Preliminary Cruise Report for R/V *Atlantis*/ROV *Jason-II* Expedition AT18-07: Hydrogeologic, Geochemical, and Microbiological Experiments in Young Ocean Crust of the Northeastern Pacific Ocean Using Subseafloor Observatories

Expedition Dates and Ports 28 June 2011 to 14 July 2011, Astoria, OR to Astoria, OR

Supported by NSF projects: OCE-1031808, MCB-0604014, and OCE-0726887
(and linked proposals) and C-DEBI project 152423

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Preliminary Report: 8 September 2011

I. Expedition Overview

A. Summary of Grants and Goals

Expedition AT18-07 was supported through three NSF projects, each having multiple co-PIs and with different leaders participating at sea and on shore:

(1) Eleven days: OCE-1031808, "Collaborative Research: Completion of single- and cross-hole hydrogeologic experiments on the eastern flank of the Juan de Fuca Ridge using a borehole network"

Project Leader: A. T. Fisher

Co-PIs/Collaborators: K. Becker, J. Cowen, C. G. Wheat, J. F. Clark, K. Edwards

(2) One day: MCB-0604014, "Collaborative Research: Microbial Ecology of Ocean Basement Aquifers: ODP Borehole Observatories"

Project Leader: J. Cowen

Co-PIs/Collaborators: Cowen, Glazer, Rappe and Amend

(3) One day: OCE-0726887, Collaborative Research: Establishing a three-dimensional, subseafloor, IODP observatory network in the northeastern Pacific Ocean, and initiation of large-scale, cross-hole experiments”

Project Leader: K. Becker

Co-PIs/Collaborators: A. Fisher, C. G. Wheat, J. Cowen, J. F. Clark

In addition, an extensive education, outreach and communication (EOC) program during AT AT18-07 was supported through the Center for Dark Energy Biosphere Investigations, Project 152423. The Project Leader for this part of the expedition was S. Cooper, with co-PI, L. Peart. A complete list of AT18-07 participants is included as **Appendix A** of this report.

The primary set of NSF grants supporting this expedition included 11 dive/science days. In addition, mechanical problems during AT15-66 in Summer 2010 resulted in work associated with two additional (related) projects being left incomplete, so two additional dive days were added to AT18-07, one for each of these programs. Work locations during AT18-07 are summarized in **Table 1** and shown in **Figures 1**, **2**, and **3**. Primary tasks completed during AT18-07 and planned for Summer 2012 are listed in **Table 2**.

OCE-1031808 (Project Leader: A. T. Fisher) supports multidisciplinary borehole experiments in oceanic crust, to assess hydrogeologic, solute, gas, and colloid transport, and microbiological processes and properties at multiple spatial and temporal scales (meters to kilometers, minutes to years). Results of these experiments will comprise a major advance in our understanding of hydrogeologic properties and fluid processes within the volcanic oceanic crust. This grant supports scientific activities that follow completion of Integrated Ocean Drilling Program Expedition 327, which operated in Summer 2010. This expedition drilled two holes through sediments and into the volcanic crust on 3.5 m.y. old seafloor on the eastern flank of the Juan de Fuca Ridge, Holes U1362A and U1362B (Figures **1**, **2**, and **3**). These holes were drilled, cased, cored, and tested, then instrumented with subseafloor, borehole observatory systems (CORKs) (**Figure 4**). Expedition 327 also included a hydrogeologic, pumping and tracer injection experiment, to assess multi-scale formation properties, including the nature of azimuthal and vertical crustal anisotropy.

The Expedition 327 CORKs augment four additional observatory systems, all located within an area of about 2.5 square kilometers, creating a network of six instrumented sites where researchers are monitoring pressure and temperature at depth, and sampling fluids and microbiological material, using autonomous instrumentation (**Figure 3** and **Table 1**). These CORK systems require servicing with a submersible or remotely operated vehicle (ROV) to download data, recover samples, and replace a variety of experimental systems (pressure and temperature data are being collected from the system in Hole 1026B by the Neptune Canada cabled network). Servicing these observatories was a primary goal of the Summer 2011 expedition with the R/V *Atlantis* and ROV *Jason-II*. In addition, we planned to install a flow meter on the top of one of the CORK observatories, then open a large-diameter ball valve (**Figure 4**), allowing overpressured hydrothermal fluid from the crust to flow freely into the overlying ocean. This provides fluid and microbiological sampling opportunities, and creates a pressure perturbation that will extend within the seafloor to other CORK observatories. By monitoring the formation pressure response at the different observatories, located at different distances and in different directions from the CORK that is discharged, researchers can assess the nature of crustal hydrologic properties. Samples recovered from the wellheads will also allow assessment of fluid transport rates based on the appearance of tracers pumped into the seafloor at one of the observatory sites in Summer 2010 during IODP Expedition 327. Results of this work will be combined with other studies, including results from past drilling expeditions, to characterize the nature of linked, subseafloor hydrogeologic, geochemical, and microbiological processes, and to provide information needed to constrain coupled models of these processes.

MCB-0604014 (Project Leader: J. Cowen) was intended to collect clean samples of crustal fluids for geochemical, microbiological and ecological characterization. Researchers are studying subseafloor microbial communities and metabolic diversity in association with geochemical processes. In situ, real-time voltammetric analyses are used to measure dissolved redox species, helping to elucidate the metabolic climate of the basement fluids. Geochemical and biological data serve as input parameters for thermodynamic calculations of potential metabolic reactions, which provide a 'reality-check' for occurrence of specific metabolisms. Biomarkers and their carbon isotopic compositions provide information about source organisms, carbon sources, and physiological processes. MCB-0604014 activities focus mainly on acquisition and measurement of pristine fluid samples from the CORK observatory systems described above.

OCE-0726887 (Project Leader: K. Becker) has overall project goals similar to those described for OCE-1031808, but also was to include servicing of the CORK in Hole 1024C, an observatory that is not part of the IODP Expedition 327 network. This CORK system was installed on younger seafloor, ~40 nmi to the west of Site U1301, during ODP Leg 168 in 1996. At present this CORK system is being used for formation pressure monitoring. During the Summer 2011 expedition, we planned to visit this CORK and download pressure data. We also planned to recover a data logger left on the ROV platform of the CORK in Hole 1025C, about 4 nmi from Hole 1024C, if there was sufficient time.

In addition to the overall scientific and technical goals listed above, AT18-07 included a significant education, outreach, and communications (EOC) program. Space was allocated for six dedicated EOC specialists: three school educators, one museum educator, a videographer, and an EOC coordinator and leader. EOC activities during AT18-07 are described in greater detail later, but included: (a) blogging, (b) web conferencing with museums, summer camps, and other venues, (c) production of videos, podcasts, and other media, and (d) curriculum development.

AT18-07 arguably comprised the first non-drilling "C-DEBI" expedition funded and scheduled following formation of this Science and Technology Center. The original proposal that funded the bulk of AT18-07 (OCE-1031808) was submitted prior to formal approval of the C-DEBI proposal, but unofficial approval of the STC just before the AT18-07 proposal was submitted required significant revision to budgets in OCE-1031808 and related projects. Much of the extensive EOC program was funded by C-DEBI. Moreover, the interdisciplinary nature of technical preparation and scientific activities undertaken during for Summer 2011, are consistent with the vision and objectives that motivated the C-DEBI effort.

B. AT18-07 Operational Objectives

Proposal OCE-1031808 requested support for two oceanographic expeditions, one in Summer 2011 (AT18-07) and one in Summer 2012 (schedule TBD), both focusing on servicing a network of six subseafloor observatories (CORKs) separated by ~40 to 2460 m (**Figure 3**, **Table 3**), collecting fluid and microbiological samples, and completing cross-hole hydrogeologic, geochemical, and microbiological experiments. Work distributed between the 2011 and 2012 expeditions is being coordinately carefully so that instruments deployed in 2011 can be recovered/redeployed in 2012, and so that data and samples are collected in a way that maximizes benefit to the full suite of experiments. Because of the close spacing between the primary CORK systems that were the focus of AT18-07 (**Table 3**, **Figure 3**), was often possible to combine operations at multiple wellheads during a single *Jason* dive, greatly increasing efficiency.

As of the start of AT18-07, pressure measurement and logging systems were installed and running in the CORKs in Holes 1026B, 1027C, U1301A, U1301B, U1362A, and U1362B. Data from Hole 1026B are being downloaded automatically using the Neptune Canada cable network. Data from the other CORKs were downloaded with *Jason*. Most pressure download work was supported with NSF grant OCE-1031808, but work at Sites 1024 and 1025 was supported by OCE-0726887. Pressure download operations at Sites U1301 and U1362 included manipulation of valves to check the hydrostatic pressure offset and evaluate gauge drift, as did work at 1027C once the new data logger system was installed.

As of the start of AT18-07, the CORK in Hole 1027C contained an older generation of data logger installed in the top of the wellhead, thought to be corroded in place by a brass electrical connector. We planned to recover and replace the pressure logger in Hole 1027C. We did not know if the old Hole 1027C data logger was still collecting data or if it could be downloaded, either before or after attempting recovery. We also did not know if the Hole 1027C CORK was still sealed, following an unsuccessful recovery attempt on IODP Expedition 327, or if the system could be resealed once the old logger was removed.

Replacement of the pressure logging system in Hole 1027C required a series of special operations and custom tools and tool system. First, we built a Top Hat Extraction Tool (THET) to remove the corroded brass electrical connector from the top of the wellhead. Once this connector was removed, we planned to deploy a Hydrostatic Pulling Tool (HPT) to latch onto the data logger and pull it out using a hydraulic ram (driven by hydrostatic pressure). Once the old logger was removed, we planned to install a Manifold Insert (MI) into the wellhead. This tool was designed with two hydraulic couplers (same design as in the OsmoSampling bay of the Expedition 327 CORKs) attached near the top of the insert. We planned to use this coupler to connect to a hydraulic umbilical plumbed into a pressure gauge and data logger. This data logger was intended for deployment in a CORK wellhead during Expedition 327, so it has the same kind of underwater mateable connector used for programming and data downloading as the pressure loggers used on other CORKs in this area. The insert placed in the Hole 1027C CORK wellhead has a rotating clamp on top, sitting above a large diameter ball valve, like on the CORKs deployed at Site U1362. This clamp was designed to hold a solid plug (dust cover) during Summer 2011 *Jason-II* operations, but a plug supporting additional instrumentation (for fluid sampling, microbiological substrate, etc) could be deployed at a later time.

We developed an autonomous flowmeter system that was to be deployed on the top of a ball valve in the wellhead of one of the Expedition 327 CORKs, most likely the one in Hole U1362B. This flowmeter uses an electro-magnetic induction sensor to determine the rate of fluid outflow from the CORK over time, with measurements made every 60 minutes for the following year. The flowmeter was designed to be held in place with a rotating clamp positioned above a ball valve in one of the wellhead bays. Opening that valve starts a long-term flow experiment, intended to last for the subsequent 12 months, as the overpressured formation fluid discharges at an anticiatd rate of 5–10 L/s. Simultaneous pressure monitoring in the flowing hole and in nearby CORKs will help to resolve the cross-hole response and thus the directional formation properties at a large scale. A vertical pipe with a diameter of ~4" extends upward from the flowmeter sensor. Four autonomous thermal loggers are installed along the length of this pipe, to provide an independent estimate of the upward fluid flow rate (using heat as a tracer). In addition, this pipe provides fluid and microbiological sampling opportunities. Inlets to fluid samplers can be "hung" over the top of the pipe, allowing fluids to be sampled during long-term discharge from the hole.

As of the start of AT18-07, OsmoSampler systems were installed on wellheads in Holes 1026B, U1301A, and U1301B. Existing and new OsmoSampling systems include Teflon coils, copper coils, and microbiological FLOCS incubation chambers. We planned to replace existing systems at these locations and install new systems on CORKs in Holes U1362A and U1362B, which were deployed on IODP Expedition 327 without samplers in place. The OsmoSamplers installed on the CORK in Hole U1362B were designed to draw fluids from the discharge from the flowmeter system, rather than from smaller diameter lines on the wellhead. OsmoSampler and FLOCS designed for new CORKs used milk crates and umbilical lines rather than being mounted directly on the wellhead with steel plates, allowing for more flexible configuration and deployment.

Additional fluid samples were planned for collection from from wellheads using a variety of techniques. Active pumping systems were to be deployed and recovered on a short-term (single dive) basis, with samples collected on *Jason* or an elevator and returned to the surface for immediate processing. These systems were designed to be attached to dedicated sample ports on wellheads, and to permit in-line electro-chemical measurements to assess redox chemistry and other fluid characteristics. These systems also permit pumping of large fluid volumes through filters to assess the nature of fluid particulates. In addition, we planned to recover a long-term fluid sampling and measurement system, the GeoMICROBE sled, deployed during AT15-66 (in Summer 2010) on the wellhead in Hole U1301A. This system was intended to collect fluids at ~3 week intervals and store them until the entire system was recovered. We also planned to reconfigure and redeploy the GeoMICROBE sled at Hole U1301A or another wellhead, depending on observed pressure, temperature, and fluid sampling conditions. This work was supported by a combination of NSF grants OCE-1031808 and MCB-0604014. We also planned to use a variety of smaller volume samplers to collect fluids as they flowed from wellheads under a variety of conditions: gas-tight samplers, major ion samplers, and squeeze samplers. And we prepared a new "fast-sampling" OsmoSampler-style system for testing, to see how this technology could be adapted for use during relatively short deployments (hours to days).

II. Expedition AT18-07 Narrative

Start of AT18-07

In this section, we describe activities as they occurred during AT18-07. *Jason-II* dive numbers, dates and times, work sites, and Virtual Van image numbers are listed in **Table 5**. AT18-07 has initial and final ports of call in Astoria, OR. We were pleased to arrive in port and find refurbished lab spaces, with brighter lighting, new bench and table surfaces, and new floors. Unfortunately, several shipments did not arrive as intended, and we ended up delaying departure for a day to make sure that key equipment and supplies arrived and were functional. This ultimately proved to be a good decision, as late-arriving components were used successfully during the cruise and were required to achieve primary expedition goals. The delay was also useful for the *Jason* team, who benefited from additional port time for assembly and testing of the ROV and supporting equipment. Expedition AT18-07 departed Astoria at 09:30 on 8/29 (PDT is used throughout this report) for the 18-hour transit to Site 1027.

Dive 565 (1/9 on AT18-07)

Dive 565 focused on remediation of the vintage-1996 CORK installed in Hole 1027C. We had attempted to recover and replace this CORK (and deepen the hole) during Expedition 327, but that effort was not successful because we were unable to get the old CORK to unlatch from the casing. Prior to Dive 565 we prepared and deployed an elevator with the Hydrostatic Pulling Tool (HPT) and a new data logger and umbilical system, and prepared the Manifold Insert with weights and floatation as a separate "elevator" deployment. We also deployed an additional floatation package and weights, with the intent of having the floatation available for removing the old data logger with the HPT, and returning these items to the ship. We carried the Top Hat Extraction Tool (THET) with floatation on the front *Jason-II* basket, along with the old style OD Blue connector (for communicating with the old logger, if necessary) and the ODI connector for communicating with the new logger). We spent a few hours calibrating navigation after the elevator was deployed, then launched the ROV at about 22:00 on 6/30.

The 1027C wellhead was found to be tilted by about 5-10° when we arrived with the ROV (**Figure 6**), most likely because of stresses applied when trying to recover the CORK during Expedition 327 (up to 140,000 lbs of force were applied up and down). This raised questions about whether this CORK would still be hydraulically sealed, but we proceeded with remediation operations. We moved to the elevator to drop weights and bring components closer to CORK, but the elevator was too light and it immediately began to rise to the surface (slowly). We moved to the CORK to begin connector extraction, then later recovered and redeployed the elevator with more weight.

We deployed the THET on the top of the CORK, and proceeded to insert the cleat and begin rotating the arms of the THET to lift the connector. Eventually, the spacer was added as the connector rose in the wellhead (**Figure 6**). We attempted to place a T-pin (from the Manifold Insert boot) in holes on either side of the connector, to assist in lifting the connector, but the T-pin could not be made to go all the way through. We inadvertently dropped the spacers and ended up having to craft replacements using *Alvin* weights, which were sent to the seafloor with a dedicated elevator. These replacement spacers worked well (arguably better than the original spacers), and we were eventually able to jack the electrical connector virtually entirely out of the CORK and lift the THET, so that the THET was sitting just above the top of the wellhead (**Figure 6**), but we still could not lift the connector off of the wellhead. We added additional floatation to the THET using a snap hook to see if we could lift it off the wellhead with the connector, but this did not work. After numerous additional attempts, we elected to recover the additional floats and both elevators and end the dive, then consider additional options.

Dive 566 (2/9 on AT18-07)

Dive 566 was intended to download pressure data from CORKs in Holes U1301A and U1301B, check pressure as measured on OsmoSampling lines in Hole U1301B (to determine if retrofit for pressure measurement was possible), recover GeoMICROBE sled from Hole U1301A, recover OsmoSamplers/FLOCS from Holes U1301A and U1301B, and deploy new OsmoSamplers/FLOCS on these CORKs. We planned to end the dive with a brief return to the CORK in Hole 1027C to recover a large snaphook left behind during previous dive, for use in potential future THET recovery operation.

We started at the CORK in Hole U1301B and downloaded pressure data using the ODI connector. We recovered three OsmoSamplers deployed on the U1301B wellhead (Teflon, copper, FLOCS), and used an analog pressure plate to measure pressure in the OsmoSampler lines in each of the three positions in the bay. No pressure deviation from hydrostatic was observed in any of the OsmoSampler lines, a result consistent with the unaltered appearance of the Teflon and FLOCS OsmoSamplers recovered from the wellhead. This suggests that, like the pressure lines from depth that appear to be clogged, necked, or otherwise occluded, the

OsmoSampler lines may be similarly disconnected from the formation below the CORK. With OsmoSamplers recovered from U1301B, all fluid sampling valves were left in the closed position.

We deployed an experimental "fast sampling" OsmoSampling system on the seafloor near Hole U1301B, with the intent of leaving it for about a week to see how it performed. This system uses osmotic membranes different from those used in regular (long term) OsmoSamplers, and their response to deep sea pressure and temperature was uncertain.

We transited to Hole U1301A and approached the GeoMICROBE sled. The Aeroquip connector was removed from the wellhead (somewhat "too easily"), and the sled was secured and lightened for recovery to the surface. OsmoSamplers were removed from the wellhead and replaced with new units from the *Jason-II* basket (**Figure 6**). Pressures were measured in the OsmoSampler lines on U1301A, as at U1301B, and once again there was no indication of pressure differences from hydrostatic. However, in this case because the CORK in U1301A is not sealed (cement pumped during IODP Expedition 321T in Summer 2009 having drained downward through the platform and through the annular gap between 16" and 10-3/4" casing strings), we did not expect to see much signal, if any. Pressure data were downloaded from the U1301A logger, and a Niskin bottle was filled with bottom water.

An elevator holding the Large Volume Bag Sampler (LVBS) was moved into position near the U1301A wellhead, and a connection was made to the Aeroquip connector in the microbiology bay. Sampling and electrochemistry commenced and continued with a variety of operations for 13 hours, using both the LVBS and the Medium Volume Sampler (MVS) located in the rear *Jason-II* basket. The elevator was released and returned to the surface with the LVBS, and we transited to Hole 1027C to recover the snap hook left on the THET.

Flowmeter calibration following Dive 566

Following completion of Dive 566, we used a small Alvin elevator and the hydrowire to calibrate the flowmeter. This was accomplished by cutting a hole in the elevator grating, and securing the flowmeter so that the bottom adapter penetrated through the hole, near the center of the elevator. Two *Alvin* weights (32 lbs) were secured to the base of the elevator to center the load, and give additional weights were added in two groups (80 lbs each) at opposite corners of the elevator, to help prevent the elevator from kiting in the water column. The elevator was lowered over the side and downward through the water column for periods of 20-40 minutes at a steady rate, across a range of ~10 to 60 m/min, equivalent to about 0.5 to 5 L/s passing through the flowmeter. Data from this test were subsequently added to additional measurements made prior to AT18-07 in a test tank, using flow rates of ~0.5 to 1.2 L/s. The composite data set was found to be internally consistent and provides an excellent calibration curve for the flowmeter.

Dive 567 (3/9 on AT18-07)

Dive 567 was intended to recover pressure data from the wellheads in Holes U1362A and U1362B, deploy a flowmeter on U1362B and open a ball valve to initiate a long-term flow experiment, deploy OsmoSamplers on U1362A (but not open valves yet), and recover OsmoSamplers from 1026B. The *Jason-II* basket was configured with new style OsmoSamplers in milk crates and the flowmeter standing vertical, with fluid sampling equipment left in place to avoid having to reconfigure the vehicle (**Figure 7**). The flowmeter was held in place with a manipulator during launch, but it tumbled in the basket, as did one of the milk crates holding OsmoSamplers. Fortunately the pilot was able to prevent the flowmeter and OsmoSamplers from falling off the basket.

We arrived at Hole U1362B, performed a hydrostatic check, and downloaded pressure data. The flowmeter was wrangled from the basket and placed on the wellhead, which was challenging because of awkward weight distribution and a rigging and T-handle arrangement that was not optimal for handling with the ROV. Eventually the flowmeter was secured in the ring clamp on the wellhead, and the ball valve was opened, releasing a satisfying discharge of shimmering hydrothermal fluid (**Figure 7**). Visual inspection of the data logger showed the LED lighting on the hour+3 seconds, indicating that the system was operating and logging data. Fluid samples were collected with four squeeze samplers as water discharged from the top of the flowmeter chimney (**Figure 7**).

With initial work at Hole U1362B complete, we offset the ROV to Hole U1362A, performed a pressure download, then deployed a two sets of new OsmoSampler systems. Unlike the old style OsmoSamplers that were mounted on the wellheads using metal plates, new OsmoSamplers were deployed in milk crates, with umbilicals that connected sampler inlets to valves on the wellhead. Systems deployed include Teflon, copper coil, and FLOCS samplers. These OsmoSamplers were not opened right away, as we wished to allow the pressure perturbation from the free flow at Hole U1362B to propagate to this hole without additional disturbance for a couple of days. The new OsmoSamplers draw fluids from freely flowing ½" lines, and this results in considerably more flow from depth that would flow from 1/8" or 1/16" lines, as used with older style OsmoSamplers.

We transited to Hole 1026B, opened and closed valves for a hydrostatic check (no download, as pressures are being logged by Neptune Canada), and recovered three old-style OsmoSamplers from the wellhead (**Figure 7**, left to right: copper, FLOCS, Teflon).

Neptune conflict prior to Dive 568

We moved the ship back to Site U1362 in anticipation of additional operations in this location, but were surprised to find the R/V *Thomas G. Thompson* on site with the ROV *ROPOS* in preparation for Neptune Canada operations (recovery of a bottom pressure recorder, deployment of a piezometer in shallow mud). After some discussion, it was agreed that we would reorganize our activities so that we could proceed next to Holes 1024C and 1025C for pressure download and logger recovery operations.

Dive 568 (4/9 on AT18-07)

Dive 568 supported activities funded through OCE-0726887, which remained incomplete as of the end of Summer 2010 dive activities. This involved a pressure download from the CORK in Hole 1024C and recovery of a data logger from the wellhead at Hole 1025C (**Figures 1 and 2**). A few hours were required for the transit from Site 1026, and *Jason* was in the water by 08:00 on 7/6. The pressure download at Hole 1024C was uneventful, although the wellhead was found to be extensively overgrown (**Figure 8**), and we did lose the serial connection once during communication. We then transited to Hole 1025C and the old datalogger was recovered with little trouble.

Weather delay before Dive 569

The weather became rougher during Dive 568, and by the time we had recovered the ROV and returned to Site U1362, conditions had built to the point that we were forced to delay additional *Jason-II* work (sustained winds of 25 kts, gusts up to 35 kts, swell plus waves up to 15 feet). We used this time to complete a CTD cast and run a cable stretch experiment using the hydrowire, then stood by for conditions to clear. We ultimately lost 24 hours because of poor weather, but this was to be the only weather day of the expedition.

Dive 569 (5/9 on AT18-07)

Dive 569 supported activities at Holes U1362A, U1362B, and 1026B (**Figure 9**). We dove initially on Hole U1362A to hang a third OsmoSampler crate on the wellhead, connected to the deepest monitored interval, and open valves allowing ½" fluid sampling lines to flow. We transited to Hole U1362B and used four squeeze samplers to collect fluids discharging from the flowmeter, collected a sample with a gas tight sampler, then hung an OsmoSampling crate from the wellhead, and attached the inlet to an umbilical tube to the top of the flowmeter chimney ("UmbiloSnork," **Figure 9C**).

We moved an elevator with the Large Volume Bag Sampler (LVBS) and replacement (old-style) OsmoSamplers form Hole 1026B to the wellhead at U1362B, and proceeded with fluid sampling. An adapter for use with the LVBS and Medium Volume Sampler (MVS, located in the aft *Jason-II* basket) was attached to the lower of two fittings in the microbiology/flowmeter bay, and sampling began with the LVBS. Electrochemical measurements were made simultaneously. The pump system worked very well, indicating a flow rate on the order of several L/min, and electrochemical sensors suggested that fluids flowing into sampling bags were of high quality. Additional sampling was completed using major samplers and gas tight samplers using a gas trap with the pump system. When sampling with this system was complete, major and gas tight samplers were moved to the elevator, OsmoSamplers n the elevator were transferred to the *Jason-II* front basket, and the elevator was released.

Jason transited to Hole 1026B to install replacement OsmoSampler plates. Teflon and copper tube OsmoSamplers were attached, but there was a hydraulic failure with one of the *Jason-II* manipulators before the FLOCS OsmoSampler could be installed, and the dive was terminated.

Dive 570 (6/9 on AT18-07)

Dive 570 supported an attempt to recover the THET and other components from the CORK in Hole 1027C (**Figure 10**). We had received permission from shore to use the *Jason-II* control and power vehicle, *Medea*, for this purpose, pulling with the winch on *Atlantis* and using a spliced Spectra harness and large snap hooks to engage the THET. We did not know how much pulling would be required, but were prepared to pull with several thousand pounds if necessary. A weak link was placed above the Specta harness, below *Medea*, so that we would avoid damaging the vehicle if the THET, connector, or underlying data logger became stuck. We did not plan originally to pull on the old data logger with the THET, expecting that after removing the electrical connector, we would have to use the Hydrostatic Pulling Tool (HPT) to push aside latch dogs in the throat of the CORK and release the logger. But based on observations during earlier attempts to lift the THET and connector suggested that the logger might be attached.

Jason-II and *Medea* were launched with the Specta harness and snap rings hanging below *Medea*, and we dove on Hole 1027C. *Jason* gathered the snap hooks and attached them to the THET, making sure that they were secure to guide arms on the sides of the THET (not the arms used to turn the jacking nut). When we were confident that the snap hooks and harness was oriented correctly, we backed off and watched as *Medea* was slowly raised, watching the weight indicator carefully. Just before taking weight from the tool, the indicator showed ~7000 lbs of load, which comprised the normal operating weight for *Medea.* The THET began to rise from the top of the 1027C CORK once the load indicator showed we were pulling ~7800-7900 lbs. This is about 400 lbs more than the calculated weight of the THET, *Alvin* weights, brass connector, and old data logger.

All of these pieces came out of the wellhead together, but we did not know how securely the old data logger was attached to the electrical connector. We surmised that it was attached only by a thin rind of corrosion, and so moved to bring these pieces onto the ship as quickly as possible. *Jason* and *Medea* were recovered first, and the harness was tied off on the rail until everything else was secured. Then the deck crew carefully managed bringing the pieces onto the deck using the crane and a capstan and rope. Once the pieces were on deck, it was easy to separate the electrical connector and logger from the THET, and these were staged on the fantail, cleaned, then brought into the lab.

A few hours later, the electrical connector was separated from the old logger with just the weight of a large pipe wrench. It may be that differential expansion during warming of the components helped to break the corrosion between the connector and logger. We were subsequently able to attach an OD Blue electrical connector to the old logger, then awaken the logger and download a complete two-year record of pressure readings.

Fast Turn Around Between Dives 570 and 571

Normal turn around time between *Jason-II* dives is 12 hours, but the *Jason* group graciously offered to perform a rapid turn around following Dive 570 because that dive was so short, involving only recovery of the THET and other components from Hole 1027C. Bringing all of the pieces from Hole 1027C over the rail and onto the deck took several additional hours, as did preparation and deployment of the GeoMICROBE sled. Nevertheless, we ended up with only about five hours between the end of Dive 570 and the start of Dive 571.

Dive 571 (7/9 on AT18-07)

Dive 571 supported installation of the final OsmoSampler plate on the CORK in Hole 1026B, fluid sampling from the Hole U1362B wellhead, and long-term deployment of the GeoMICROBE sled on Hole U1362B (**Figure 11**). We planned to complete a second hydrostatic check and download with the pressure logger in Hole U1362A, as the earlier check was not transmitted during the associated data download. And we planned to read absolute pressure values from the U1362A and U1362B wellheads with the gauge on *Jason-II*, for comparison to seafloor pressures measured on by CORK gauges, to check apparent elevation differences between the wellheads.

The GeoMICROBE sled was configured and deployed independently before the start of Dive 571, near Hole U1362B where it would be left for long-term sampling. *Jason* was deployed on Hole 1026B to install the final OsmoSampler (FLOCS), then transited to U1362A. We completed a hydrostatic check and data download at Hole U1362A, and verified water pressure with the vehicle sitting on the wellhead platform, then transited to Hole U1362B. We verified wellhead platform pressure and completed a data download at Hole U1362B, then collected four squeeze samples from the discharging flowmeter chimney. We located the GeoMICROBE sled on the seafloor nearby and moved it to the wellhead platform in preparation for later deployment. We proceeded with fluid sampling using the MVS system and real-time electrochemical measurements. This work went smoothly, and we ended the dive by configuring the GeoMICROBE sled on the wellhead, and making a connection to the lower sampling port in the flowmeter/microbiology bay.

Dive 572 (8/9 on AT18-07)

Dive 572 supported completion of Hole 1027C CORK remediation to restore measurement and monitoring capabilities to this observatory (**Figure 12**). This effort appears to have been a complete success. A Manifold Insert (MI) was delivered to *Atlantis* during the port call and was configured in port for deployment. The MI replicates the form of the old data logger that was extracted from the wellhead on Dive 570, including multiple o-rings near the base. At the top are two valves and fittings identical in form to those used on the OsmoSampling and microbiology sampling bays in Hole U1362A and U1362B CORKs. There was also a ring clamp and ball valve of the same design as used on these CORKs, to allow additional instrumentation to be deployed in the CORK or on the MI in the future.

The MI was deployed prior to the first dive of AT18-07, adjacent to Hole 1027C, including a clump of *Alvin* weights attached to the deployment boot. A floatation package was designed and hung from a harness, secured with T-pins, with the intent of keeping the MI vertical when it landed on the seafloor. Part of this floatation package had been released during Dive 565 when the T-pin was pulled from the MI boot (in an attempt to secure the old electrical connector being removed with the Top Hat Extraction Tool), so additional floatation was carried to the seafloor on the front *Jason-II* basket and added above the MI (**Figure 12**). The MI was still top heavy, but *Jason* was able to lift and carry it to the wellhead platform, then lay it out so that the o-rings (which has been installed and greased prior to deployment at start of AT18-07) could be cleaned with a brush. Then the MI was lifted using both of the *Jason-II* manipulators and lowered vertically into the CORK. The MI went most of the way in with its own weight (offset by floatation), and both *Jason* manipulators were used to push it the rest of the way in and land the MI at the top of the CORK. The CORK wellhead had been cleared of the old electrical connector and data logger during Dive 570, so the observatory had been open for about 36 hours prior to insertion of the MI.

The ball valve below the MI had been left open during deployment, to avoid trapping air at the top of the MI, and this valve was now closed. We still did not know if the entire CORK system was sealed, as it could have been severely damaged during Expedition 327, or the seal area for the MI could have been damaged during recovery of the old logger (we subsequently recovered data from the old 1027C data logger, showing that the observatory had been sealed through Expedition 327 and prior to removal of the old logger). We carried the new data logger over from an elevator and placed it on the wellhead platform, then attached an umbilical tube to a valve on the top-side of the MI. This valve and the valve on the opposite side of the MI were opened, allowing a hydrostatic check, and then the valve opposite the umbilical connector was closed. Data were collected after waiting for an additional 30 minutes, and we were gratified to see that the pressure in the CORK (when it was sealed) was underpressured by about 20 kPa relative to hydrostatic, exactly as the CORK had functioned in previous years. With these operations complete, the CORK in Hole 1027C was left monitoring pressure every minute using modern instrumentation.

Dive 573 (9/9 on AT18-07)

Dive 573 was the last dive of AT18-07, and completed a variety of activities in and around Holes U1301A, U1301B, U1362A and U1362B (**Figure 13**). We deployed an elevator with two Major Samplers at Hole U1362A prior to the dive, then dove on Hole U1301B. We recovered the fast-sampling OsmoSampler system from the seafloor, then transited to Hole U1301A to collect eight sediment cores from adjacent to the wellhead and measure local sediment temperatures with the *Jason-II* temperature probe. We transited to Hole U1362B and used a temperature probe to assess the temperature of fluid exiting above the flowmeter (**Figure 13**), finding a temperature of 62.3°C, a bit lower than the 63.5°C fluid temperature determined during Expediiton 327 at nearby Hole U1301B. This suggests that the rise of fluid from depth through the CORK system and out through the flowmeter occurs relatively quickly, as surmised from the billowing and shimmering water existing from the top of the chimney. In contrast, temperatures measured at the exit of sampling bays used for OsmoSamplers were never higher than 8.2°C, most likely because these fluids rise more slowly through smaller tubes, then transit through 1-2 m of large-diameter Tygon tubing, giving the fluids a greater opportunity to cool prior to measurement.

We transited to the elevator near Hole U1362A and moved the elevator closer to the wellhead, placing Major Samplers in the *Jason* basket. Fluid sampling commenced using the Medium Volume Bag Sampler and in-line electrochemical sensors. Additional samples were collected from the pump manifold using the gas trap (**Figure 13**). Sampling continued until all containers were full and sufficient water volumes had been passed through filters. Valves were closed, the elevator was released, and the ROV was recovered.

Multibeam Survey at End of AT18-07

We completed essentially all planned CORK servicing and related activities but did not have enough time for another ROV dive. Nevertheless, we had sufficient time to complete a multibeam survey, and this option had been mapped out a few days before. We planned to survey several basement outcrops that were known entry or exit points for hydrothermal fluids, using the new Kongsberg SM122 system that had been installed on *Atlantis* during the transit prior to AT18-07. We had also been asked by W. Wilcock (University of Washington) prior to our expedition if we had time to survey some additional sites of opportunity that were to be instrumented later in the summer for OBS monitoring. We added two of these sites (J52 and J53) to our multibeam track (**Table 4**). For all targets to be surveyed, we identified way points that would allow the ship to be on a fixed heading and running at a suitable speed (5–7 kts) when each feature was crossed. We initially used CTD data from near Site U1301 to provide information on water column velocities, but we also launched an XBT part way through the multibeam survey to provide additional data. It took a few hours to get the new system operating correctly, but then the rest of the survey was completed without problems.

End of AT18-07

After completion of the multibeam survey, we steamed back to Astoria OR for the final port call of AT18-07. We arrived at the dock around 09:30 on 7/14/11, and offloading of equipment was accomplished quickly. One shipment was loaded directly into a rental truck, and other equipment was picked up by various freight companies. Virtually all gear was removed from the ship and labs were cleaned by the end of the day on 7/14/11, making spaces available for the oncoming science party.

III. Summary of CORK Pressure Downloads

CORK pressure download operations were completed as planned during AT18-07 with few problems. A summary of download operations and data files retrieved is presented in **Table 6**. Data were recovered from data loggers of different vintages using a variety of serial connectors under water and in the lab.

CORKs in Holes U1301A and U1301B were visited during Dive 566, hydrostatic checks were performed, and data were downloaded without trouble using the ODI connector. CORKs in

Holes U1362A and U1362B were visited on Dive 567 and data were downloaded with the ODI connector. Hydrostatic checks were performed prior to download, but insufficient time was allowed to fill out a full data register before downloading, so the check from Hole U1362A was omitted and the check for Hole U1362B was very short. These checks were repeated during subsequent download operations.

Data were acquired from the logger on Hole 1024C using the Seacon connector on Dive 568, and the logger at Hole 1025C was recovered before data were downloaded in the lab. The old logger from Hole 1027C was retrieved during Dive 570 (still connected by corrosion to the electrical connector), and an OD Blue pin was pressed into the (partly disassembled) connector to permit a download in the lab.

We attempted an additional data download on Dive 571 to capture hydrostatic check data from Hole U1362A, but the data had been erased following the previous download of this logger, so no check data were provided. We returned to this CORK for a final time on Dive 573, performed a long hydrostatic check and waited 30 minutes prior to the download, assuring that we would collect the hydrostatic check data. We also performed a longer hydrostatic check with the CORK in Hole U1362B (Dive 573), and acquired hydrostatic check data with the new logger attached to the CORK in Hole 1027C (on Dive 572) as part of that installation.

IV. Summary of OsmoSampling for Geochemistry and Microbiology

OsmoSampler operations went smoothly during AT18-07. OsmoSamplers were recovered during AT18-07 from the wellheads of CORKs installed in Holes 1026B, U1301A, and U1301B. All of these OsmoSampler systems were installed in Summer 2010 during Expedition AT15-66. No OsmoSamplers had been deployed on the old style wellhead in Hole 1027C, and the new Expedition 327 CORKs in Holes U1362A and U1362B were deployed without OsmoSamplers. New versions of old style OsmoSamplers, using metal plates attached directly to wellheads, were deployed on CORKs in Holes U1301A and 1026B (**Figures 6 and 9**). New style OsmoSamplers were deployed on CORKs in Holes U1362A and U1362B using milk crates and umbilicals to attach sample tubing to custom wellhead adapters. In the case of Hole U1362A, three OsmoSampler crates were deployed to monitor both shallow and deep crustal intervals (**Figures 7, 9, 13, and 14**). For Hole U1362B, a single OsmoSamper crate was deployed with an umbilical leading to the top of the flowmeter chimney (**Figures 9, 11 and 14**).

Some of the OsmoSamplers recovered from and deployed on each wellhead included FLOCS microbiological growth substrate. A summary of FLOCS deployments and recoveries is provided in **Table 7**. Here we provide a brief narrative of FLOCS operations. Two sets of FLOCS systems were recovered on Dive 566 from Hole U1301B, from the left and right bay positions, but neither showed much discoloration or other indication of alteration. This is consistent with the lack of pressure response detected with the analog pressure gauges (**Figure 6**), and suggests that the fluid lines leading to the OsmoSampler bay in Hole U1301B are blocked.

A FLOCS system was recovered from the right position on Hole U1301A and although this CORK is discharging copious quantities of altered hydrothermal fluid, the FLOCS system recovered also appeared to be relatively unaltered. This may be because the lack of a casing seal means that there is little force available to drive fluids up the sampling lines. An additional FLOCS system was recovered from the center position on the wellhead of Hole 1026B.

Passive and enrichment FLOCS systems were deployed on the wellhead of Hole U1301A, in the left bay position on Dive 566 (**Figure 14**). Passive and enrichment FLOCS were deployed using a milk crate hung from the CORK in Hole U1362A to monitor the shallow interval (Dive 567) and the deep interval (Dive 569). Passive and enrichment FLOCS were deployed to collect fluids exiting the flowmeter on the wellhead in Hole U1362B during Dive 569.

V. Summary of Active Fluid Sampling from CORKs

The University of Hawaii group led efforts in sampling fluid delivery lines from CORK wellheads, using both the Mobile Pumping and Sensor (MPS) system coupled to either the Large Volume Bag Sampler (LVBS, mounted on an elevator) or the Medium Volume Bag Samper (MVBS, mounted in the rear *Jason* basket). Additional sampling was completed with the autonomous GeoMICROBE sampling sled, with Major Element samplers and Gas Tight samplers, and in the water column with a CTD. The MPS and MVBS worked especially well, with the latter generally configured with six 15 L bags, three 0.5 L bags, two 25 mm in-line filters with combusted GFF filters, and flow cells or use in real time electrochemical measurements. Flow rates were ≤0.65 L/min when pumping on the CORK in Hole U1301A (modified Aeroquip connector), and exceeded 5 L/min when pumping from CORKs in Holes U1362A and U1362B (new custom wellhead connector). A listing of the total quantity of fluid samples collected with various tools is provided in **Table 8**. In addition, 10 L volumes were passed through combusted GFF filters in situ when pumping on CORKs in all three holes, with filtrate to be used for later studies of particulate organic carbon, particulate nitrogen, and stable C/N analyses. Finally, two additional 70 L volumes were filtered in situ when pumping on CORKs in Holes U1362A and U1362B for genomic and transcriptomic studies.

Wellhead fluid sampling was combined with in-situ voltammetry as a means to assess borehole conditions and sample quality in real time, during dives 566, 571 and 573 at CORKs in Holes U1301A, U1362B, and U1362A, respectively. For sampling from Hole U1301A, in situ voltammetric scans were made while pumping from the lower microbiology sampling line, during collection with the MVBS. Fluids showed reasonable consistency and stability over time, with typical temperatures of ~29°C, O_2 <8μM, and Fe^{2+}~1.5μM during electrochemical measurements.

The lower microbiology ports were also used when sampling from CORKs in Holes U1362A and U1362B, once again in line with MVBS sampling. When pumping from Hole U1362A, temperatures were ~15°C, O_2 <8μM, and Fe^{2+}~1.5μM. When pumping from Hole U1362B, temperatures were ~30°C, O_2 <8μM, and Fe^{2+}~1.5μM.

The autonomous GeoMICROBE sled was deployed to sample from the CORK in Hole U1301A in late June 2010 (during AT15-66), then recovered on July 3, 2011 (during AT18-07). The GeoMICROBE sled was intended to awaken monthly to collect fluid samples for 12 months. Fluids are pumped to flush the fluid delivery line extending to the depth of interest below the CORK, followed by collection of whole fluids or filtering several liters of fluids through in-line filters while simultaneously monitoring fluid flow, temperature, pH, and O_2 concentration via in-line sensors. Fluids are also periodically analyzed for redox sensitive species (e.g., O_2, iron, reduced sulfur species) with an in-situ voltametric electrochemical analyzer.

When the sled was recovered, we found that the six 24V-40A DSPL batteries had lasted only 6 months, collecting 6 months of periodic sensor data and 12 discreet samples. Preliminary analyses of whole fluid samples for Mg^{2+} concentration indicate that the sled collected a mixture of borehole fluid and bottom seawater. Fortunately, the extent of dilution can be calculated from major fluid chemistry. Because the primary goal for GeoMICROBE sampling in this case was to detect and quantify fluorescent particles pumped into Hole U1362B during Expedition 327, the next dilution by bottom water will be to decrease the effective concentration of the particles. The valve pack that diverts fluids for electrico-chemical failed during the deployment, so no data of this kind were collected.

Following recovery of samples and data from the GeoMICROBE sled, the system was refurbished and deployed on the CORK in Hole U1362B. In addition to replacing all sampling bags and in-line filters, a new primary pump, computer controller, and flow sensor were installed. All fluid plumbing was cleaned or replaced. Four of the original 6 batteries were replaced and all six batteries charged to full capacity. A new electro-chemical analyzer, valve pack, and minipump were installed in the refurbished GeoMICROBE sled, along with a new oxygen optrode and a new pH sensor.

We anticipate that the refurbished GeoMICROBE sled will perform as intended during the coming year because the CORK in Hole U1362B produces large volumes of fluid much more easily than does the CORK in Hole U1301A. This is because sampling will be accomplished through a ½" Tefzel (PVDF) line rather than a ¼" stainless steel line, greatly reducing drag. In addition, mineral oil in the primary pump was replaced with a lower viscosity silica oil, and sampling was configured to decrease fluid volumes filtered and the duration of voltametric analyses. All of these modifications should help to conserve power.

IV. Summary of Education, Outreach and Communication Activities

We ran a variety of education, outreach, and communication (EOC) activities during AT18-07, facilitated by an energetic and talented team of six EOC specialists. In addition to our EOC team leader, three of the team are secondary school science teachers, one is a museum educator, and one a videographer and college instructor. We also operated an extension of the "Adope a Microbe from the Deep Biosphere" project, which was launched initially for IODP Expedition 327 in Summer 2010. Collectively, the EOC program focused on *the nature and process of science* – how researchers ask questions, test ideas, gather data, problem-solve, circle back to new questions and collaborate with both the local, on-board community of participants and the broader science community at large – all in the service of a transformative research agenda.

During AT18-07 we held 13 real-time video webcasts (**Table 9**) using the Fleet Broadband internet connection. We had significant limitations on bandwidth and occasional loss (and subsequent reestablishment) of the connection, but managed to complete these webcasts with good results. We provided shorebased participants with videos and other materials in advance of the web events, so that they could view these materials without the bandwidth limitation and we could make better use of opportunities to interview expedition participants and show examples of ongoing activities and facilities. We started the expedition by holding these events in the main science lab, but worked with shipboard technical personnel to sort out options for making a wireless broadcast, and by the end of the expedition we were moving freely about the ship during web conferences (bridge, fantail, labs, etc.).

EOC specialists received training in interviewing and video production, and a variety of video products were created during the expedition (with additional videos still in production). These included extended interviews and interview clips addressing common questions, overview presentations on expedition goals, videos about deep sea observatories and the C-DEBI STC, and a video from the R/V *Atlantis* to the Space Shuttle *Atlantis* during the latter's last mission. EOC educators also developed curricular materials based on AT18-07 goals and related topics.

The Adopt a Microbe project (https://sites.google.com/site/adoptamicrobe3/) was started before and run throughout Expedition AT18-07 and included a variety of activies, including: answering shorebased questions concerning the deep biosphere and our expedition, building "play-dough" microbes, writing acrostic microbe poems, assessment of microbial habitats (sedimentary, rocks), evaluating microbial growth, and creating microbe art. The Adope a Microbe project also produced numerous videos with interviews and examples of shipboard operations.

EOC specialists blogged and tweeted about the expedition on a regular basis, responding to questions and requests from shore. We also had excellent participation in the EOC program by members of the scientific party, and by the ship's officers and crew and members of the *Jason* team, who told their stories and discussed their experiences during voyages of exploration and discovery. Equally important, the EOC team fully engaged as members of the shipboard party and helped to achieve primary expedition goals, collecting data and samples, standing watch in the *Jason* van, and putting instruments over the rail.

We ran a pre-expedition and post-expedition survey program to help in assessing the achievements of this EOC program and are now evaluating the results. These data will be combined with results from other EOC programs developed through C-DEBI, which will provide a critical number of surveys so as to permit robust statistical assessment.

Table 1. Sites of CORK servicing with the ROV *Jason* during AT18-07.

Location ID	Latitude	Longitude	Water depth (m)	Year CORK installed	Expedition when CORK was installed
CORK 1026B	47°45.759'N	127°45.552'W	2658	1996/2004	Leg 168/Exp. 301
CORK 1027C	47°45.387'N	127°43.867'W	2656	1996	Leg 168
CORK U1301A	47°45.209'N	127°45.833'W	2658	2004	Exp. 301
CORK U1301B	47°45.229'N	127°45.826'W	2658	2004	Exp. 301
CORK U1362A	47°45.662'N	127°45.674'W	2658	2010	Exp. 327
CORK U1362B	47°45.499'N	127°45.733'W	2658	2010	Exp. 327
CORK 1024C	47°54.531'N	128°45.005'W	2612	1996	Leg 168
CORK 1025C	47°53.247'N	128°38.919'W	2606	1996	Leg 168

Additional sites were surveyed by multibeam during the last day of scientific operations, as shown in Figure 4 and listed in Table 4.

Table 2. Summary of tasks completed/to be at each of the CORKs serviced in Summers 2011 and 2012.

Location ID	[1]Attach/ Exchange OS	[2]Active fluid/MBIO sampling	[3]Deploy/recover flowmeter	[4]Recover/deploy MBIO sled	[5]Download P data	[6]Retrofit P logging
CORK 1026B	E: 2011 E: 2012	2011 2012			[Neptune]	
CORK 1027C					2011 2012	2011
CORK U1301A	E: 2011 E: 2012	2011 2012		R: 2011 D: 2012?	2011 2012	
CORK U1301B	E: 2011 E: 2012	2011 2012			2011 2012	2011 2012?
CORK U1362A	A: 2011 E: 2012	2011 2012	D: 2012?	D: 2011 R/D: 2012?	2011 2012	
CORK U1362B	A: 2011 E: 2012	2011 2012	D: 2011, 2012? R: 2012	D: 2012?	2011 2012	
CORK 1024C					2011	
CORK 1025C					2011[7]	

[1] OS = OsmoSampler. Several kinds of OsmoSampler systems were/are to be deployed on and recovered from CORK wellheads, as described in the text. A = attach. E = exchange.
[2] Active sampling = using mechanical pumps to draw fluids from wellheads, or sampling from direct flow from overpressured formations.
[3] Flowmeter is most likely to be deployed on wellhead at Hole U1362B, but could be deployed on at Hole U1362A if desired (will depend on how these systems are seen to function early in the dive sequence). D = deploy. R = recover.
[4] Microbiology sampling sled was left to draw fluids from CORK in Hole U1301A during Summer 2010 Atlantis/*Jason* expedition (immediately prior to IODP Expediton 327). This system was recovered in Summer 2011 and redeployed on Hole U1362B. D = deploy. R = recover.
[5] Pressure and temperature logging systems installed with CORK in Hole 1026B are currently being downloaded automatically with the Neptune Canada cabled network. Hole 1027C contained an older generation of pressure data logger, recovered and downloaded on AT18-07. New pressure logging system was deployed and a data download of the first few days of data was completed.
[6] We retrofitted the older generation of CORK installed in Hole 1027C to monitor pressure using new instrumentation. We tested pressure on OsmoSampler lines on CORK in U1301B using analog guges, and were prepared to attempt a retrofit of this system, but found no evidence that formation pressure could be measured through the OsmoSampler lines. Option remains to retrofit in 2012, but would need evidence that OsmoLines are not clogged.
[7] Data logger recovered from ROV platform.

Table 3. Distances between CORK systems, in meters, located in the primary work area for AT18-07.

	Hole 1026B	Hole U1362A	Hole U1362B	Hole 1027C	Hole U1301B	Hole U1301A
Hole 1026B		235	532	2199	1039	1076
Hole U1362A	235		311	2296	825	861
Hole U1362B	532	311		2322	514	550
Hole 1027C	2199	2296	2322		2446	2458
Hole U1301B	1039	825	514	2446		36
Hole U1301A	1076	861	550	2458	36	

Table 4. Features surveyed with SM122 multibeam system during last day of science operations of AT18-07.

Location ID	Latitude	Longitude
Baby Bare	47°42.6'N	127°47.2'W
Mama Bare	47°50.0'N	127°45.0'W
Papa Bare	47°51.0'N	127°37.0'W
Zona Bare	48°11.0'N	127°33.0'W
Grizzly Bare	47°16.7'N	128°03.5'W
J52 (OBS site)	46°59.0'N	127°02.4'W
J53 (OBS site)	47°09.8'N	127°55.4'W

Notes: Way points for survey were positions so that ship crossed features once (most features) or twice (Zona Bare, Grizzly Bare) while moving on a straight track. OBS sites were surveyed to assist with an unrelated seismic monitoring program at the request of W. Wilcock (UW).

Table 5. Summary of *Jason* dive numbers, dates/times, dive locations, and Virtual Van image/event numbers.

Dive ID [a]	Date/Time start	Date/Time end	VV start [b]	VV end [b]	CORK(s) serviced [c]
J2-565-1	6/30/11 22:25	7/2/11 15:50	26	1530	1027C
J2-566-2	7/3/11 7:15	7/4/11 22:25	1532	2874	U1301B, U1301A
J2-567-3	7/5/11 15:10	7/6/11 3:01	2877	3209	U1362B, U1362A, 1026B
J2-568-4	7/6/11 15:05	7/6/11 23:42	3211	3307	1024C, 1025C
J2-569-5	7/8/11 15:01	7/9/11 7:01	3311	3954	U1362A, U1362B,
J2-570-6	7/9/11 19:11	7/9/11 23:07	3961	4014	1027C
J2-571-7	7/10/11 4:18	7/9/11 20:37	4016	4747	1026B, U1362A, U1362B,
J2-572-8	7/11/11 6:55	7/11/11 15:20	4748	4988	1027C
J2-573-9	7/12/11 3:03	7/13/11 0:29	4990	5917	U1301B, U1301A, U1362B, U1362A

[a] Dive ID in format J2-XXX-Y; XXX = *Jason* dive number, Y = sequential dive number during expedition AT18-07

[b] Virtual Van ID refers to events in the automated logging system. Numbers are approximate, corresponding to days/times listed

[c] CORKs serviced are listed in order of operations

Table 6. Summary of CORK data downloads during AT18-07.

CORK	Dive	Date/Time [a]	Data start [b]	Data end [b]	Interval	Filename
U1301B [c]	566	7/3/11, 10:06	6/20/10, 08:20	7/3/11, 09:13	1 minute	11p1301b_1.raw
U1301A [c]	566	7/3/11, 23:07	6/20/10, 09:54	7/3/11, 22:35	1 minute	11p1301a_1.raw
U1362B [c]	567	7/5/11, 19:23	8/22/10, 20:20	7/5/11, 19:08	1 minute	11p1362b_1.raw
U1362A	567	7/5/11, 22:29	8/10/10, 21:22	7/5/11, 22:04	1 minute	11p1362a_1.raw
1024C	568	7/6/11, 5:57	9/23/09, 23:00	7/6/13, 17:00	1 hour	11c1024j.raw
1025C [d]	568	7/7/11, 20:21	9/10/07, 18:34	7/7/11, 19:19	1 minute	11p1025c_1.raw
1027C [d]	570	7/10/11, 21:55	8/9/09, 22:00	7/10/11, 21:00	1 hour	11c1027i.raw
U1362A	571	7/10/11, 7:53	7/5/11, 22:48	7/10/11, 7:33	1 minute	11p1362a_2.raw
U1362B [c]	571	7/10/11, 9:25	7/5/11, 19:51	7/10/11, 9:08	1 minute	11p1362b_2.raw
1027C [c]	572	7/11/11, 12:16	6/29/11, 23:10	7/11/11, 11:57	1 minute	11p1027c_1.dat
U1362A [c]	573	7/12/11, 10:04	7/10/11, 7:58	7/12/11, 9:42	1 minute	11p1362a_3.raw

[a] all times GMT

[b] as reported in converted data file

[c] File contains hydrostatic check. Hydrostatic check for U1301A is difficult to see in data because CORK is not sealed. First hydrostatic check in Hole U1362B is very short and first two checks in Hole U1362A were not reported because data buffer was not fully filled prior to download. Final checks on Dives 571 and 573 are longer

[d] data logger downloaded in lab following recovery

Table 7. Summary of FLOCS/microbiology deployment and recovery during AT18-07, led by the USC team.

Dive ID	VV event [a]	CORK, position	D/R [b]	Type [c]	FLOCS ID
J2-566	1643	U1301B, left	R	P	FLOC2010-1-V4 (sleeves 1–4)
	1680	U1301B, right	R	P	FLOC2010-1-V6 (sleeves 5–8)
J2-566	1898	U1301A, right	R	P	FLOC2010-3-V3 (sleeves 1, 5, 4, 2, 3)
J2-566	2027	U1301A, left	D	P	Chambers 60, 45, 46, 47, 48
J2-567	3058	U1362A, upper #1	D	C	Chambers 55, 49, 62, 61, 73
J2-567	3158	1026B, center	R	P	FLOC2010-4-V5 (sleeves 1–5)
J2-569	3348	U1362A, lower #3	D	C	Chambers 57, 51, 67, 65, 71
J2-569	3435	U1362B, flowmeter	D	C	Chambers 56, 50, 64, 63, 72
J2-571	4040	1026B, right	D	P	Chambers 58, 52, 66, 70

[a] Virtual van event corresponding to photograph of system being recovered or deployed

[b] D = deployment, R = recovery

[c] P = plate (old style, placed directly on wellhead), C = crate (new style, connected with umbilical)

Table 8. Summary of fluid sample types and volumes collected at CORK wellheads using active sampling systems fielded by the University of Hawaii team during AT18-07.

Dive ID	Date	CORK	Type [a]	N [b]	Volume acquired (L) [c]
J2-566	7/4/11	U1301A	MVBS	6	89.4
J2-566	7/4/11	U1301A	LVBS	2	2.3
CTD	7/7/11	Near U1362B	CTD	8	60.5
J2-569	7/8/11	U1362B	Major	1	0.7
J2-571	7/10/11	U1362B	MVBS	6	86.3.6
J2-571	7/10/11	U1362B	LVBS	2	38.5
J2-573	7/12/11	U1362A	MVBS	6	85.2
J2-573	7/12/11	U1362A	Major	2	1.4

[a] MVBS = Medium Volume Bag Sampler, LVBS = Large Volume Bag Sampler, Major = Titanium Major Sampler

[b] Number of discrete samples acquired in individual sample containers (many samples subsequently split for multiple purposes)

[c] Product of N x (sample volume per container)

Table 9. Summary of real-time video webcasts completed as part of the Education, Outreach, and Communication Program during AT18-07.

Date	Venue	Location	Audience	Shore participants
6/29/11	St. Joseph's Elementary Summer School	Alameda, CA	K-8 students	50
6/30/11	North Museum	Lancaster, PA	Museum public	20
7/1/11	Hui-Wen High School	Taichung, Taiwan	9th grade	15
7/5/2011	NASSA	Ava, New York	Middle school science club	15
7/6/2011	North Museum	Lancaster, PA	Museum public	20
7/6/2011	Seymour Center	Santa Cruz, PA	Museum public	20
7/7/2011	Pennington Marine Science Center	Avalon, CA	Middle school boy scouts	30
7/8/2011	Smokey Hill High School	Denver, CO	High school students	15
7/11/11	Science Explorers Club	Lancaster, PA	Ages 7-11	20
7/11/2011	Pacific Science Center	Seattle, WA	4-6th graders	25
7/12/2011	Global Environmental Microbiology Summer Course	University of Southern California, Los Angeles, CA	College freshmen	20
7/13/2011	National Museum of Natural History, Smithsonian	Washington, DC	Museum public	25
7/13/2011	Pacific Science Center	Seattle, WA	6-8th graders	25

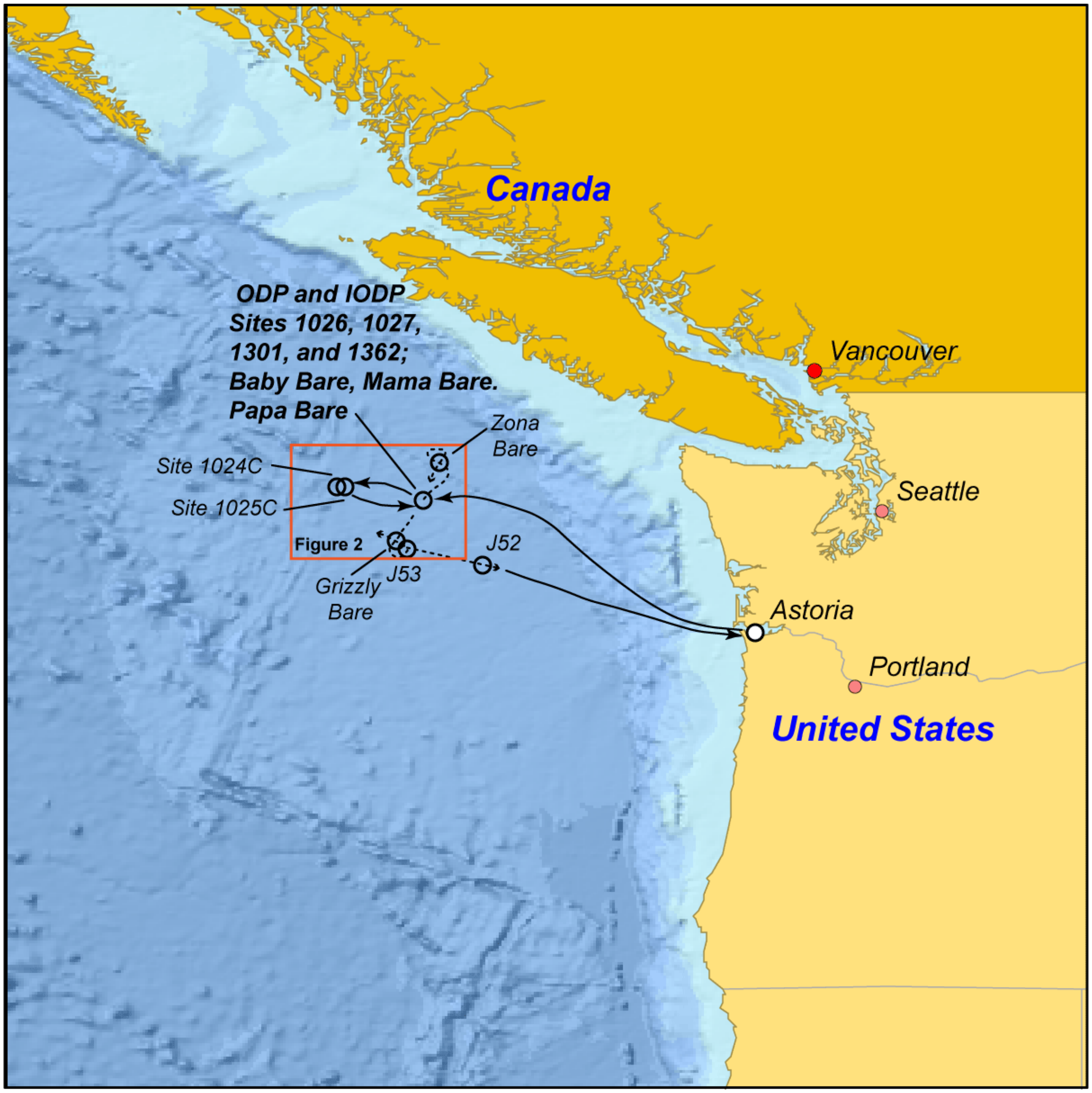


Figure 1. Overview of cruise track for AT18-07 expedition with R/V *Atlantis*/ROV *Jason* in Summer 2011. Initial and final port was Astoria OR. Primary ship track is shown with solid line. Most expedition activities focused on sites where long-term, subseafloor observatory systems (CORKs) were installed as part of Ocean Drilling Program and Integrated Ocean Drilling Program expeditions. Dashed line indicates general track of multibeam survey completed at end of expedition. Red box indicates area of **Figure 2**, showing primary work sites in greater detail.

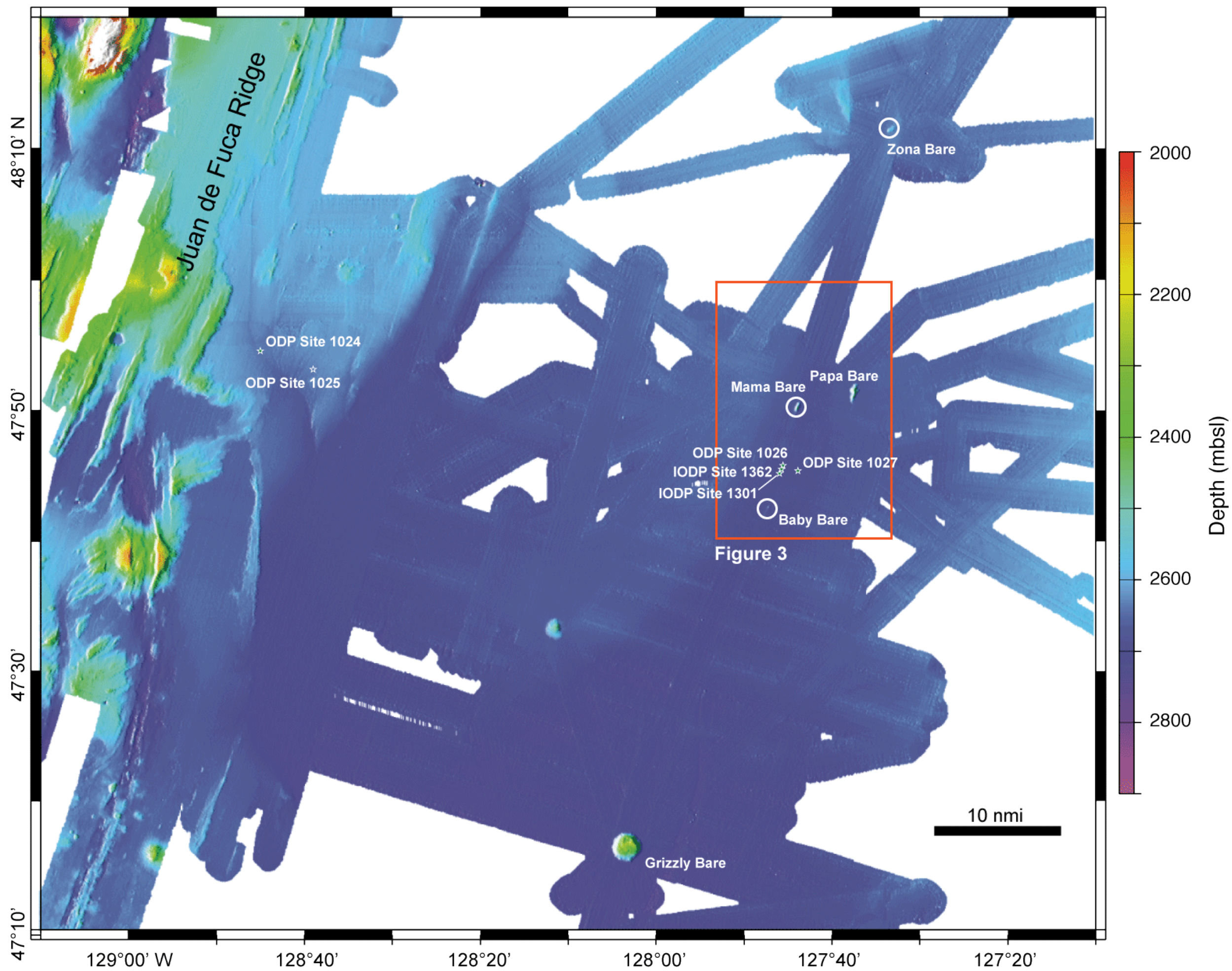


Figure 2. Bathymetric map showing work area for AT18-07. The work sites for most CORK servicing are located within the red box (shown in greater detail in **Figure 3**). Additional CORK Sites 1024 and 1025 are located closer to the Juan de Fuca Ridge, to the west. All sites are location east of the Juan de Fuca Ridge, where volcanic rocks are covered by relatively thick accumulations of marine sediments. Also shown on this map are locations where volcanic rock outcrops penetrate sediment and are exposed at the seafloor. Several of these features were cleared as secondary work sites prior to AT18-07, but no dive work was completed in these locations. They were surveyed by multibeam at the end of the expedition (**Table 4**).

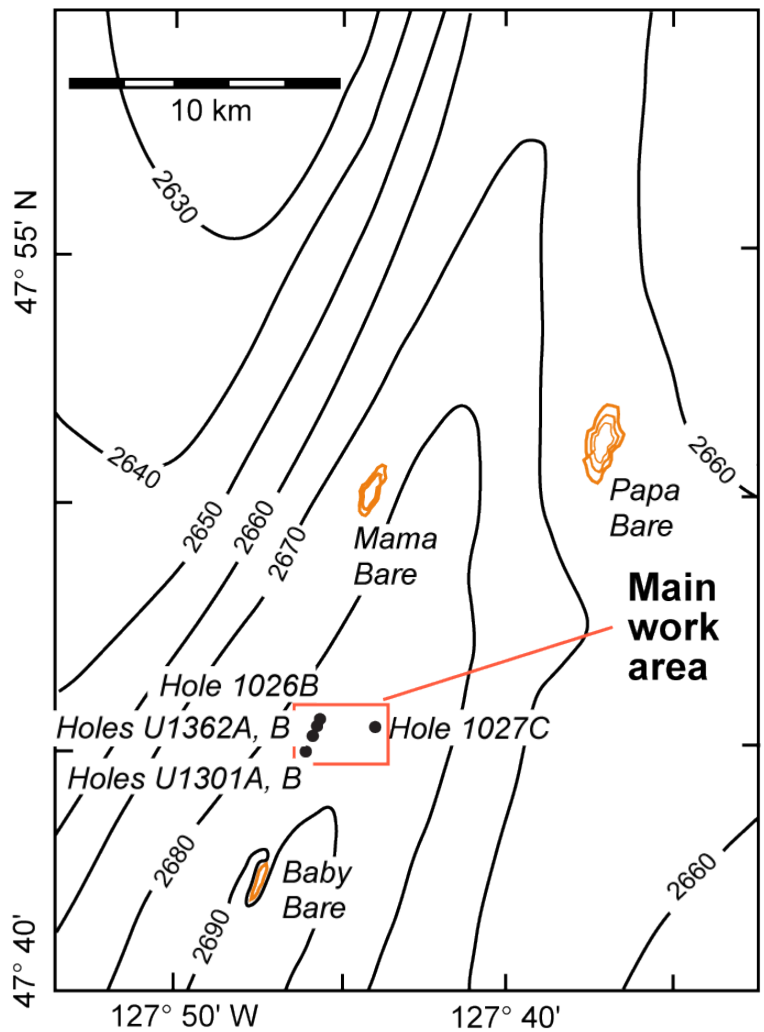


Figure 3. Detailed contour chart showing primary work area for proposals OCE-1031808 and MCB-0604014 during AT18-07. All of these work sites are located within a few kilometers of each other, where the seafloor is relatively flat and comprises thick marine sediments over basement volcanic rocks. Gold contours show locations of small volcanic rock outcrops, as labeled. Two additional CORK sites are located to the west (**Figure 2**).

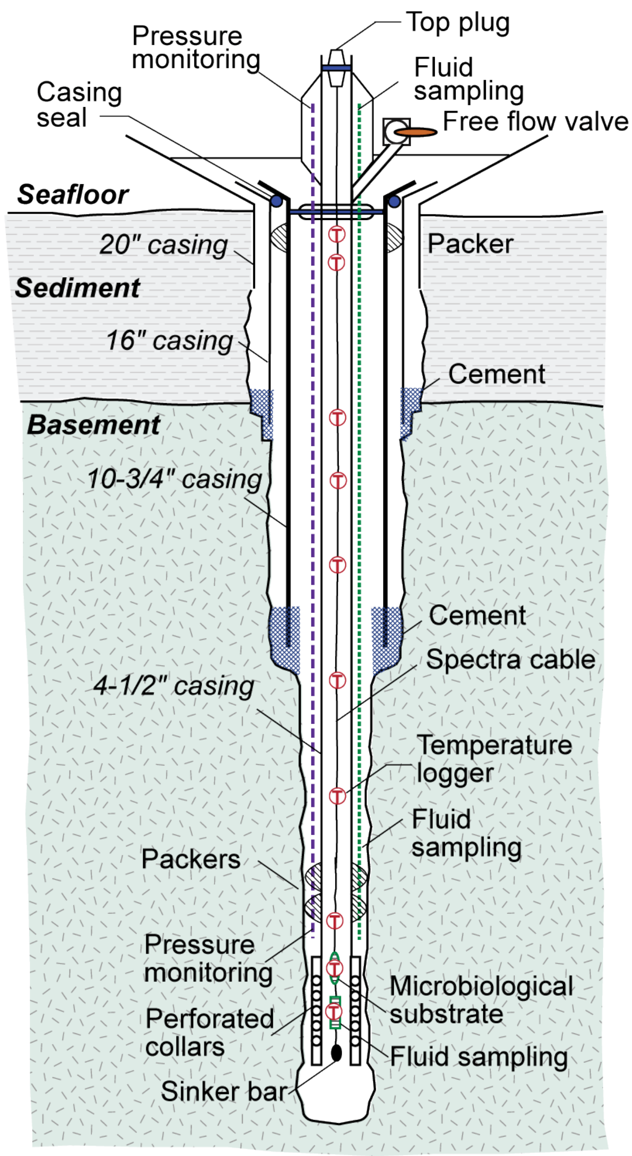


Figure 4. Cartoon showing features of CORK systems deployed during IODP Expedition 327. Earlier CORKs have some of these characteristics, but Exp. 327 CORKs have additional features including: perforated and coated drill collars and casing at depth, two kinds of CORK and casing packers (inflatable and swellable), a casing seal between 10-3/4 inch and 16 inch casing strings, a tapered gravity plug for a top seal, and a free flow valve in the L-CORK wellhead. Additional features that Exp. 327 CORKs have in common with the last generation of CORKs deployed on IODP Expedition 301 include: main CORK seal in the throat of the reentry cone within 10¾ inch casing, primary CORK casing diameter of 4½ inches, up to eight fluid, microbiological, and pressure sampling lines, with ports and screens at various depths, and a mixture of fluid and microbiological sampling systems suspended on Spectra cable at depth. Temperatures are recorded with autonomous sensor and logging instruments incorporated into the fluid and microbiological samplers or hung independently from the Spectra cable. The CORK in Hole 1027C is from an earlier generation and lacks casing that extends into basement.

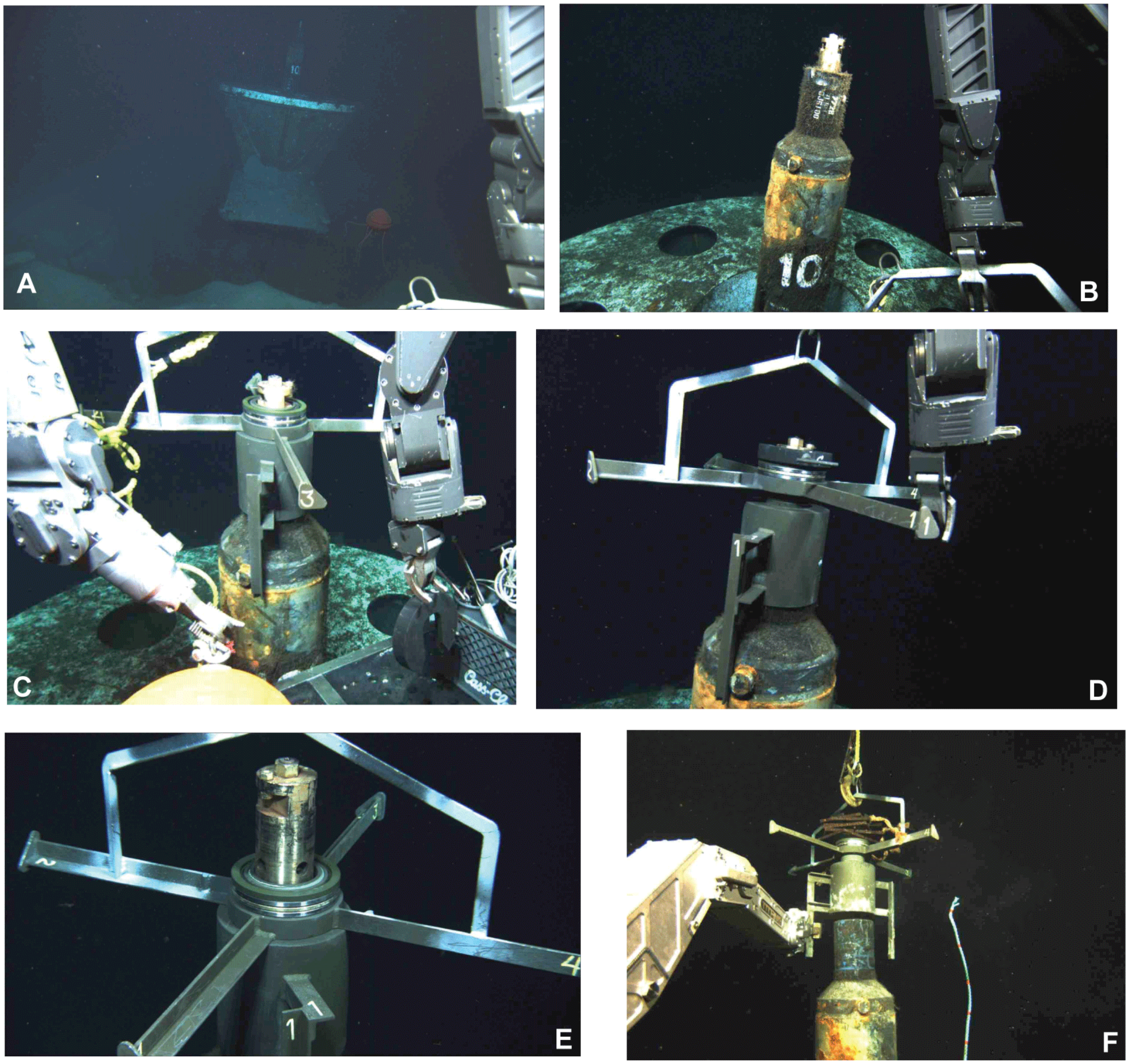


Figure 5. Images of CORK in Hole 1027 during dive 565, first dive of AT18-07. A. Initial approach to CORK. Note large hole below mud skirt of CORK, and angle of CORK relative to vertical (~5 or 10°, camera is also a bit tilted). B. Initial appearance of brass electrical connector extending from top of CORK, before recovery attempt. C. Top Hat Extraction Tool (THET) placed over wellhead, with connector extending through. D. Cleat in place, arms of THET being rotated by *Jason*, connector being lifted upward. E. Connector after several rounds of lifting with cleat and spacer, this is as high as the connector could be raised with these parts. F. *Alvin* weights modified for use as spacers, electrical connector is additionally elevated. Note also that THET is being lifted by *Jason* and is virtually clear of the wellhead, but this is as high as we were able to lift given weight of THET, weights, connector, and data logger (latter not visible, inside CORK wellhead).

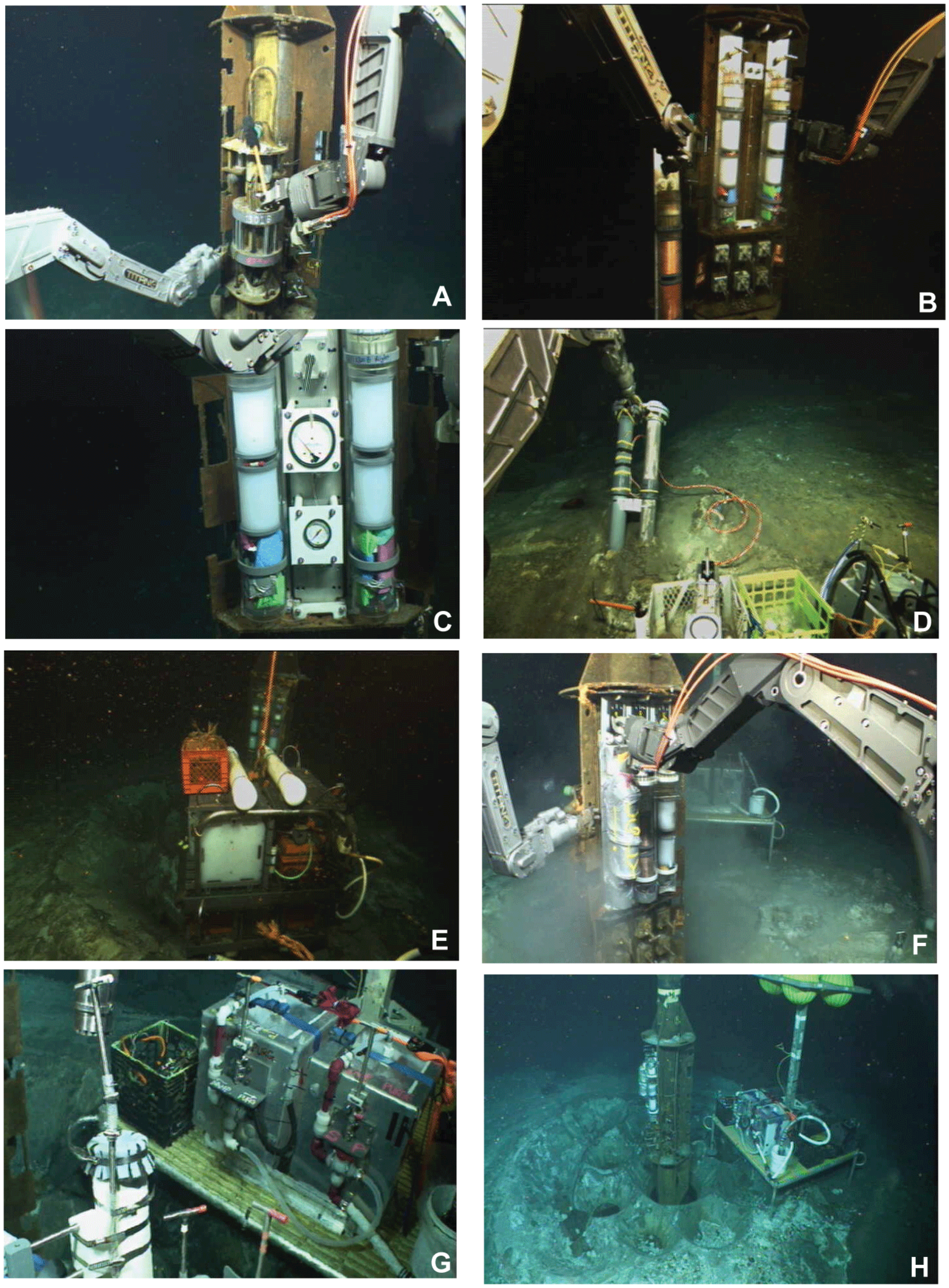
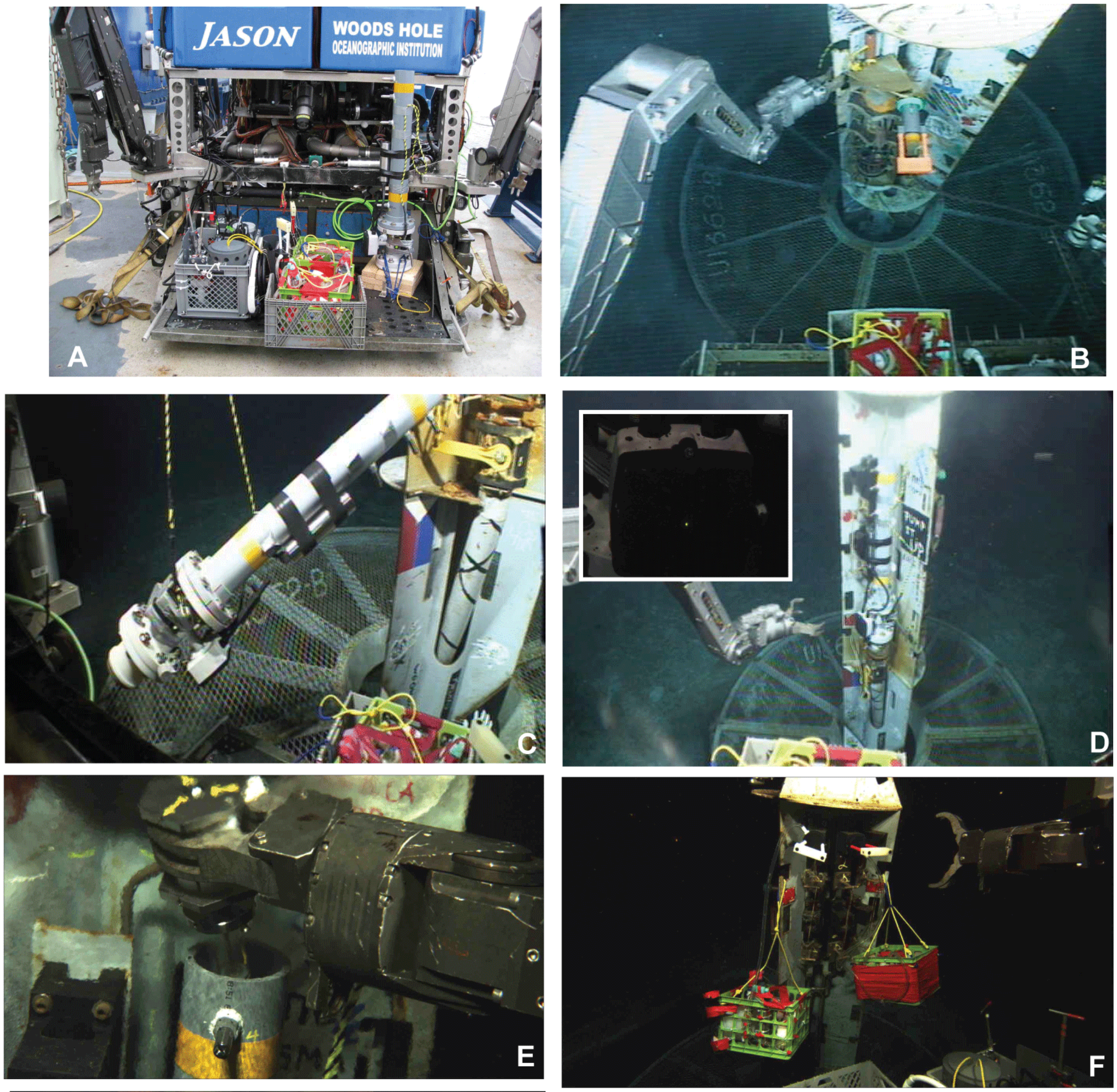


Figure 6. Images from Dive 566 to Holes U1301B and U1301A. A. Cleaning ODI connected on pressure logger at U1301B. B. Recovering center (copper coil) OsmoSampler from Hole U1301B. C. Testing pressure in OsmoSampler lines on U1301B, between two FLOCs OsmoSamplers deployed in Summer 2010. D. Placing experimental "Fast sampler" on seafloor near U1301B. E. GeoMICROBE sled as deployed on approach to U1301A, subsequently recovered. F. Installing new OsmoSamplers on U1301A. G. Running Large Volume Bag Sampler (LVBS) on elevator adjacent to U1301A. Note gas-tight sampler being deployed to left of LVBS. H. View of CORK and area around Hole U1301A just before release of elevator with LVBS.



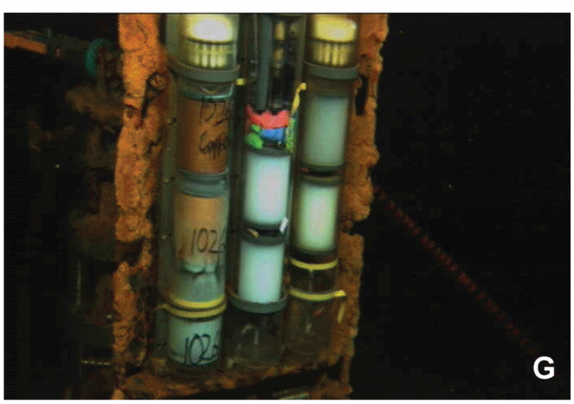


Figure 7. Images from Dive 567. A. *Jason-II* basket prior to dive, showing fluid sampling tools (left), new OsmoSampler crates (center), and flowmeter (right). B. Downloading pressure data from Hole U1362B. C. Lifting flowmeter from basket at U1362B. D. Shimmering water exiting flowmeter at top (inset shows LED

E. Squeeze sampler deployed at exit to flowmeter chimney at U1362B. Upper temperature logger is visable near top of chimney. F. OsmoSampler crates hung on wellhead at U1362A. Old OsmoSamplers prior to recovery at 1026B (left to right: copper, FLOCS, Teflon).

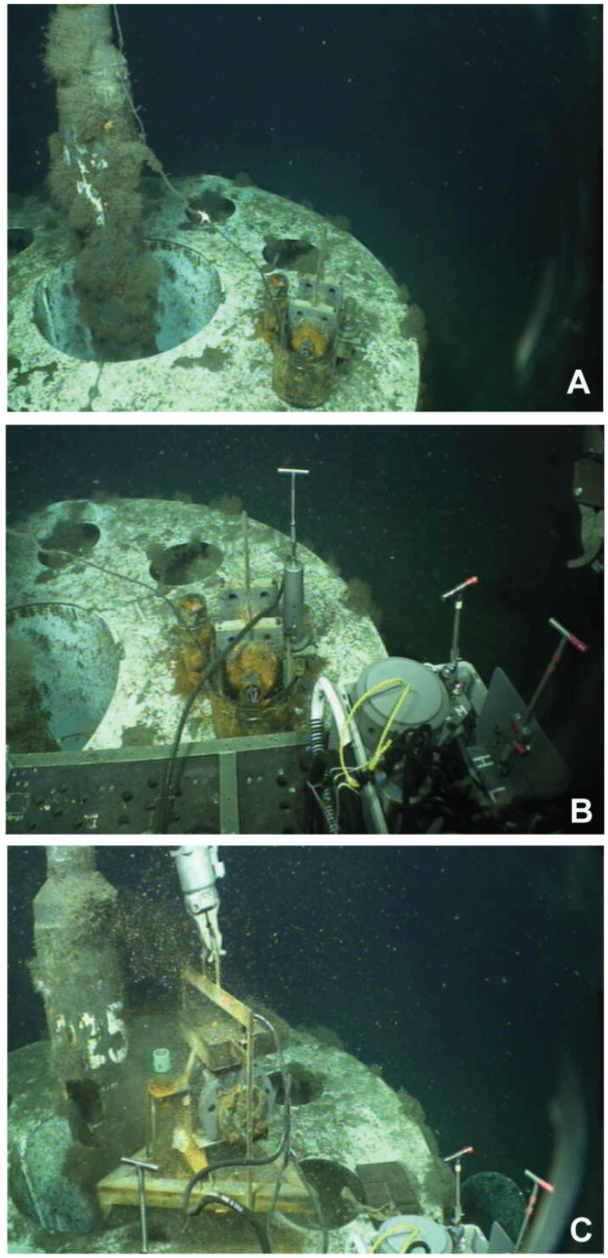


Figure 8. Images from Dive 568. A. Approaching Hole 1024C, data logger on wellhead (with cable to old-style logger and gauge on top of wellhead). B. Seacon connector attached to logger at Hole 1024C, downloading data. C. Retrieving data logger from platform on CORK at Hole 1025C.

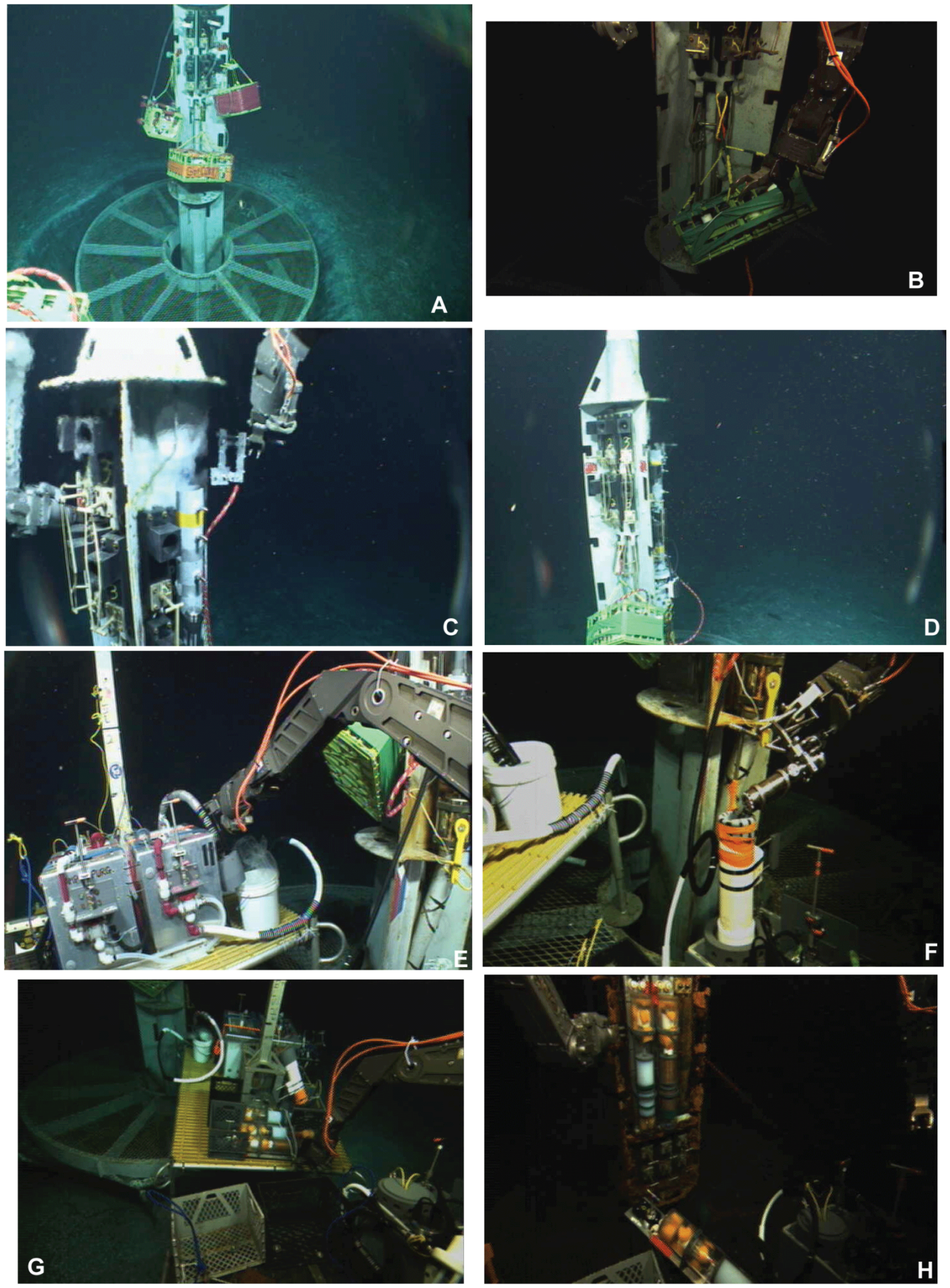


Figure 9. Images from Dive 569. A. View of CORK in Hole U1362A after attaching a third OsmoSampler crate (two others were attached on Dive 567) and opening valves to allow water to flow. B. Hanging OsmoSampler crate from wellhead in Hole U1362B. C. Attaching inlet to umbilical ("UmbiloSnork") at top of chimney connected to flowmeter in Hole U1362B. D. View of CORK in Hole U1362B showing OsmoSampler crate and umbilical leading to flowmeter in adjacent bay. E. Picking up manifold inlet for Large Volume Bag Sampler (LVBS) positioned on elevator adjacent to Hole U1362B. F. Placing gas tight sampler inlet in gas trap connected to LVBS. G. Lifting OsmoSamplers intended for CORK in Hole 1026B from elevator. H. Two new OsmoSamplers placed on CORK in Hole 1026B. Third OsmoSampler (FLOCS) could not be installed during this dive, but was deployed later.

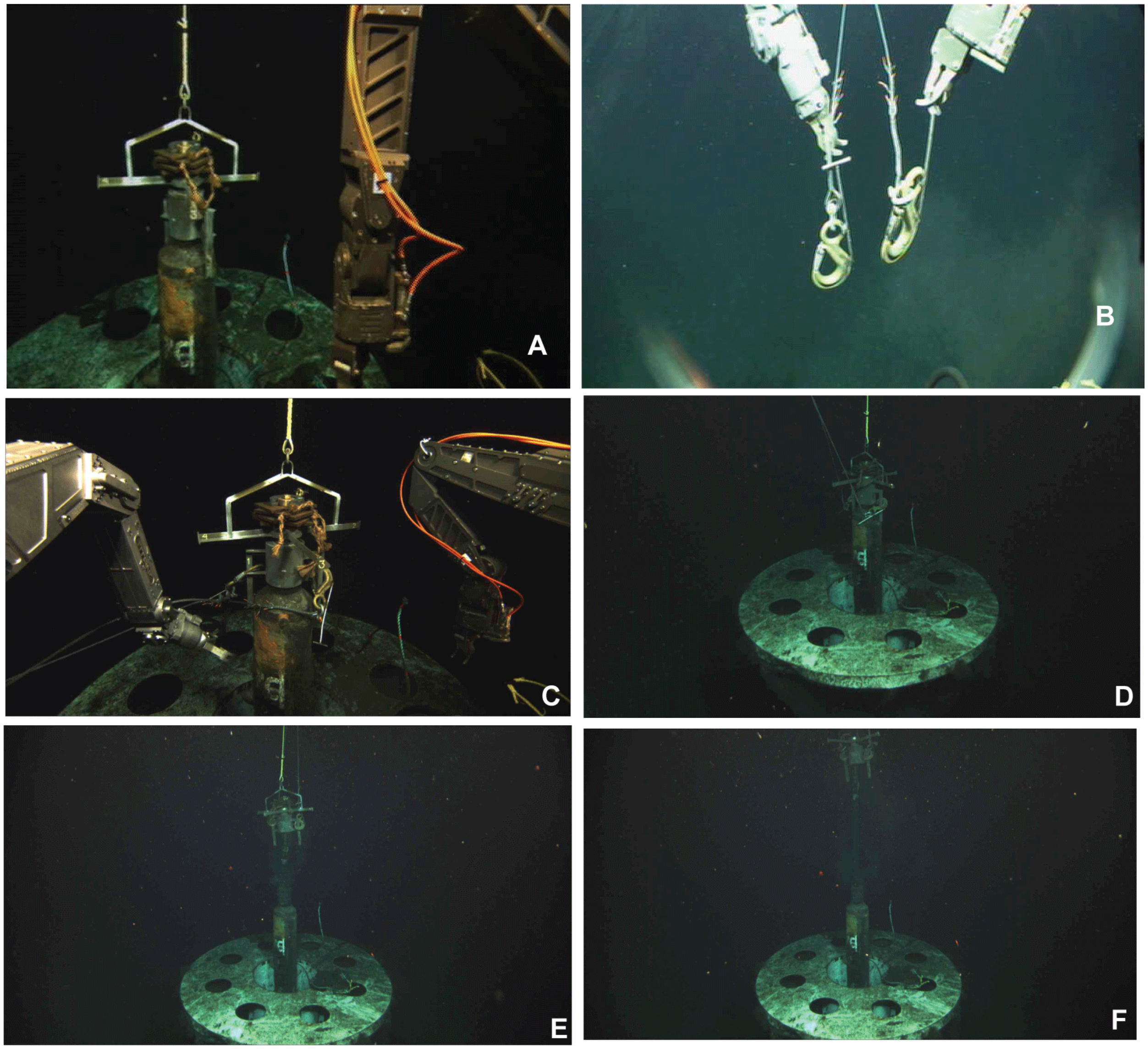


Figure 10. Images from Dive 570 at Hole 1027C. A. View of Hole 1027C CORK upon arrival of *Jason*, with Top Hat Extraction Tool (THET) attached to brass connector on the top of the wellhead. *Alvin* weights modified for service as spacers below a cleat are clearly visable. B. Large snap hooks hung on a Spectra harness below the *Jason* control and power vehicle, *Medea*. C. Snap hooks are attached to arms on the sides of the THET, where we thought the tool would have sufficient strength to handle several thousand pounds of lift. D. Harness being tensioned as *Medea* is pulled with the winch on *Atlantis*. E. With only a few hundred pounds in excess of its weight, the THET, brass connector, *Alvin* weights, and the old 1027C data logger are lifted from the wellhead. F. Virtually the entire logger is exposed. The THET is barely visable at the top of this image. All components were subsequently recovered on *Atlantis.*

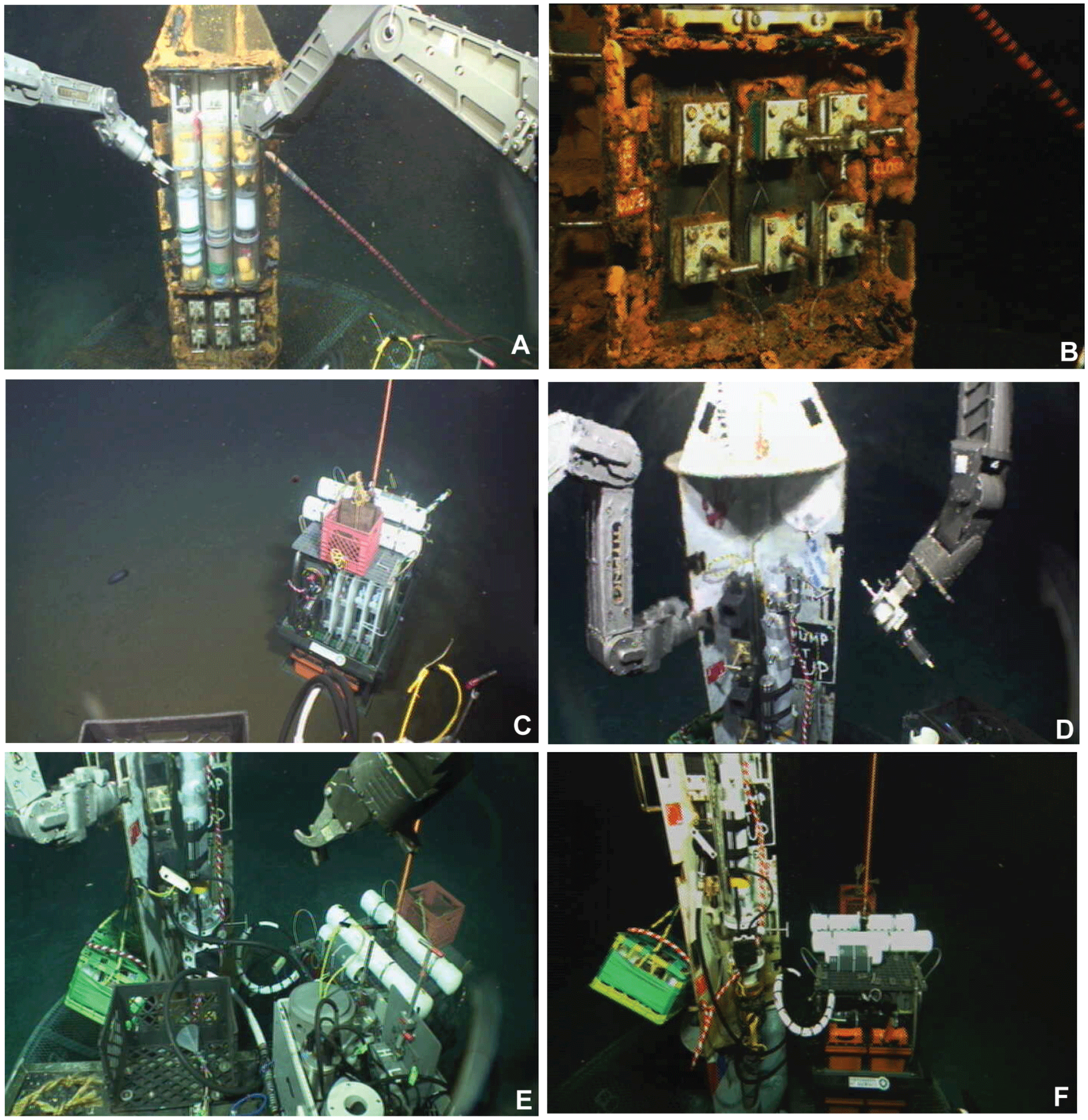


Figure 11. Images from Dive 571 at Holes 1026B and U1362B. Additional work was also completed at Hole U1362A during this dive. A. Connecting the third OsmoSampler (FLOCS) on Hole 1026B. B. Final configuration of valves at Hole 1026B. C. Configuration of GeoMICROBE sled on seafloor following elevator deployment. D. Lifting a squeeze sampler to discharing flowmeter chimney on Hole U1362B. E. Manipulation of valves and pump componets during fluid sampling and electrochemical measurements on Hole U1362B. F. Final configuration of GeoMICROBE sled on Hole U1362B, with adapter for umbilical connected to lower most fitting. OsmoSampler crate visable to left, is sampling from top of flowmeter chimney.

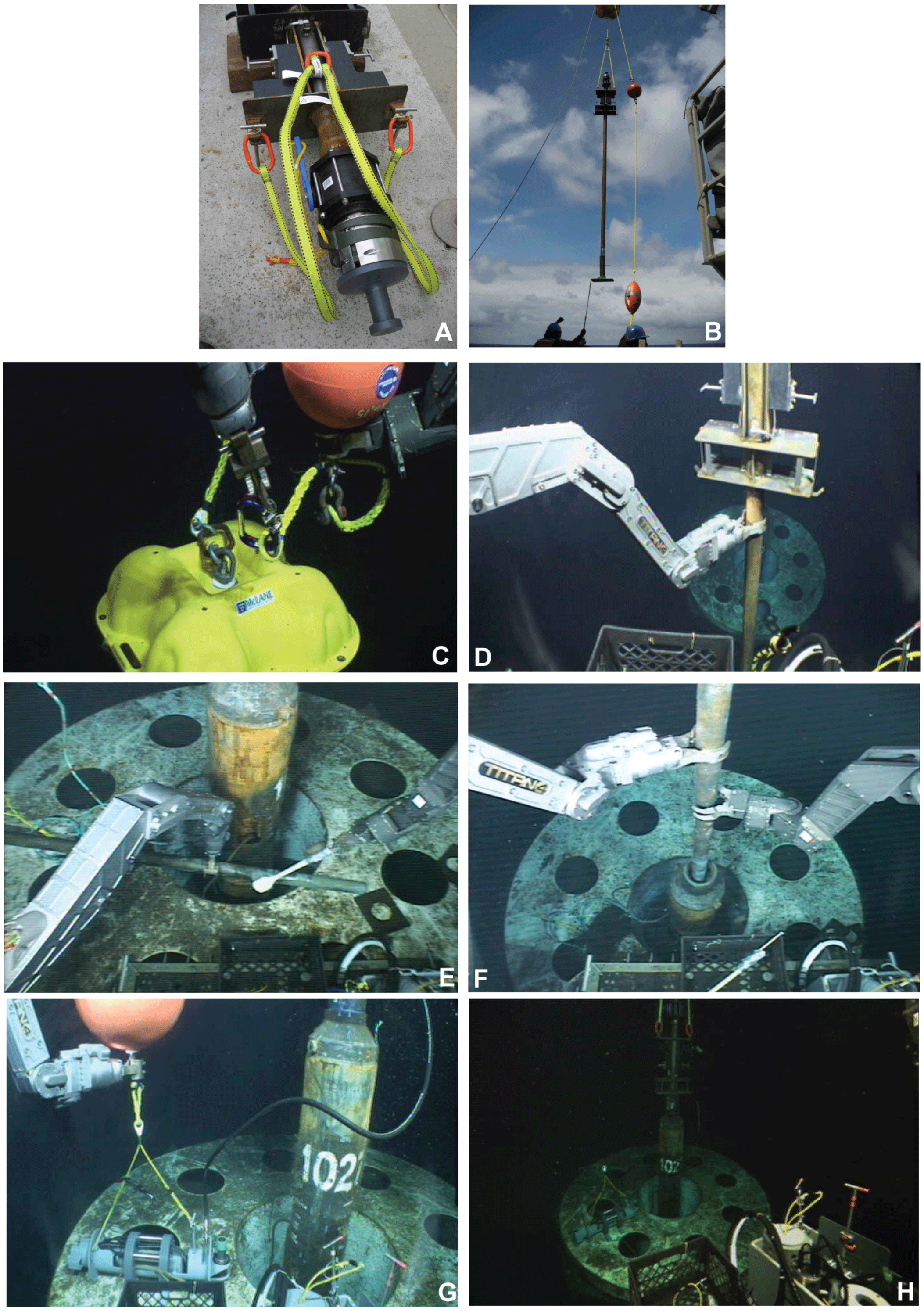


Figure 12. A. Manifold Insert (MI) for CORK in Hole 1027C as configured on deck at start of AT18-07. B. MI being hoisted over side prior to first dive of expedition, with deployment boot, drop weights, and floatation. C. Adding floatation during Dive 572. D. Lifting MI and carrying to wellhead. E. Cleaning o-rings prior to insertion. F. Inserting MI into CORK in Hole 1027C. G. Data logger on platform with umbilical leading up to valve near top of MI. H. Final configuration of Hole 1027C, just before releasing harness by pulling T-pins.

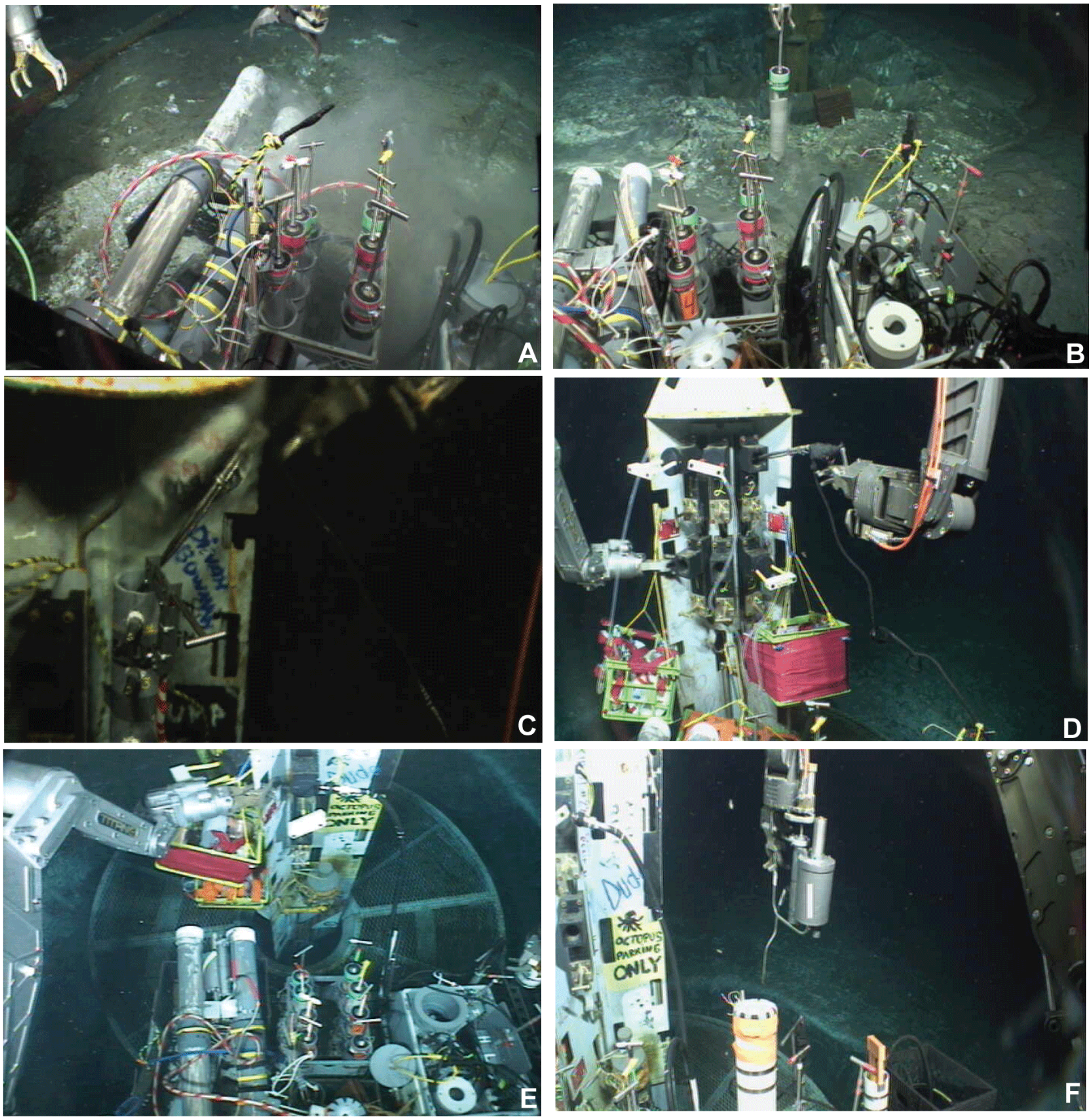


Figure 13. Operations during Dive 573, final dive of AT18-07. A. Fast sampler being recovered from seafloor near Hole U1301B. B. Push cores being collected near Hole U1301A. C. Checking fluid discharge temperature at flowmeter exit, top of chimney. D. Measuring fluid temperature exiting OsmoSampler valve. E. Collecting fluid samples with Medium Volume Bag Sampler. F. Collecting fluids from gas trap using Major Sampler.

Figure 14. Deployment of FLOCS microbiology growth substrate during AT18-07. A. "Ugly" FLOCS system being installed on wellhead at Hole U1301A. B. New style FLOCS crate assembled in the lab for deployment to monitor shallow interval from Hole U1362A. C. Shallow FLOCS crate on left of wellhead, deep FLOCS crate hanging in center. Right image shows deep crate in lab prior to deployment. D. FLOCS crate hanging from wellhead in Hole U1362B, with umbilical leading to flowmeter bay. Right image shows crate in lab prior to deployment.

Appendix A. Expedition AT18-07 Participants

Table 1. Science and EOC Specialists

Name	Affiliation	email
Ausejo (Robador), Alberto	UH	arobador@hawaii.edu
Becker, Keir	UMiami	kbecker@rsmas.miami.edu
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Cooper, Sharon	CoL	scooper@oceanleadership.org
Cowen, James	UH	jcowen@soest.hawaii.edu
Edwards, Katrina	USC	kje@usc.edu
Fisher, Andrew	UCSC	afisher@ucsc.edu
Glazer, Brian	UH	glazer@hawaii.edu
Gross, Andrew	UAF	grossa@usc.edu
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Hseih, Chih-Chiang (Oliver)	UH	oliver.hakka@gmail.com
Hulme, Sam	UAF	samiam0101@gmail.com
Inderbitzen, Katie	UMiami	kinderbitzen@rsmas.miami.edu
Jungbluth, Sean	UH	seanpj@hawaii.edu
Kane, Jackie	CoL	jackie.kane@gmail.com
Lin, Huie-Ting (Tina)	UH	hueiting@hawaii.edu
Orcutt, Beth	USC	beth.orcutt@biology.au.dk
Ramirez, Gus	USC	bassiousmaximus@hotmail.com
Ringlein, Jim	CoL	jringlein@northmuseum.org
Slovacek, Amalia	UCSC	aslovace@ucsc.edu
Strong, Lisa	UCSC	lisa@strongmountain.com
Wheat, C. Geoffrey	UAF	wheat@mbari.org

Table 2. Atlantis Officers, Crew and Technicians

Name	Position
Lunt, Al	Captain
Crane, Mitzi	First mate
Dickson, Craig	Second mate
Biddle, Amy	Third mate
Brennan, James	ComET
Bailey, Wayne	Bos'n
Popowitz, Ed (Catfish)	AB
Wills, Lance	AB
Whims, Ronnie	OS
Arthur, Robert	AB
Little, Jeff	Chief engineer
Vieira, Marcel	First asst. engineer
Lavache, Jean	Second asst. engineer
Walsh, J.T.	Third asst. engineer
Stairs, Richargd	Oiler
Taylor, Alex	Oiler
Standfill, Reese	Wiper
Jackson, Larry	Steward
Nossiter, Mark	Cook
Hall, Cecile	Mess attendant
Sims, David	SSSG
Heater, Allison	SSSG

Table 3. *Jason* Group

Name	Position
Collasius, Alberto (Tito)	Expedition leader, pilot
Hansen, Scott	Pilot
Hood, Jeff	UAF
Verhein, Korey	Technician, navigator
Agee, Casey	Technician, navigator
Miller, Jonathan	Technician, navigator
Hutchinson, Baxter	Technician, navigator
Work, Jonathan	Technician, navigator
Scott, Dara	Pilot
Pelowski, James	Technician, IT specialist