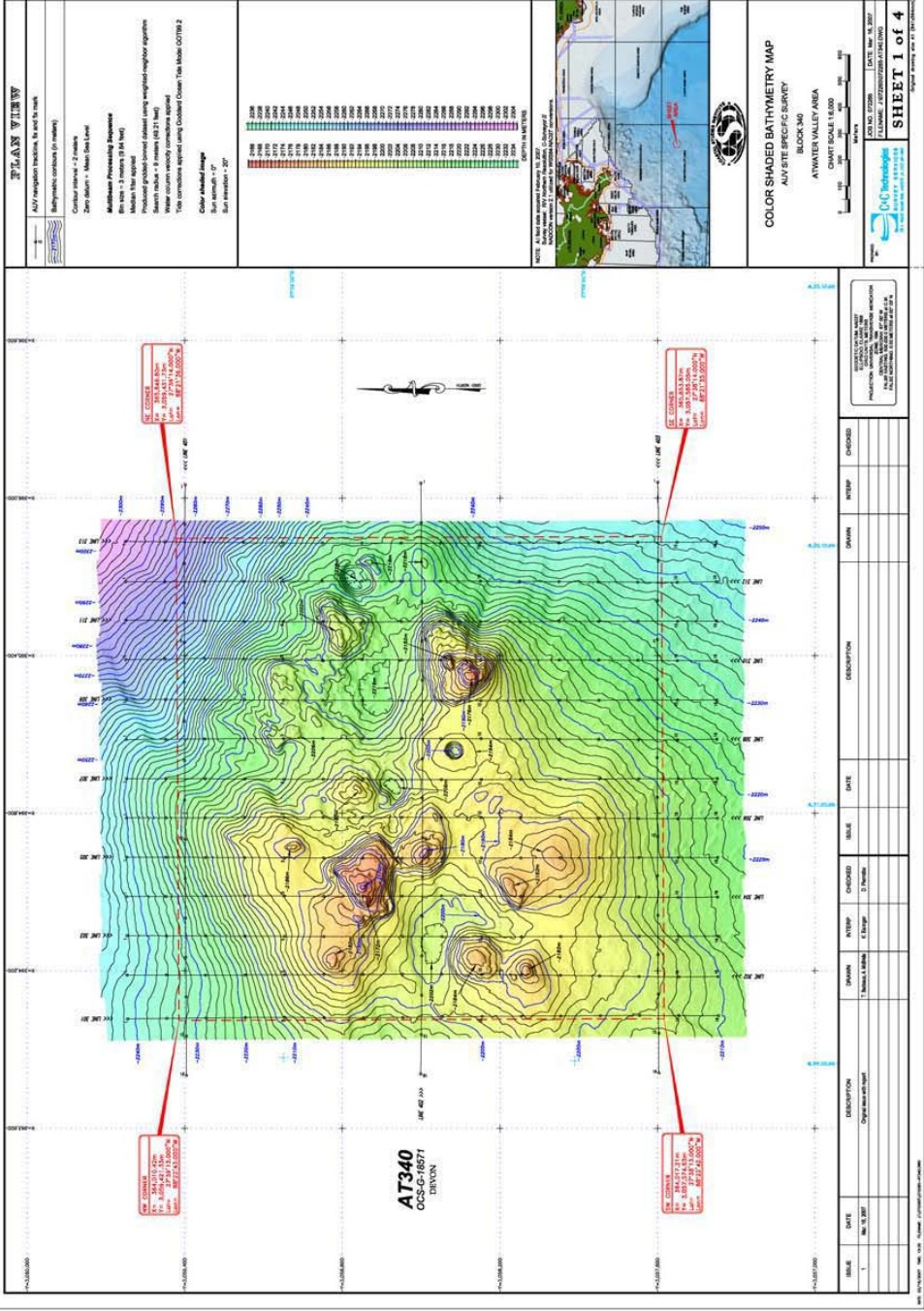
PLAN VIEW
 ALL dimensions shown unless otherwise noted.
 BACKSCATTER
 DATE: 08/15/2008

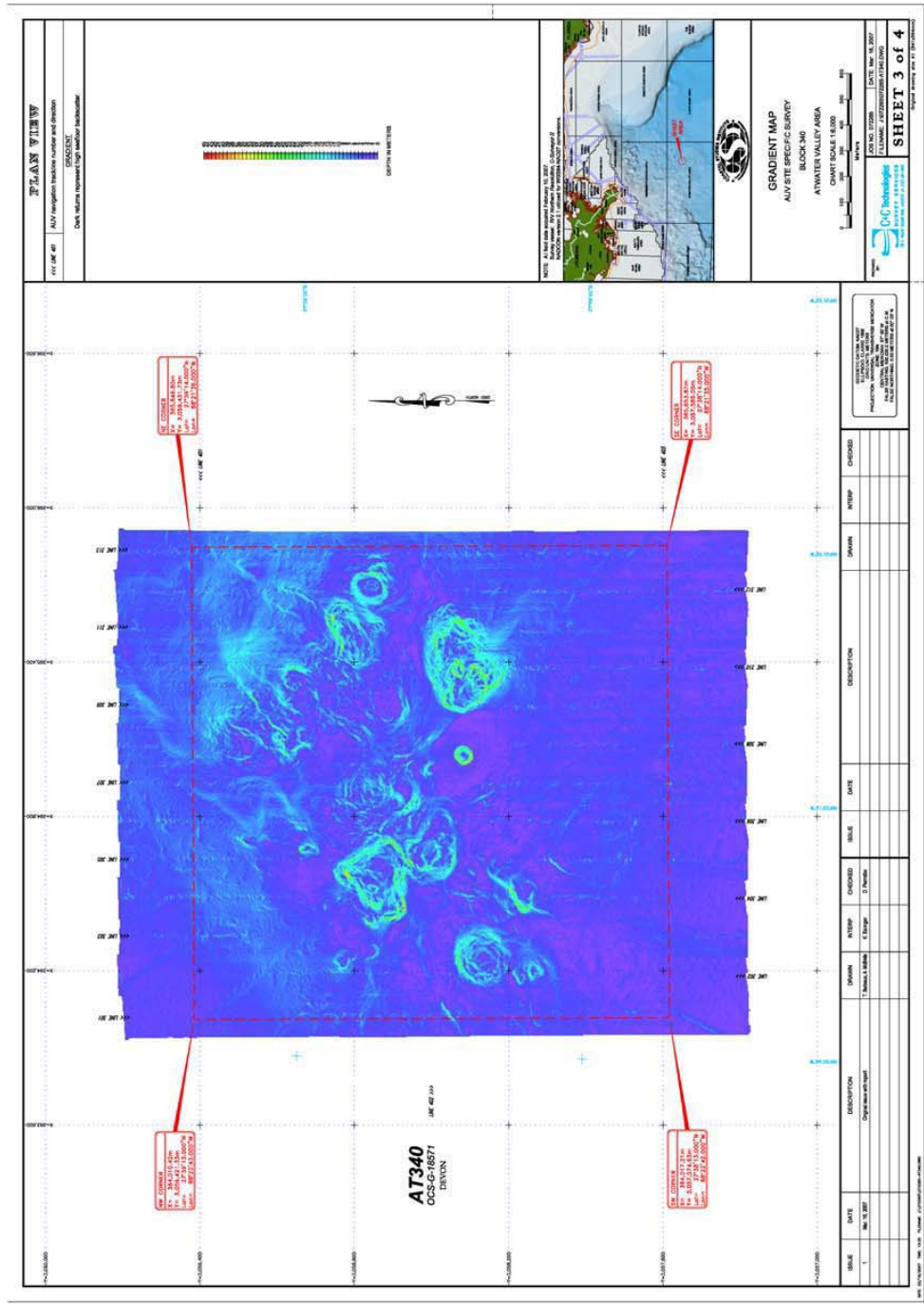


BACKSCATTER MAP
 ADJ SITE SPECIFIC SURVEY
 BLOCK 340
 ATWATER VALLEY AREA
 DATE: 08/15/2008
 SCALE: 1:1000
SHEET 2 of 4

STATIONING AND ELEVATION DATA
 PROVIDED FOR INFORMATION ONLY.
 THIS INFORMATION IS NOT TO BE USED FOR ANY PURPOSES OTHER THAN AS SHOWN ON THIS DRAWING.

DATE	DESCRIPTION	SCALE	DATE	DESCRIPTION	SCALE	DATE	DESCRIPTION	SCALE
08/15/2008	Original Backscatter	1:1000						





PLAN VIEW

ANY irregularities shown on this plan view are shown as such.

DATE: 01/15/2014

SCALE: 1" = 100'

LEGEND

Gradients are shown in feet above sea level.

GRADIENT MAP

ANY SITE SPECIFIC SURVEY

BLOCK 340

AT WATER VALLEY AREA

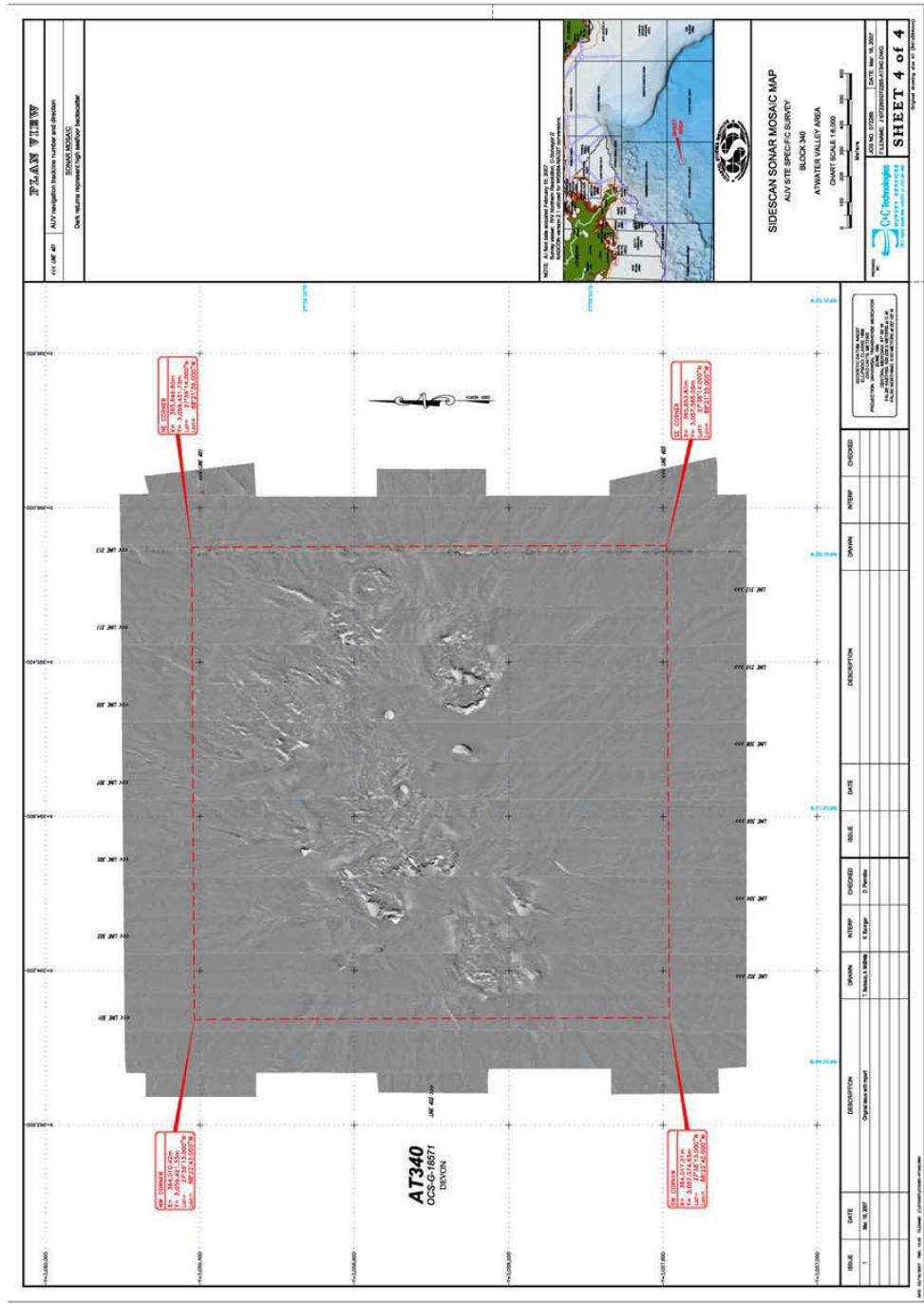
DATE: 01/15/2014

SCALE: 1" = 100'

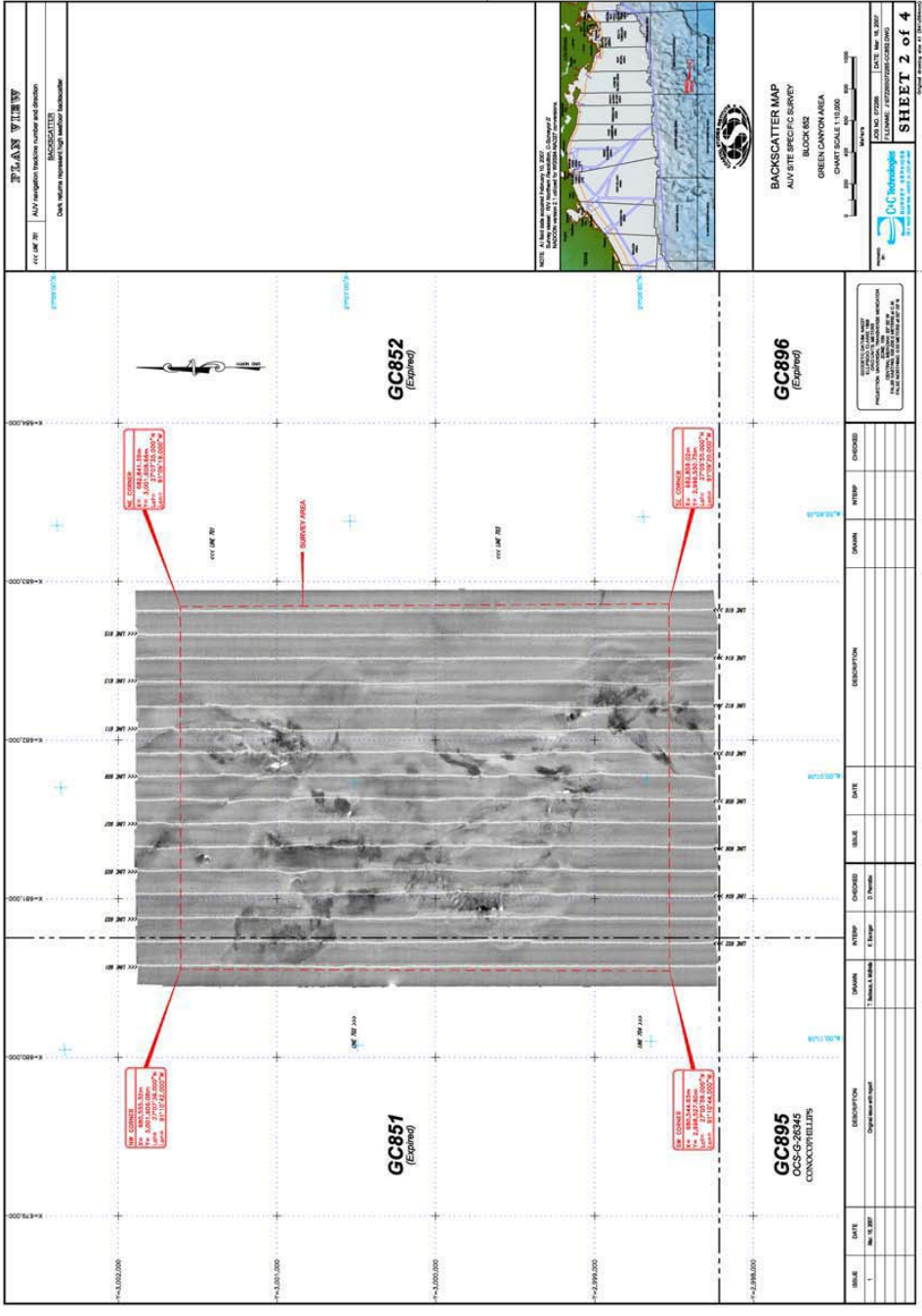
NOTE: All measurements are in feet unless otherwise noted.

SHEET 3 of 4

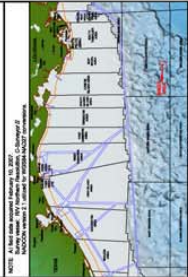
Scale: 1" = 100'



GC852



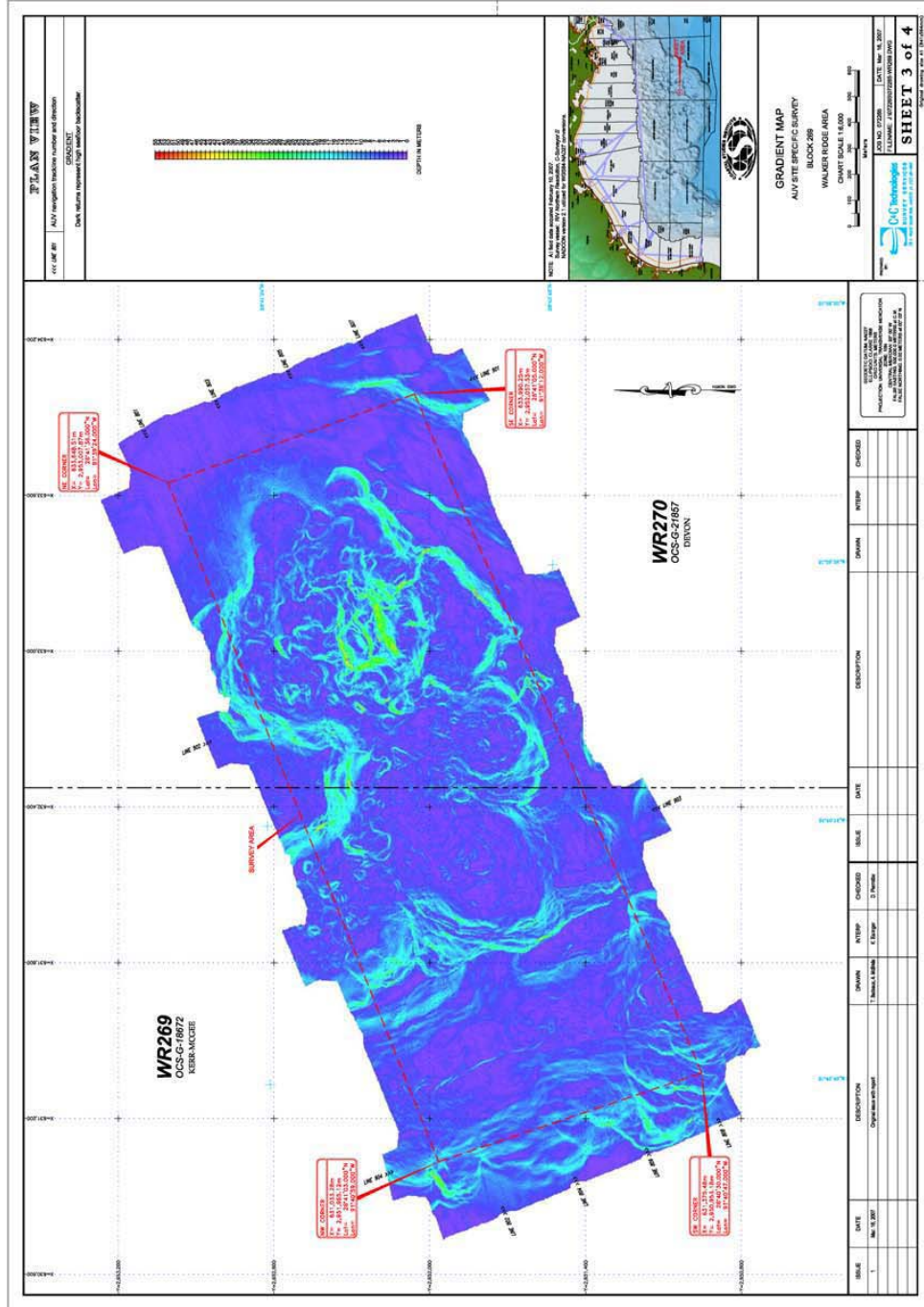
PLAN VIEW
 ANY irregular boundary corner and elevation
 BACKSCATTER
 DATE: 10/15/2024

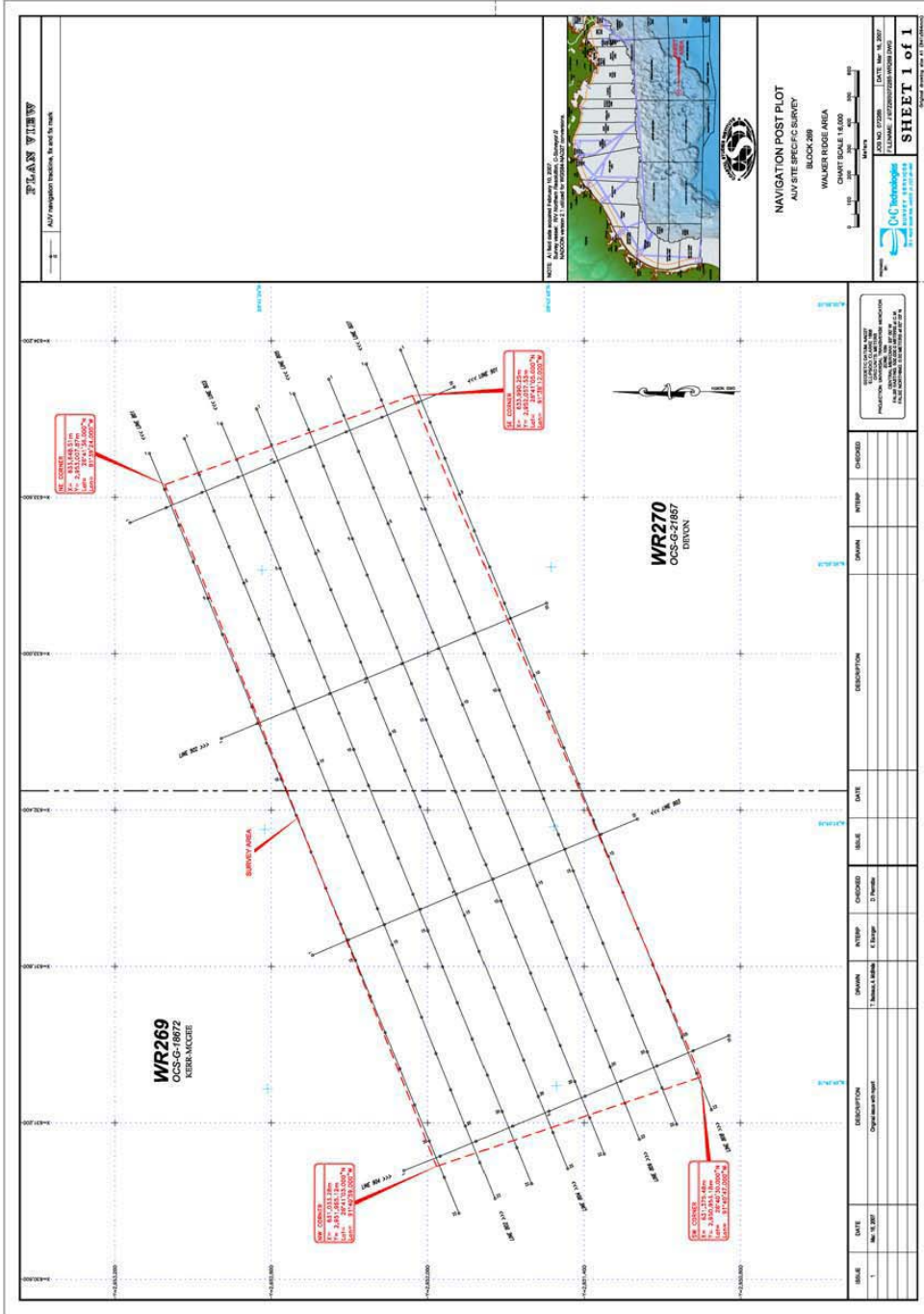


BACKSCATTER MAP
 ADV SITE SPECIFIC SURVEY
 BLOCK 62
 GREEN CANTON AREA
 CHARTER SCALE 1:10,000
 DATE: 10/15/2024
SHEET 2 of 4

DATE	DESCRIPTION	SWATH	INTERP	CHORD	SCALE	DATE	DESCRIPTION	SWATH	INTERP	CHORD
10/15/2024	Original Backscatter	7.5m Swath	4 Edge	2 Points	1:10,000					

WR269







The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.



The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.