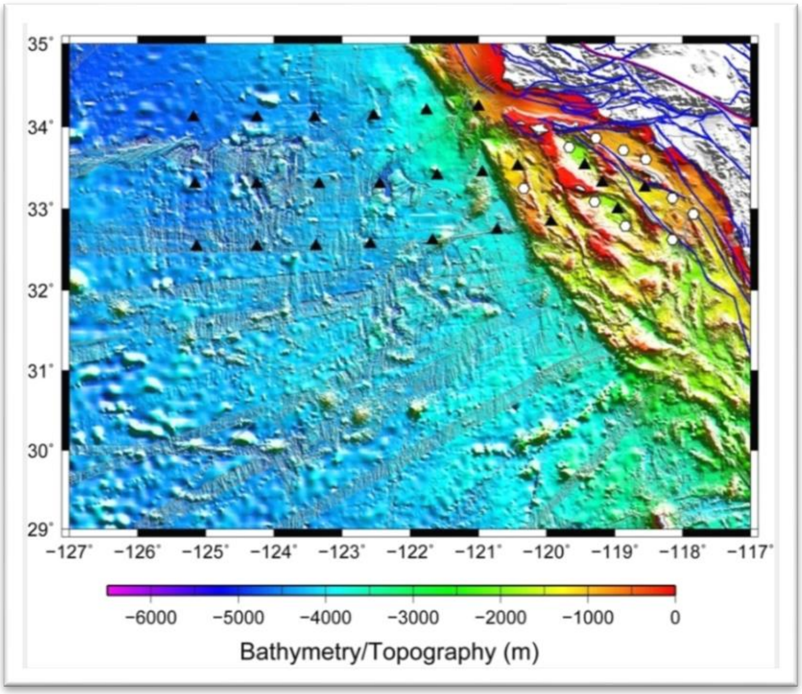
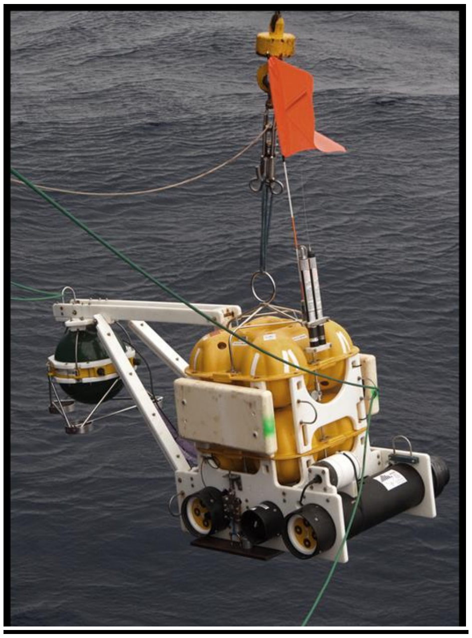
R/V Melville Cruise MV1010
August 14-27, 2010

ALBACORE OBS Deployment Cruise Report





(Version: September 5, 2012)

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Ship's Crew

Christopher Curl	Master
Chris Hammond	1st Officer
Brennan Grout	2nd Officer
Chris Sheridan	3rd Officer
Edward Keenan	Boatswain
Cletus Finnell	Able Seaman
Kent Ingalls	Able Seaman
Sandor Vinkovits	OS (Ordinary Seaman)
Paul Shute	OS (Ordinary Seaman)
Robert Seeley	Sr. Cook
Oscar Buan	Cook
Dave Seltzer	Chief Engineer
Pat Fitzgerald	1st Assistant Engineer
Warren Bruce Prine	2nd Assistant Engineer
Richie Boyce	3rd Assistant Engineer
John Boing	Electrician
Joey Ramos	Oiler
Philip Hogan	Oiler
William Brown	Oiler
Matthew Slater	Oiler
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A. Introduction

The primary goal of the 2010 ALBACORE (Asthenospheric and Lithospheric Broadband Architecture from the California Offshore Region Experiment) cruise was to deploy 34 ocean bottom seismometers (OBSs) in a 150 km (north-south) by 400 km (east-west) region off the coast of Southern California (Fig. 1). The cruise took place on R/V Melville, departing out of San Diego on August 14, 2010 and arriving back in San Diego on August 27, 2001 with no port stops in between.

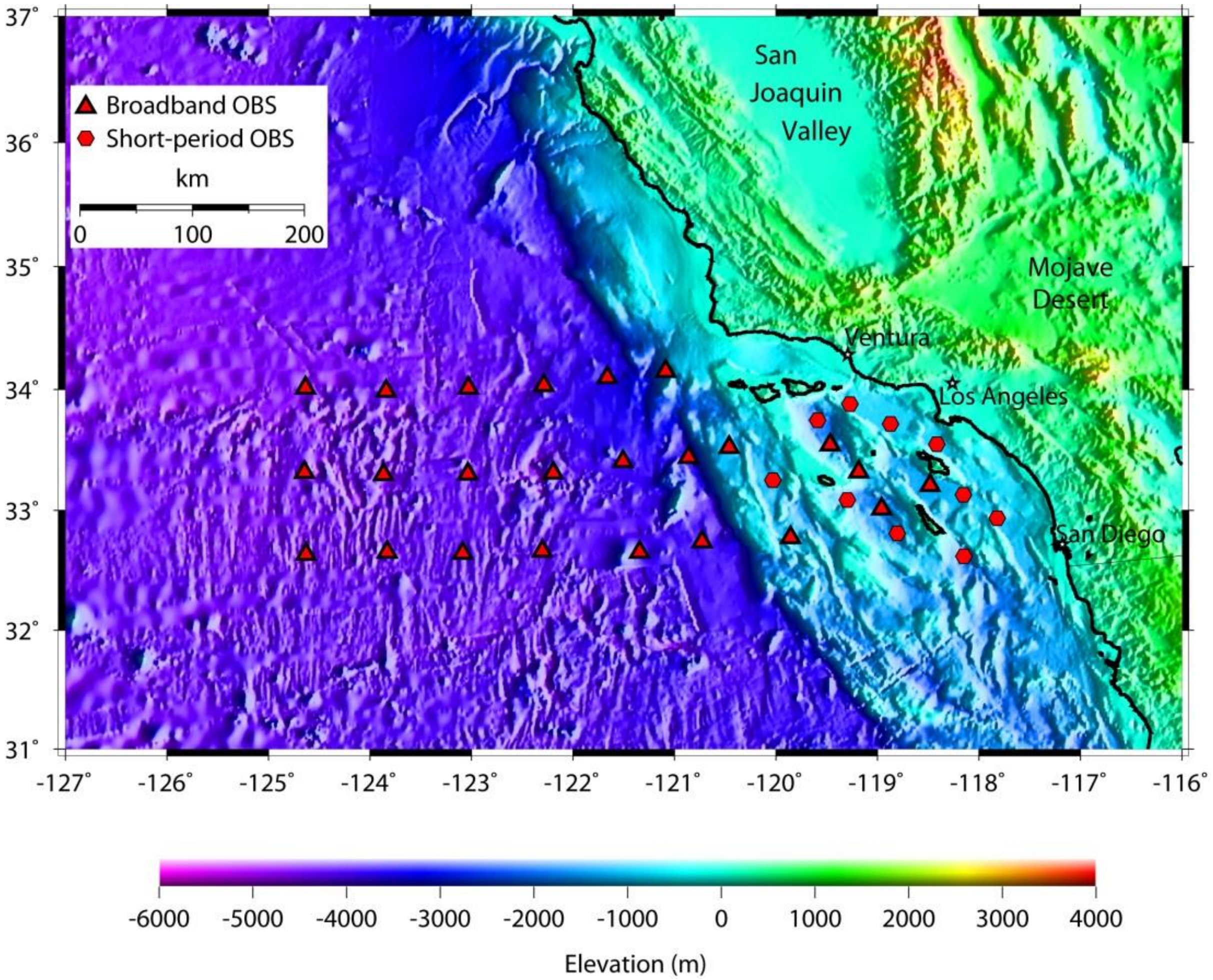


Figure 1. ALBACORE ocean bottom seismometer locations.

Scientific Motivation

The overall objective of the ALBACORE project is to understand the tectonic interaction at the Pacific-North America plate boundary by identifying the physical properties and deformation styles of the Pacific plate and transition to continental lithosphere. The results will be used to distinguish among contrasting upper mantle geodynamic scenarios that predict large-scale mantle flow patterns beneath western North America. Seismic studies using broadband ocean bottom seismometer (OBS) data will characterize the driving plate motion consequences of collision between the rift system, a fragmented subducted plate, the geometry of the San Andreas transform fault system, and block rotations. The boundaries for the seismic array overlap the region of complex breakup and fracture of the Pacific plate nearshore where several microplates are observed. The array extends far to the west to provide comparison with oceanic lithosphere that is not fractured.

Studies using seismic anisotropy and plate motion GPS data in western North America infer SW-NE plate motion over uniformly EW mantle flow. Some predict eastward passive drag with little or no mechanical coupling between lithosphere and asthenosphere, while others predict westward active drag. In addition, studies based on compilations of plate velocity and anisotropy results suggest that toroidal flow occurs in the asthenosphere beneath much of the western U.S. to accommodate mantle flow around the subducted Juan de Fuca plate. If this is the case, then toroidal mantle motions also occur below the Pacific-North American plate boundary in southern California. If coupling with the lithosphere is occurring, this could be contributing significant driving forces for plate motions and fault loading. These different scenarios have implications for whether lithospheric deformation occurs passively with little or no mechanical coupling with the deep mantle, or actively with the primary source of plate motion coming from the deep mantle.

A combined study of azimuthal and polarization anisotropy from dispersive Rayleigh wave and SKS splitting studies recorded on the OBSs will distinguish the lithospheric and asthenospheric components of anisotropy from which to infer lithospheric-asthenospheric coupling. If splitting reflects the shear strain field related to deeper mantle flow, possibly only weakly coupled to surface plate motions across the plate boundary, no change in fast directions or amplitude would be expected in and west of the southern California Borderland.

The widely observed uppermost mantle high-velocity anomaly beneath the Transverse Ranges exhibits an apparent rotation with decreasing depth in the uppermost mantle. The western boundary of the Transverse Ranges high-velocity anomaly appears to terminate at the coastline, but its western lateral extent is not imaged due to lack of offshore data. The high-velocity seismic anomaly and adjacent low-velocity anomalies may be the result of asthenospheric flow processes such as small-scale upwellings and downwellings. A tomographic study using onshore and offshore seismic stations, with sufficiently long-period data, will provide estimates of lithospheric thickness across this plate boundary to test these various model predictions.

The recorded local earthquake data will be used to map offshore fault and seismicity features, and to compile phase arrival times for crustal velocity modeling. The local offshore seismicity recorded by the OBS array is expected to produce a more accurate offshore hypocenter catalog which will be examined for seismicity. Unresolved features of offshore earthquakes are that offshore hypocenters do not always closely correlate with mapped fault locations indicating either the existence of unmapped faults or errors that are too large in the hypocenters to associate them with mapped faults, local magnitudes are almost always smaller than moment magnitudes, and aftershock sequences are smaller than those of onshore earthquakes, suggesting differences in strain release styles and geometries between onshore and offshore faults. Wherever possible, focal mechanisms will be computed for the offshore earthquakes. Of additional interest are tsunami implications from reverse/thrust faulting mechanisms. Focal mechanism analysis will help identify the potential for faulting necessary in evaluating the tsunami risk.

The secondary purpose of the cruise was to collect underway gravity, magnetic, multibeam bathymetry, and echosounder sedimentary profile data. Initially we expected that bathymetry would be used only to assess each deployment area prior to dropping the OBS. Because the OBS deployments were carried out much faster than scheduled, additional routes were added specifically to collect new multibeam bathymetry data (Fig. 2). The additional bathymetry surveys involved mapping complex seafloor features on oceanic Pacific Plate around the deep-water stations, as well as mapping fault and fault-related seafloor features in the Continental Borderland.

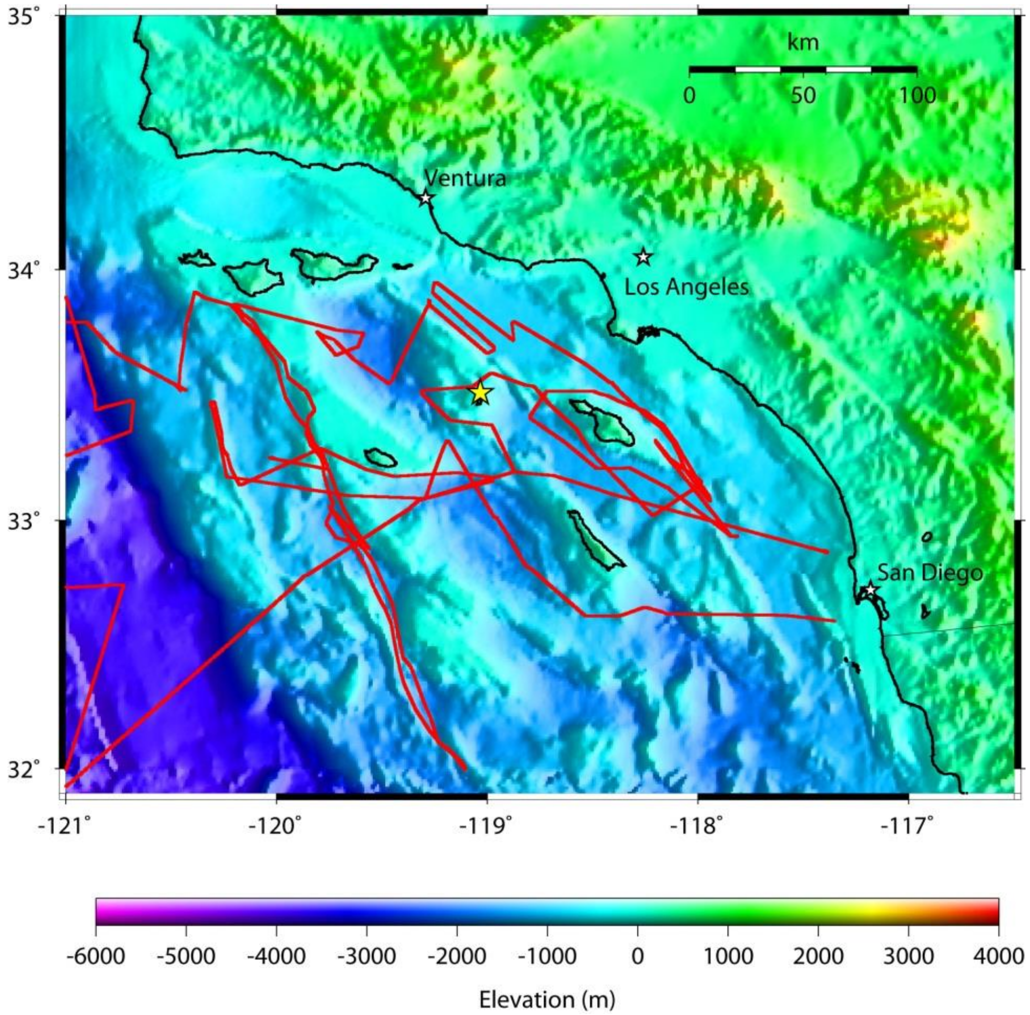


Figure 2. Track lines (red) showing where multibeam bathymetry data were collected in the Inner and Outer Borderland during the 2010 R/V Melville cruise. Yellow star shows location of August 24, 2010 M_L=4.0 earthquake. ETOPO1 topography-bathymetry.

For the multibeam bathymetry mapping, we targeted sections of four major fault systems for their active seismicity, large lateral extent, geometric complexity, tsunamigenic potential, and lack of detailed bathymetry data:

1) San Clemente fault system within the Inner Borderland focusing on two significant strike-slip triple junctions where the San Clemente, San Diego Trough, Catalina, Santa Cruz-Catalina Ridge, and San Pedro Basin faults merge or intersect; the San Clemente fault system is the largest and most seismogenic within the Borderland, which produced the August 24, 2010, M_L=4.0 earthquake near Santa Barbara Island at the northern triple junction;
2) Ferrelo fault system along its entire extent in U.S. waters, which represents one of the largest active fault structures in the Outer Borderland; three major fault sections of the Ferrelo fault system were covered by new data from this cruise;

3) East Santa Cruz Basin fault system (ESCB) in the complex area where the San Nicolas Island escarpment intersects from the west; the ESCB is the major structural boundary between the Inner Borderland Rift and Nicolas forearc terrane of the Outer Borderland;
4) San Nicolas Island escarpment that represents a major transverse structure and possible segmentation boundary between the ESCB and Ferrelo fault zones.

In addition, we obtained data along the NS-trending Patton Ridge fault zone that defines the structural boundary between the subduction complex of the Patton terrane and the forearc rocks of the Nicolas terrane of the Outer Borderland.

Deployment and instrumentation logistics

The OBSs will sit on the seafloor for 12 months and recovery of the instruments is planned for September, 2011. The OBSs will record earth vibration data continuously at a sample rate of 50 samples per second. The OBS locations were chosen such that approximately uniform station spacing could be achieved, taking advantage of existing Southern California Seismic Network stations installed on Catalina, San Clemente, San Nicolas, Santa Barbara, Santa Rosa, and San Miguel Islands. In the shallow-water Continental Borderland region, station spacing was approximately 50 km, and in the deep-water oceanic plate region station spacing was approximately 75 km. The OBSs consisted of 24 three-component long-period sensors with differential pressure gauges (DPGs) and 10 three-component short-period sensors with hydrophones. Each long-period OBS weighs approximately 1000 lbs (according to Ernie Aaron: 911 lbs) in air with the anchor. Without the anchor, each weighs 850 lbs. Negative buoyancy in water as the OBS is sinking adds 50 lbs, and positive buoyancy as the OBS is rising without anchor subtracts 50 lbs. Each short-period OBS weighs approximately 400 lbs (according to Ernie: 427 lbs) in air with the anchor. Without the anchor each weighs 300 lbs. Negative buoyancy in water adds 40 lbs and positive buoyancy subtracts 40 lbs. The loaded short-period rack (with 3 SP OBSs) is 1018 lbs and the loaded 24-transducer rosette rack is 1091 lbs.

Our Science Party arrived at the UCSD Scripps Institution of Oceanography (SIO) Nimitz Marine Facility (MarFac) on August 12, 2010 to assist OBS technicians with loading the instruments on the deck of R/V Melville. Upon arrival we discovered that the OBS technicians were only able to load some of the equipment because a large container unit needed to be unloaded from Melville's deck. In addition, Melville needed to be moved for refueling on the morning of the 13th. Once back at MarFac, OBS and MarFac technicians completed loading the OBS equipment on the afternoon of the 13th. The OBS components were loaded onto Melville's main deck for assembly and easy access to the starboard deck for deployments. We departed onboard from MarFac on August 14 at 08:00 Pacific Daylight Time.

Weather during the cruise was mostly cloudy, windy, and cold, resulting in mild to choppy seas with nearly continuous swells during transit and deployment. We did not encounter any serious storm or sea state conditions that hampered the OBS deployments.

Members of the science party, including senior scientists, acted as observers or loggers ("watchstanders") during predetermined shift hours. Three student volunteers were assigned to shifts that mirrored the bridge officer shifts: i) 12 a.m. - 4 a.m. and 12 p.m. - 4 p.m. (Emmet, Stephanie and Lei), ii) 4 a.m. - 8 a.m. and 4 p.m. - 8 p.m. (Brian, Connie and Katie), and iii) 8 a.m. - 12 p.m. and 8 p.m. – 12 a.m. (Natsumi, Mollie, and Jennifer). Monica and Dayanthie rotated as necessary so that at least one was on call during every OBS deployment.

On Tuesday, August 24 (during the cruise) at 05:42:16 UTC (August 23, 10:42:16 Pacific Daylight Time), an M_L=4.0 earthquake occurred at 33.511° N 119.052° W, just north of Santa Barbara Island. Given that several OBSs had already been deployed and were recording data, we decided to go back to OBS #5, recover the instrument, swap flash cards to download the data, and redeploy the instrument. The OBS technicians had brought one extra steel plate and burn wire, making the redeployment possible. OBS #5 is a short-period L-28 velocity transducer, making it a good candidate for recovery and redeployment because it is an easier, simpler package to deploy. It was the closest short-period OBS to the August 24 earthquake (distance~50 km), also making it a good candidate for evaluating the short-periods' performance to intermediate-size local seismicity. The downloaded segy-format data files were viewed using pql II (Fig. 3).

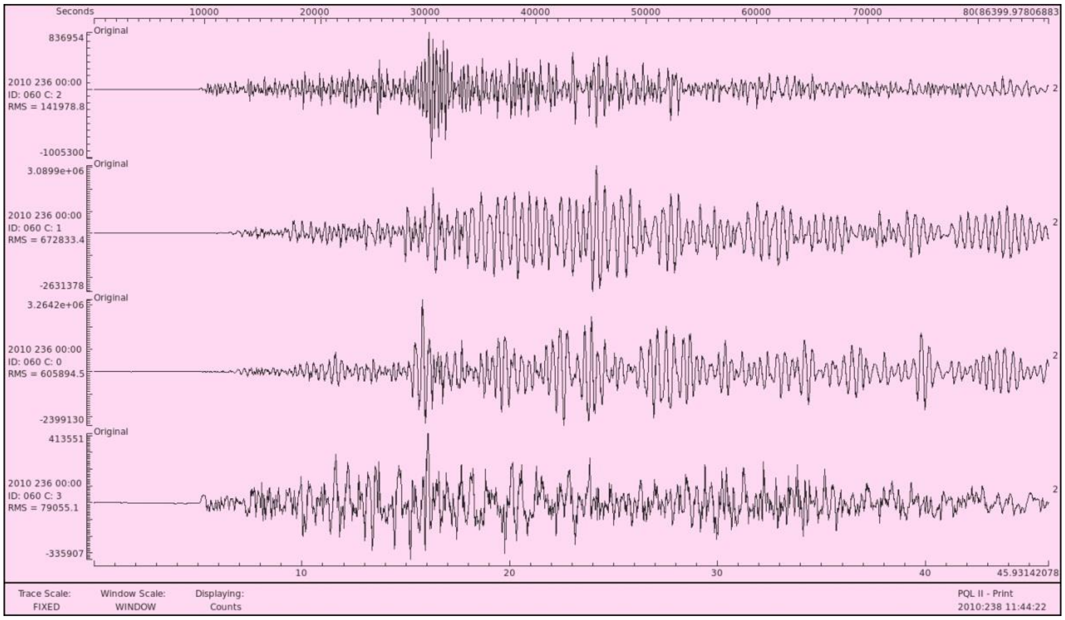


Figure 3. Velocity seismograms resulting from the August 24, 2010 Santa Barbara Island earthquake recorded at OBS Station 05 after recovery on August 26, 2010.

B. OBS Deployments

SIO Instruments

Each OBS datalogger is a Scripps-developed instrument that consists of four channels recording waveform data at 4000 sps. The datalogger contains solid state memory (CF) cards and a temperature-compensated oscillator. Power consumption is 350 mW and rated to 6000 m water depth where pressure is approximately 10,000 psi.

The long-period (LP) sensors are three-component Nanometrics Trillium 240s ("T-240") for 21 sites and Trillium 40s ("T-40") for three sites. The response of the T-240 is flat in velocity from 240 seconds to 35 Hz. The measured self-noise is below the NLNM (Peterson New Low Noise Model) from 100 seconds to 10 seconds. The clip level is 15 mm/s up to 1.5 Hz. Power consumption is 800 mW nominal and the sensor has 20 g shock resistance. The T-240s have motorized mass centering; no mass lock is required. The short-period (SP) sensors are three-component Sercel L-28 (“L-28”) passive velocity transducers. Each LP also has a battery bottle to power the Trillium sensor and two mechanical release mechanisms. Each SP contains one mechanical release mechanism. The DPGs measure differential pressure between 100 s and a few Hz, and the hydrophones measure absolute pressure between 1 Hz and several thousand Hz. All sensors recorded waveform data downsampled in the datalogger to 50 samples per second.

The seismometers can level themselves (up to 120 degrees correction by the LPs and up to 45 degrees by the SPs) using a gimbal system. The LP gimbal system contains two-axis active leveling and a three-point coupling lock. It is low-power but the more leveling that is required, the more battery power will be required.

The acoustic release system has an 18-V release pack for disconnecting the OBS from the metal grate that keeps it on the seafloor. It operates by frequency shift key operation and there are unique codes for each serial number. It contains two redundant release circuits and is also rated to 6000 m water depth. The OBS flotation system consists of two components. Each seismometer has 88 lbs of glass buoyancy and 12 lbs of syntactic foam buoyancy. The net buoyancy of the entire system is 46 lbs.

Acoustic Transponder Tests

Communication with the OBSs was made possible by acoustic pings using acoustic communication boxes (“deck units”) provided by SIO OBSIP. All acoustic signal pings to the OBSs were made in the 9-13 kHz range. More specifically, the acoustic units were interrogated with 11 kHz pings and confirmation pings were received from the OBS at 13 kHz. In order to enable or release one of the OBSs, we interrogated it with a specific code which was unique for every command type and for each individual acoustic unit. These codes were preset (hardcoded) and the OBS acoustic code depended on the specific acoustic unit selected for the site. All communication with the OBSs used an OBS station-specific identifier code as well as additional codes to identify the OBS’s operational status (e.g., “enable” to wake the station up and “disable” to put the station to sleep). The acoustic codes are transmitted on a frequency shift key principle. When we left each site, the units were disabled. It would be nearly impossible for someone to intentionally or accidentally trigger a release (i.e., the Navy during an exercise) without knowledge of our specific codes.

The OBS transponders were tested in water at two locations. The first shallow water site was at 32 37.445° N, 118 08.820° W (near the first OBS drop location). The first set of transponders was tested at a water depth of 1900 m by applying “enable,” “ranging,” and “disable” commands. These transponders were subsequently used at OBS drops in water depths of less than 1900 m. The remaining transponders were tested at 31 53.952° N 121 01.883° W, in a water depth of 4400 m. These transponders were subsequently used at deep-water OBS drop sites. Note for the text of this report that the term “rosette test” is used to refer to the transponder tests even though they were configured horizontally on a pallet and did not require the use of a rosette frame. The rosettes were deployed off the squirt boom and hydro wire, and the OBSs were deployed with the Alaska crane. The squirt boom and Alaska crane were close to one another on the starboard side of the ship.

As part of the communication system, each OBS was equipped with a radio beacon (an Edgetech acoustic transponder system). The Edgetech transponder hardware consisted of off-the-shelf equipment commonly used by fishermen and for Acoustic Doppler Current Profiling and moorings measurements. The radio beacons emit acoustic signals and were tested individually before each OBS drop using a Radio Direction Finder (RDF) receiver in Melville’s bridge as well as a portable RDF receiver carried by OBS techs. The RDF receiver uses a directional antenna arrangement to determine the direction of arrival of the OBS's radio signal. The RDF was used to identify when the OBS is on the surface of the water during the recovery process, and which direction relative to the ship it is in while floating.

In addition, each OBS was equipped with a strobe light to aid in recovery at night. The strobe light has a photo cell (light-sensitive switch) so that it will only go off between dusk and dawn during the recovery process.

Deployment Procedures

Prior to setting sail, the OBS technicians staged all instruments on the main deck for easy access with a pallet jack. Once the vessel reached a position close to the drop location, an OBS was placed in position just outside the main lab and secured to the deck with large ratchet straps. The datalogger was taken out of the instrument casing and brought into the main lab, where it was placed on custom-designed mounts that kept it elevated approximately three inches above a workbench. The datalogger was opened up slightly from one end, exposing the CPU card, the analog-to-digital converter card, three 16-Gb compact flash cards, and the power card. Inside the package but not visible were the primary lithium batteries that were checked in the SIO OBS lab prior to setting sail.

With the datalogger case open, the OBS technicians prepared the system for deployment by first setting the firmware parameters specific to this experiment. Next, the clock battery pack was installed. In case of power failure or if the instrument depletes its power supply, the clock battery pack supplies power to the CPU for an additional three months. If this were to happen, the instrument would no longer record data but would run in a low-power mode (clock only) to allow communication for OBS retrieval. Once the clock battery pack was installed, a software version check was implemented and updated if necessary. Confirmation was made that the CPU recognized the compact flash cards. For accurate time and data acquisition, the datalogger clock was then synchronized with GPS time and configured with the appropriate sampling rate and gain. Once these steps were completed, the CPU was put into a power conservation mode, all exposed components were placed back into the external packaging case, and the case was sealed with a mechanical vacuum pump. The OBS crew then placed the datalogger back into the instrument package outside the main lab and attached the appropriate cables in preparation for deployment.

Note for future: The OBS technicians had to change the gain on the short-period OBS hydrophones from 16 to 1 to accommodate our 40 sps sample rate. Initially the gain was set to 16 associated with 100 sps from a previous deployment. A gain of 16 produces better signal-to-noise ratios but would have required lengthy firmware changes for our lower sample rates. If we had been asked in advance for our parameter preferences, we would have been able to use higher gain with lower sample rate.

While the datalogger was in the ship's lab, an OBS technician simultaneously tested the instrument's acoustic release hardware. A test box was hooked up to the instrument with a 75-Ohm load applied to the burn wire. Two separate commands, Burn#1 and Burn#2, were sent to the instrument to check for the appropriate voltage. Continuous voltage was applied for over a minute to confirm that the release mechanism would work at OBS retrieval time. A two-minute cycle was applied to confirm that the instrument sensed a ground connection. Once these steps had produced positive results, the box was detached from the instrument.

Following the completion of the datalogger and the acoustic release checks, the instrument was detached from its staging area by releasing the ratchet straps from eyehook bolts on deck.

With a pallet jack, the instrument was then repositioned to the starboard side, approximately three feet from the edge of the vessel and four feet from the deploying crane arm. The instrument was then reattached to the deck using ratchet straps and the eyehook bolts. The Resident Technician then powered up the deploying crane, and raised the arm and hook in position above the instrument where a pelican release was attached between the instrument and the crane hook. The Resident Technician then raised the deploying crane arm to the point where the line between the instrument and crane arm was taut.

When the vessel arrived at the specified station location and vessel dynamic positioning was in place, tag lines were put in place to assist in a manually-controlled deployment. A designated OBS technician confirmed with the tag operators, as well as the Resident Technician, that all positions were ready and alert for deployment. The Resident Technician was signaled to raise the crane to an appropriate height and to begin positioning the instrument above the water. All deploying OBS technicians and science party members involved in the deployment moved along with the instrument in a steady fashion until each person had reached the vessel rail and the instrument was in the appropriate position above the water approximately 15 feet away from the vessel. A hand signal was made to the Resident Technician to lower the instrument to the point of contact with the water. Once it was confirmed that the water was releasing the instrument weight from the crane by a small amount, the tag lines were detached from the instrument and the Pelican Release was triggered. At this point the instrument was no longer in contact with any technician or equipment, and was free to descend into the ocean.

The preceding procedures were applied to both short-period (SP) and long-period (LP) OBSs. In the case of the LP OBSs, additional steps were taken. While still on deck, the LP sensor ball was placed in front of the instrument where an armature was lowered and attached to the sensor ball. This resulted in the sensor being suspended above the deck by approximately two feet. A communication cable was attached from a laptop computer to the sensor to allow communication through a terminal window. At this point the sensor was checked for the appropriate wake-up time, sleep time, and logging time. Once all times were confirmed accurate, the memory was cleared and the sensor was put to sleep.

Surveys

In order to calculate an accurate final geographic location for each OBS, a location survey was conducted around each OBS after the bridge was alerted that it had landed on the seafloor. The survey consisted of steaming through five points relative to the OBS drop location: a north point, west point, south point, east point, and center point which was the OBS drop location. During the survey, the OBS was continuously pinged acoustically for updates to an accurate location. The survey radius for the north, south, east, and west points was equal to half the water depth at the OBS drop site. For stations 1-15 and 29, the survey began by heading to the north point. The ship then travelled clockwise to the east, south, and west point in a diamond-like pattern. When approaching the west point, the ship slowed to four knots and waited for the OBS crew to send the “disable” code to the OBS’s acoustic communication transponder. For stations 16-34, the survey began at the north point. The ship then headed in a counterclockwise direction to the west, south, and east point. When approaching the east point, the ship slowed to four knots and waited for the OBS crew to send the disable code. For most of the OBS surveys, it was not necessary to visit the center point at the end of the survey because communication with the OBS was consistently clear and the disable code was successfully sent at either the west point (stations 1-15) or east point (stations 16-34). For the OBS sites where communication was lost, the ship returned to the center point to finish the survey and send the “disable” code. During the survey for Station 1, communication was lost with the OBS when the ship traveled above six knots. Consequently for all following surveys, ship speed was kept under six knots. At each survey point the latitude, longitude, time of arrival, and ship speed were recorded.

The multibeam system was turned off during the survey so as not to interfere with communication to the OBS’s acoustic transponder. After confirmation that the disable code had been successfully sent, the survey ended and the multibeam data recording was turned back on.

OBS Deployment Details

OBS Station 1

OBS station 1 was an SP L-28 using an acoustic transponder from the first, shallow-water rosette test #1. The drop site of the first OBS was also the test site of the first rosette test. Sea state was a 3 on the Beaufort scale. The echosounder showed that the sediment appears to be flat and thick with defined layers. The multibeam showed a relatively flat plain with some hills to the far west side of the drop side. The 1-arcmin slope was 0.004249. The OBS was deployed at 23:38:29 UTC on JD 226. It hit the seafloor bottom at 00:21:00 UTC on JD 227. We drifted about 3/10 of a mile south of the original drop site, but it was decided that we would go with the original survey points. During the deployment, the radio was checked by the bridge. There was immediate successful communication with the OBS. The initial descent rate was 60 m/min but it slowed to 48 m/min. During the survey, the bridge was told to slow down to under 6.5 knots because, according Ernie Aaron, anything faster than that will cause the instrument to not receive transponder pings. The OBS was disabled at 01:11:04 UTC. Total time on site was 2:00:09.

OBS Station 2

OBS station 2 was an SP L-28 using an acoustic transponder from the shallow-water rosette test #1. The echosounder recorded sediments that appeared to be thick and layered with no sharp discontinuities. The topography of the seafloor was flat. The OBS was deployed in water at 04:52:34 UTC on JD 227. This OBS needed to be dropped at the exact location specified by the Navy because it was in the Southern California Offshore Range/Southern California Anti-Submarine Warfare Range (SCORE/SOAR) which is underlain by a cabled hydrophone array installed and operated by the Navy. The OBS hit bottom at 05:22:20 UTC on JD 227. The sink rate was about 60 m/min. Everything went well and communication was good while the ship did the location survey of the site.

OBS Station 3

OBS station 3 was an LP T-240. The third OBS deployment went as planned. The acoustic transponder used was tested at the shallow-water rosette test #1. The OBS was deployed at the exact planned site location because it also was in the SCORE/SOAR region. The sediments looked fairly thick; there appeared to be a slight valley with a shallow gradient. The OBS hit the water at 07:43:15 UTC on JD 227. Sinking at a rate of 50 m/min, it landed on the bottom at 08:19:20 UTC. Everything went well and communication was good as the ship surveyed. The OBS was disabled at 09:00:00 UTC. The total time, from time in water to disable time, was 1 hour and 17 minutes.

OBS Station 4

OBS station 4 was an LP T-240 using acoustic transponder 134 from the shallow-water rosette test #1. The OBS hit water at 11:10:11 UTC on JD 227. The instrument sank at a rate of 60 m/min, reaching the bottom at 11:31:00 UTC. Upon reaching the bottom, the survey began with the north point, proceeding clockwise and ending at the west point at a speed of 4.5 – 5.3 knots. All pings were successful on the survey, and the OBS was disabled at 12:02:00 UTC. When finished, the multibeam was turned back on.

OBS Station 5

OBS station 5 was an SP L-28 using an acoustic transponder from the shallow-water rosette test #1. The sea state was a moderate breeze (4 on the Beaufort scale). The seafloor consisted of undulating hard sediment. The multibeam showed the seafloor looking relatively flat with a couple of ledges to the far north and west of the drop site. The 1-arcmin slope was 0.005907. The OBS was deployed at 13:33:48 UTC on JD 227. It landed on the bottom at 14:06:00 UTC. Before deployment, the bridge confirmed that all stations are on the same channel. The watchstander turned off the echosounder and the multibeam. There was immediate successful communication with the OBS and continued communication was loud and clear. By the time the OBS hit bottom the sea state had calmed down to a 3. There was no problem with communication during the survey, nor was there any problem with disabling the OBS. The initial descent rate was 27-33 m/min. The OBS was disabled at 14:35:10 UTC. The total time on site was 1:11:19 and the average drop rate was 50 m/min.

OBS Station 6

OBS station 6 was an LP T-240 using acoustic transponder #113 from the shallow-water rosette test #1. The echosounder showed thin layered sediments at this site and flat topography. The OBS time in the water was 17:58:00 UTC on JD 227. The descent rate was 50 m/min and communication with the OBS was good throughout its descent. The OBS hit the bottom at 18:21:45 UTC. Communication was good throughout survey and there was no need to go back to the center point. The disable code was sent to the OBS at 18:54:00 UTC. The ship then headed to the deep-water rosette (transponder) test site #2.

OBS Station 7

OBS station 7 was an LP T-240 and the acoustic transponder was from the deep-water rosette test #2. The seventh OBS deployment went as planned. The sediment on site was a flat and moderately thick layer, with noticeable intensity that feathers out. The site is approximately 2.96 km away from the Patton Escarpment. The OBS hit the water at 11:19:50 UTC on JD 228, and dropped at a rate of 50 m/min. It landed on the bottom at 12:35:28 UTC. Communication was good as the ship surveyed. The OBS was disabled at 13:35:59 UTC. The total time, from time in water to disable time, was 2 hours and 16 minutes.

OBS Station 8

OBS station 8 was an LP T-240. This OBS site was changed from its original location due to seamounts in the vicinity. We arrived at the new site just south of the original site at 16:43:00 UTC on JD 228. The site consisted of soft, moderately thick sediments. This OBS used acoustic transponder #131 from the deep-water rosette test #2 and was deployed at 16:55:03 UTC, sinking with a descent rate of ~50 m/min and landing on the ocean floor at 18:17:00 UTC. The survey started at 18:24:00 UTC, beginning with the north point, followed by the east, south, and west points. Communication was good through the south point while traveling at 5-6 knots. While heading to the west point, 8 pings were lost so the ship slowed down to 3.8 knots, solving the ping issue. The OBS was disabled at 19:35:00 UTC, after which the magnetometer was deployed and the multibeam was turned on.

OBS Station 9

OBS station 9 was an LP T-240 using an acoustic transponder from the deep-water rosette test #2. Sediment coming up to the site was slightly inclined, sloping upward but slowly leveling off. The gradients looked less defined, more layered and softer. The sea state was a 3. The multibeam showed the drop site to be relatively flat; there may be a small pillar-shaped feature nearby. The 1-arcmin slope was 0.006431. The OBS was deployed at 0:19:30 UTC on JD 229. It landed on the bottom at 01:38:00 UTC. Before the deployment, the bridge confirmed that the RDF is functioning. There was immediate successful communication with the OBS, and continued communication was loud and clear. The initial descent rate was 33 m/min, significantly slower than the average expected rate. The survey communication was good until after turning at the southern point, when we started getting poor communication with the OBS. Since in-between points are not as critical (according to the OBS technician), we continued heading to the western point to see if communication was clear there. At the western point the OBS was disabled successfully at 02:40:00 UTC. Total time on site was 2:33:22 and the average drop rate was 49 m/min.

OBS Station 10

OBS station 10 was an LP T-240 using an acoustic transponder from the deep-water rosette test #2. The sediment condition at this site consisted of soft sediments and steep slopes, probably associated with the Arguello fracture zone. The OBS site was moved a little west from the planned location to move away from steep slopes. The OBS was in the water at 05:54:57 UTC on JD 229 and it landed on the bottom at 07:10:40 UTC. The descent rate was 45-50 m/min. The survey was carried out from north to east to south to west points. Communication was good throughout; the survey was conducted at 5.7 knots. The disable signal was sent at 08:22:04 UTC. The magnetometer was then deployed and the multibeam was turned back on.

OBS Station 11

OBS station 11 was an LP T-240 using an acoustic transponder tested at the deep-water rosette test #2. The planned OBS site was shifted 1 nautical mile west to avoid a ridge, and the survey points were also shifted. The echosounder showed that the sediments at the drop site were sloping up slightly and were sharply defined with thin layers just beneath the surface. The OBS hit the water at 11:53:00 UTC on JD 229. It dropped at a rate of 50 m/min, and landed on the bottom at 13:19:56 UTC. Communication with the OBS was good until we reached the western point of the survey where there were issues with disabling it, so we headed back towards the center point. It was then successfully disabled at 14:42:50 UTC. The total deployment time, from time in water to disable time, was 2 hours and 49 minutes.

OBS Station 12

OBS station 12 was an LP T-40. While approaching the OBS site, an XBT was performed but it was unsuccessful due to a wire leak. Another XBT was performed and this time was successful. The sediments near the OBS site were thick with light reflections. There was a high ridge to the east, so the drop location was moved 0.2 NM west. The final site was reached at 18:22:00 UTC on JD 229, after which the RDF test was completed and the multibeam was turned off. The OBS was deployed at 18:36:16 UTC and had a descent rate of 50 m/min. Upon landing on the ocean floor at 19:56:10 UTC, the survey began. The ship speed was 5.5 – 6 knots during the survey, and there was good communication with the OBS throughout except for two pings along the north-to-east point route. The ship then slowed down to 4 knots and the OBS was disabled at 20:58:02 UTC.

OBS Station 13

OBS station 13 was an LP T-240 using an acoustic transponder from the deep-water rosette test #2. The sediments looked layered and soft with a slight incline sloping up. As we approached the site, the seafloor began to level out, but was still layered and soft. The ship turned 180 degrees during the final stage of coming onto site. The multibeam showed the drop site to be in a relatively flat area between a couple of seamounts. Leading up to the drop site were a few small ridges. The 1-arcmin slope was 0.005832. Before deployment the bridge confirmed that they heard the RDF and the watchstanders turned off the multibeam. The OBS was deployed at 01:08:00 UTC on JD 230. It landed on the bottom at 02:31:00 UTC. The initial descent rate was 51 m/min but slowed down to 48 m/min. We had changed the location of the drop site and the bridge called to check if the new survey points should be equidistant from the new location (1 NM by 1 NM) (NM=nautical mile). Monica said no and that she will give them the new survey points. There was immediate successful communication with the OBS and continued good communication as it was going down. As we were approaching the western point the bridge slowed down to 4 knots. Communication during the survey was fine but the OBS crew was not able to disable it. We went back past the center and the disabling was successful. Note: the communication was bad from the west, possibly from the seamounts on the southwest side. The OBS stopped communicating during the westward portion of survey. We traveled east to the drop point where communication was restored and the OBS was disabled at 4:05:00 UTC. Total time on site was 3:08:36 and the average drop rate was 52 m/min.

OBS Station 14

OBS station 14 consisted of an LP T-240 and the acoustic transponder was from the deep-water rosette test #2. The sediment conditions indicated relatively constant gradients (looks like we're on top of a plateau), after just having gone over north-south-trending linear troughs. The deployment site was on a high, flat area where the sediments looked thick. The RDF test from the bridge was successful and the OBS hit the water at 07:57:28 UTC on JD 230. The descent rate was 48 m/min and communication was good throughout descent. The OBS landed on the seafloor at 09:30:17 UTC on JD 230 and the survey began with the northern point, east, south, and west points. There was good communication throughout the survey except near the western point when the disable command was attempted. The ship headed back to the center point because of trouble communicating (difficulty disabling). The bridge was asked to first hove to on center, then change direction 180 degrees to go over the center again. The bridge was then asked to slow down near center so that disable could be attempted again. The bridge replied that we were "stopped in the water." The disable command was sent successfully at 11:06:32 UTC on JD 230. The magnetometer was then deployed and the multibeam turned back on.

OBS Station 15

OBS station 15 consisted of an LP T-240 sensor and an acoustic transponder tested at the deep-water rosette test #2. The site was shifted; we first moved 0.75 NM at a 45 degree heading, then a bit more at a 50 degree heading. The survey points were correspondingly shifted. The multibeam showed that we were passing a seamount on the starboard side as we approached the site. The sediment was layered, soft looking, and slightly inclined upwards. The bathymetry did not seem to consist of any surrounding flat spots. The sediment gradient was slowly becoming more defined but remained sloping up as we approach the site. The onsite sediment was soft. The OBS hit the water at 15:18:35 UTC on JD 230. Dropping at a rate of 50 m/min, it landed on the bottom at 16:44:00 UTC. Communication with the OBS was good, both while it was dropping and throughout the survey. It was successfully disabled at 18:03:00 UTC, and the total time on site was 1 hour and 19 minutes.

OBS Station 16

OBS station 16 consisted of an LP T-240 sensor with acoustic transponder #130 from deep-water rosette test #2. During the approach to station 16 we crossed the Murray fracture zone. We reached the final site at 03:14:53 UTC on JD 231. The multibeam was turned off at 03:13:40 UTC and the OBS was deployed at 03:21:06 UTC. The OBS landed on the ocean floor at 04:51:00 UTC, at which time the bridge had just finished raising the bow thruster. Surveying began at a speed of 5-6 knots, beginning with the north point and finishing with the east. Communication with the OBS was good throughout the survey; however we had to slow down to 3.7 knots around the east point due to traffic. At 06:08:00 UTC the OBS was disabled successfully.

OBS Station 17

OBS station 17 was an LP T-240 using an acoustic transponder from the deep-water rosette test #2. Sediment coming on to the site was moderately thick with medium-strong (moderate) reflections. As we were approaching the site, Dayanthie called the bridge requesting we move east 0.1 NM to avoid a slope. The actual site was located just west of a small ledge, with a relief of ~100 m so the pings might be less clear from the that side. The 1-arcmin slope was 0.010718. Just before deployment (and before the multibeam was turned off), the multibeam depth was fluctuating by 20 m even though we had come to a full stop. The OBS was deployed at 10:15:32 UTC on JD 231. It landed on the bottom at 11:48:30 UTC. We changed the location of the drop site so new survey coordinates were sent to the bridge. We had communication with the OBS as it was descending but we were having trouble hearing some of the pings sent back from the OBS. It seemed to skip a ping every now and then. During the survey at the northern point we were not hearing a lot of pings from the OBS. It could have been sitting in an awkward position (tilted). At this point the OBS crew was still confident that they could disable it. When we approached the western point, communication failed due to the ledge shadowing. We navigated back to the center point and successfully disabled the OBS at 13:05:16 UTC. The total time on site was 3:01:34 and the average drop rate was 48 m/min. While en route to Station 18, the magnetometer was in the water during which we could not make sharp turns. To accommodate this, the captain turned the ship by looping instead.

OBS Station 18

OBS station 18 was an LP T-240 using acoustic transponder #127 from the deep-water rosette test #2. Sediments appeared to be loose and thick with diffuse reflections in a few sedimentary layers. Gradients in the sediments did not look strong. We avoided a possible trough northwest of the planned deployment site by moving to a new site. The OBS was in the water at 21:55:31 UTC on JD 231. The initial descent rate was 51 m/min. The OBS hit bottom at 23:31:52 UTC and the survey was begun from the northern point to west, south, and eastern points. Communication with the OBS was good until approaching the western point when a disable was attempted. The bridge was notified to head back to the center site and maintain 4 knots. The disable code was successfully sent at 00:58:00 UTC on JD 232.

OBS Station 19

OBS station 19 was an LP T-240 sensor with an acoustic transponder tested at the deep-water rosette test #2. The OBS was deployed at the planned site location. According to the echo-sounder, we had just passed a downward slope but the bottom had leveled out. The sediments were of medium-to-high thickness. The multibeam was being buggy, so we couldn’t see anything from it and the deployment was done somewhat blindly. The OBS hit the water at 04:53:39 UTC on JD 232. Dropping at a rate of 50 m/min, it landed on the bottom at 06:25:07 UTC. Communication was clear until we reached the eastern point of the survey where there were issues with disabling the OBS. We headed back towards the center point at a slower speed of 4 knots, and the OBS was disabled at 07:57:00 UTC. The total time, from time in water to disable time, was 3 hours and 4 minutes.

OBS Station 20

OBS station 20 was an LP T-240 using acoustic transponder #112 from deep-water rosette test #2. This OBS site was located just north of the Murray fracture zone, in an area with thick, well-defined, compact sediment layers. We reached the site at 12:06:38 UTC on JD 232, at which time the bow thruster was lowered and the multibeam was turned off. At 12:17:27 UTC the OBS was deployed. The instrument sank at a rate of 50 m/min, hitting the ocean floor at 13:39:42 UTC. Once the bow thruster was raised, the survey commenced at a speed of 4-5 knots beginning with the northern point, and ending with the eastern point. All communication with the OBS was successful. The OBS was disabled at 14:52:50 UTC, after which the multibeam was turned on.

OBS Station 21

OBS station 21 was an LP T-40 sensor using an acoustic transponder from deep-water rosette test #2. The sediment condition was medium-to-high density thickness with dark reflections. The sea state was a 2 on the Beaufort scale. The site was on a somewhat flat plateau. The 1-arcmin slope was 0.002214. Just before deployment, Dayanthie called the bridge saying that we are on a bit of a ridge and that we should move the location eastward 2.5 NM. The bridge confirmed that the RDF is pinging. The OBS was deployed at 18:19:25 UTC on JD 232. It landed on the bottom at 19:37:42 UTC. During deployment one of the tag lines was loose and never properly attached. It wasn't discovered by the OBS crew until too late but it did not seem to have affected the deployment. We changed the location of the drop site and there was a new set of survey points. There was immediate successful communication with the OBS. Initial descent rate was 50 m/min. There was also good communication during the survey and the OBS was disabled at 20:39:02 UTC. The total time in water was 3:05:56 and the average descent rate was 37 m/min.

OBS Station 22

OBS station 22 was an LP T-240 sensor using acoustic transponder #122 tested at the deep-water rosette test #2. The sediments looked thin and the echosounder showed a sharp, dark reflector suggesting compact sediments. The bathymetry looked flat. The sea state was 2-3 on the Beaufort scale. The OBS was in the water at 23:29:38 UTC on JD 232. Before deployment, the OBS crew found an extra cable attached to the OBS while they were raising it. They put the OBS down on the deck and checked everything. They then decided that it was OK to pull it off and deploy the OBS. After deployment they found an extra logger ring near the staging area. Descent rate was 31 m/min and the OBS hit bottom at 00:43:00 UTC on JD 233. The survey was begun in a counterclockwise direction beginning with the northern point. Communication was spotty heading to the western point and throughout survey. The disable command was sent successfully at 01:47:57 UTC on JD 233 without having to head back to center point.

OBS Station 23

OBS station 23 was an LP T-240 sensor with an acoustic transponder tested at the deep-water rosette test #2. The site was shifted 3.5 nautical miles west, and then an additional ~0.3 NM. It also appears that the OBS drifted while dropping since the depth at bottom was 2024 rather than the 2010 m that the multibeam had recorded. The survey points were shifted correspondingly. The echosounder reflection of the sediment was sharp, dark, and thick. There were some lighter, feathered reflections beneath it which meant that there may be high-density sediments on top of lower density sediment. The echosounder showed that the topography was leveling out. The site was next to both a seamount and a ridge. It was in a deep, but somewhat narrow spot; however, the area was still big enough for deployment. The OBS hit the water at 04:19:46 UTC on JD 233, dropped at 50 m/min, and landed on the bottom at 05:00:00 UTC. The communication while dropping and surveying was clear, and the OBS was disabled at 05:42:00 UTC. The total time, from time in water to disable time, was 1 hour and 13 minutes.

OBS Station 24

OBS station 24 was an LP T-40 sensor with acoustic transponder #118 from deep-water rosette test #2. The original site location for OBS 24 was unsatisfactory, so the site location was moved 1 NM west. Upon approaching the site, the magnetometer was retrieved and the RDF test was successful. The OBS was deployed at 09:46:08 UTC on JD 233. The OBS fell through the water at a rate of 50 m/min, reaching the ocean floor at 10:58:22 UTC. The seafloor at this site consisted of thin, loose sediments producing a dark reflector. The survey began shortly after the instrument landed on the ocean bottom, beginning with the north point and ending with the east point. The ship’s survey speed was ~6 knots through the southern point, but due to communication issues it slowed down to ~3 knots. At this time, the wind picked up considerably. The OBS was successfully disabled at 11:59:00 UTC, at which time the multibeam was turned on again.

OBS Station 25

OBS station 25 was an LP T-240 using an acoustic transponder from deep-water rosette test #2. While approaching the site, Monica asked the bridge to change the heading to 270 degrees and to go one more NM. Sediments looked thin and moderately flat (sharp, dark reflector over flat, smooth seafloor). The 1-arcmin slope was not available because this area would not render in real-time on the multibeam. The OBS was deployed at 11:14:10 UTC on JD 234. It landed on the bottom at 11:40:00 UTC. Since we changed the location of the drop site, there was a new set of survey points. There was immediate communication with the OBS and the initial descent rate was 51 m/min. There was good communication all the way down and during the survey. It was successfully disabled at 12:13:59 UTC. The total time on site was 1:06:39 and the average descent rate was 42 m/min.

OBS Station 26

OBS station 26 was an SP L-28 using acoustic transponder #132. Sediment conditions for the site showed dark, smooth reflectors, and thin sediments that were moderately flat. The OBS was in the water at 22:15:21 UTC on JD 234 and it hit bottom at 22:38:08 UTC. The descent rate was 50 m/min. The survey started with the northern point, moving west, south, then east. Communication with the OBS was good throughout the entire survey. The OBS was disabled at 23:03:33 UTC.

OBS Station 27

OBS station 27 consisted of an SP L-28 with an acoustic transponder tested at the deep-water rosette test #2. The deployment site was shifted 4 NM east to avoid large gradients in the bathymetry and the survey points were changed correspondingly. The sediments at the site were low-density, fairly thick, and there was no distinct sharp reflection. The site was in a deep basin (the Santa Cruz Basin), possibly at the bottom of a landslide. The OBS hit the water at 04:20:14 UTC on JD 236, and dropped at a rate of 45 m/min. It landed on the bottom at 04:59:52 UTC. At this time the bridge was having problems with the PL10 (software that controls the navigation screen) so we were told to stand by. We began the survey at 05:13:00 UTC, and communication was clear until we went beyond the eastern point of the survey. We headed back to the east survey point and were able to disable the OBS at 06:01:55 UTC. The total time, from time in water to disable time, was 1 hour and 2 minutes.

OBS Station 28

OBS station 28 consisted of an LP T-240 sensor with acoustic transponder #47 from deep-water rosette test #2. The original location for this OBS was changed due to large gradients in bathymetry. This site was located in the Santa Cruz Basin and sediments were moderately thick. When we neared the site the bow thruster was lowered, the RDF was successfully checked, and the multibeam was turned off. The OBS was deployed at 10:03:01 UTC on JD 236. The OBS traveled to the ocean floor at a rate of 51 m/min and landed on the ocean floor at 10:42:06 UTC. The survey began just after raising the bow thruster, starting with the north point and ending with the east point. The ship traveled at a speed of 5-6 knots, slowing down to about 3 knots at each point. Communication with the OBS was good throughout the survey. The ship slowed to ~4 knots when nearing the eastern point and we successfully disabled the OBS at 11:19:30 UTC. Shortly afterwards the multibeam was turned back on.

OBS Station 29

OBS station 29 was an SP L-28 using an acoustic transponder from shallow-water rosette test #1. As we were approaching the site, the echosounder showed thick dark reflections with thin sediments underneath. The elevation dropped as we moved past a cliff-like feature. The area looked relatively flat (this area was located in the Santa Monica Basin). The sea state was a 2. The 1-arcmin slope was 0.003688. As we were approaching the site, the bridge requested that the chief scientist go up and discuss the location. Monica came back and said that we have to go 1

NM past the original planned station location in the same heading. The OBS was deployed at 13:17:00 UTC on JD 236. It landed on the bottom at 13:38:30 UTC. The initial descent rate was 51 m/min. There was immediate successful communication but since it was a shallow site there were lots of additional reflected pings and noise. Communication was not clear so we waited a few extra minutes to make sure that it was on the bottom. Survey communication was decent and the OBS was disabled at 13:56:29 UTC. After disabling, we went back to the original OBS Station #29 site and started a bathymetry survey. The total time on site was 0:40:56 and the average drop rate was 38 m/min.

OBS Station 30

OBS station 30 was an SP L-28 using acoustic transponder #136 from shallow-water rosette test #1. Sediment conditions indicated a flat basin with sharp dark reflectors indicating thin sediments. The site was in the Santa Monica Basin. The OBS was in the water at 21:05:46 UTC on JD 236. The initial descent rate was 51 m/min. The OBS hit the bottom at 21:24:22 UTC and the survey was begun. Communication was good throughout the survey's northern, western, southern, and eastern points. The OBS was disabled successfully at 21:52:38 UTC and the multibeam was turned back on.

OBS Station 31

OBS station 31 consisted of an SP L-28 with an acoustic transponder tested in the shallow-water rosette test #1. The OBS was deployed at the planned site location where there appeared to be loose sediments sloping down but leveling out. The OBS site was on the floor of the San Pedro Basin. The echosounder showed that the sediments looked flat, thin, and had a distinct reflector over the flat seafloor. The OBS hit the water at 01:30:41 UTC on JD 237, dropping at 45 m/min, and hitting the bottom at 01:50:17 UTC. Surveying was done slower than normal because of ship traffic, and communication with the OBS remained clear throughout the drop and survey. It was successfully disabled at 02:30:17 UTC, for a total onsite time of 47 minutes.

OBS Station 32

OBS station 32 consisted of an LP T-240 sensor with acoustic transponder #110 from shallow-water rosette test #1. Station 32 was located in the Catalina Basin, and the ocean floor consisted of thin sediments producing sharp reflectors. Prior to arriving at the site there was a successful RDF check. The instrument hit the water at 14:30:07 UTC on JD 237 and descended at a rate of 50 m/min until it landed on the ocean floor at 14:55:00 UTC. The survey conducted after the deployment occurred smoothly, beginning with the north point and proceeding counter-clockwise to the east point. The ship traveled at about 5 knots during the survey, slowing down to about 4 knots as it reached the eastern point for disabling. The OBS was successfully disabled at 15:26:50 UTC, after which the multibeam was turned on.

OBS Station 33

OBS station 33 was an SP L-28 with an acoustic transponder from the first rosette test. As we were approaching the site, the echosounder showed solid, high-density sediments from a relatively flat area. The bathymetry from the multibeam looked plain in this area; however we passed over a small seamount about 1 NM northwest of the drop site. The 1-arcmin slope of this area was 0.002414. Monica told the bridge to go to the exact location of the OBS drop site. Just before the deployment, the bridge confirmed that the RDF was going off. The OBS was deployed at 17:33:40 UTC on JD 237. It landed on the bottom at 17:59:20 UTC. We had immediate communication. Continued communication with the OBS was good as it was dropping and during the survey. The OBS was disabled at 18:19:49 UTC. Total time on site was 0:46:39 and the average drop rate was 41 m/min.

OBS Station 34

OBS station 34 consisted of an SP L-28 with acoustic transponder #141 tested at shallow-water rosette test #1. The sea state was 2-3 on the Beaufort scale. Sediment conditions indicated by sharp reflections showed a slightly negative slope and thin sedimentary layers. Monica asked the bridge to change the heading to 90 degrees and head 0.5 NM in that direction. Monica asked the bridge to go another 0.5 NM. OBS 34 was in the water at 20:19:57 UTC on JD 237. The descent rate was 51 m/min. The OBS landed on the seafloor at 20:41:20 UTC and the survey was begun. The bridge indicated that the ship was blown off-center after raising the bow thruster and accidentally headed east before heading towards the northern survey point. The ship then headed north, west, south, then east. Communication was good throughout the survey and the disable command was sent successfully at 21:02:27 UTC. The multibeam was turned on and a multibeam bathymetry survey was begun.

OBS Station 5a: Recovery and Redeployment

On JD 238, we transited back to OBS Station 5 to recover the OBS, swap flash cards, and redeploy the station. The purpose was to be able to take a few days of short-period data containing the 8/24/10 Santa Barbara Island earthquake back to lab, and to get a feel for a typical OBS recovery in preparation for the OBS recovery cruise in a year. We arrived at OBS station 5 at 16:02:29 UTC on JD 238 and the enable process was begun. The OBS was enabled at 16:06:00 UTC and the depth was determined to be 1619 m. Burn Code #1 was sent at 16:07:00 and determined to be successful at 16:22:12 UTC. The OBS time at the water surface was estimated to be 16:45:00 UTC and the ship positioned itself 0.5 NM downwind of the current site. The deck asked the bridge to move closer to the expected OBS position at 16:14:00 UTC since the ship was too far southeast. The bridge replied that it will stop moving away but will remain downwind from the OBS (note for recovery cruise that we do not need to be so conservative in leaving a large distance between the OBS and the ship while waiting for the OBS to approach). The bridge got visual of the OBS at 16:48:00 UTC. At first the bridge reported that they never heard the RDF; they then admitted that they hadn’t turned up the volume. The OBS was on deck at 17:09:30 UTC on JD 238. An OBS technician opened the datalogger case to replace the existing data flash card with a new one. The bridge repositioned the ship for a second deployment of OBS 5 at the original deployment location.

The newly named OBS Station 5a consists of an SP L-28 sensor with acoustic transponder #115. The OBS was in the water at 17:41:31 UTC on JD 238 at nearly the same location as the original deployment. The RDF was pinging the entire time the OBS was on deck. The OBS landed on the bottom at 18:14:50 UTC and the survey began by heading north. Communication was good throughout survey. The disable code was sent at 18:55:26 UTC and the multibeam was turned back on.

Table 1 (next page). Instrumentation and time details for each station.

OBS Drop #	LP/SP	LAT Relocated	LON Relocated	Depth (m)	Time in water (UTC) jday:hr:min	Time on seafloor (UTC) jday:hr:min	Sink rate m/min	GPS Sync Time (UTC) jday:hr:min:sec	Datalogger wake time (UTC) jday:hr:min:sec	Sensor #
1	SP	32 37.2761	-118 8.8229	2043	226:23:38	227:00:21	48	226:22:41:00	227:08:00:00	L2809006
2	SP	32 48.7081	-118 48.2175	1451	227:04:52	227:05:22	48	227:00:07:00	227:20:00:00	L2808006
3	LP	33 0.7726	-118 57.4432	1730	227:07:43	227:08:19	48	227:01:38:00	228:17:00:00	LC2000L-046
4	LP	33 19.1232	-119 10.9694	1051	227:11:10	227:11:31	50	227:06:21:00	228:22:00:00	LC2000L-031
5	SP	33 5.2220	-119 18.0102	1617	227:13:33	227:14:06	46	227:08:27:00	229:00:00:00	2007-042
6	LP	32 46.6192	-119 51.4677	1169	227:17:59	227:18:21	53	227:13:54:00	228:10:00:00	SB28
7	LP	32 44.5327	-120 43.5905	3769	228:11:19	228:12:35	50	228:03:10:00	230:05:00:00	LC-20000L-027
8	LP	32 39.2710	-121 20.5525	3888	228:16:55	228:18:17	54	228:11:37:00	229:21:00:00	LC200L-030
9	LP	33 24.5183	-121 30.4322	3819	229:00:19	229:01:38	48	228:17:15:00	230:00:00:00	10
10	LP	33 18.6516	-122 11.7082	*3777*	229:05:54	229:07:10	50	229:00:07:00	230:11:00:00	51
11	LP	32 39.8715	-122 18.0960	4185	229:11:53	229:13:19	49	229:06:13:00	230:18:00:00	LC-2000L-013
12	LP-T-40	32 38.6871	-123 5.2956	4098	228:18:36	229:19:56	51	229:12:25:00	230:18:00:00	LC2000L-017
13	LP	32 39.3025	-123 49.7155	4281	230:01:08	230:02:31	52	221:19:51:00	230:21:00:00	42
14	LP	32 38.1503	-124 37.9369	4374	230:07:57	230:09:30	47	230:01:04:00	231:22:00:00	26
15	LP	33 18.9424	-124 38.8298	4248	230:15:18	230:16:44	49	230:08:14:00	231:18:00:00	LC2000L-029
16	LP	34 0.6851	-124 38.3059	4552	231:03:21	231:04:51	51	230:15:45:00	231:13:00:00	LC2000L-057
17	LP	33 59.2225	-123 50.4051	4426	231:10:15	231:11:48	48	231:03:37:00	232:03:00:00	LC2000L-033
18	LP	33 17.9964	-123 52.1074	4461	231:21:57	231:23:31	47	231:10:34:00	233:00:00:00	LC2000L-045
19	LP	33 18.1281	-123 2.2397	4374	232:04:53	232:06:25	48	231:22:21:00	233:03:00:00	LC2000L-048
20	LP	34 0.6596	-123 1.9558	4293	232:12:10	232:13:39	48	232:05:17:00	233:17:00:00	OBSIO-BAL049
21	LP-T-40	34 1.9705	-122 17.1759	3876	232:18:19	232:19:37	49	232:14:14:00	234:00:00:00	3
22	LP	34 5.8675	-121 39.7047	3562	232:23:29	233:00:43	48	232:19:41:00	235:00:00:00	35
23	LP	34 8.9088	-121 5.1738	2010	233:04:19	233:05:00	49	232:23:51:00	234:00:00:00	56
24	LP-T-40	33 26.5622	-120 51.5388	3571	233:09:46	233:10:58	50	233:04:43:00	234:10:00:00	LC2000L-024
25	LP	33 31.3971	-120 27.5800	1093	234:11:14	234:11:40	50	233:10:17:00	235:10:00:00	LC2000L-001
26	SP	33 15.0195	-120 1.9883	922	234:22:15	234:22:38	40	234:12:31:00	236:00:00:00	L28-2007-036
27	SP	33 44.8495	-119 35.5395	1894	236:04:18	236:04:59	46	234:22:28:00	236:22:00:00	L28-2007-027
28	LP	33 32.5962	-119 27.8688	1832	236:10:03	236:10:42	47	236:05:25:00	238:10:00:00	LC2000L-002
29	SP	33 52.6342	-119 16.2139	819	236:13:17	236:13:38	39	236:10:19:00	237:10:00:00	2007-018
30	SP	33 43.0203	-118 52.3753	901	236:21:05	236:21:24	48	236:13:35:00	237:13:00:00	OBSI0-6P0034
31	SP	33 33.0174	-118 25.0643	896	237:01:30	237:01:50	45	236:21:54:00	237:01:00:00	OBSI0-GP0027
32	LP	33 12.5101	-118 28.8103	1248	237:14:30	237:14:55	50	237:02:04:00	238:21:00:00	LC2000L-054
33	SP	33 7.9721	-118 9.0874	1044	237:17:33	237:17:59	40	237:16:19:00	238:15:00:00	OBSI0-GP0028
34	SP	32 56.0838	-117 49.0863	1025	237:20:19	237:20:41	49	237:17:57:00	238:17:00:00	OBSIO-GP0026
5a	SP	33 5.2358	-119 17.8581	1616	238:17:41	238:18:14	49	238:17:24:00	239:00:00:00	2007-042

C. Underway Geophysical Data

Navigation Data

Cruise navigation data were acquired from the ship's Furuno GP150 GPS receiver at a rate of 1 sample/sec. The time series navigation data (“mv1010.gp150”) have the following format:

Data Column	Contents
1	UTC timestamp (yyyymmddhhmmss)
2	UTC timestamp (seconds since 1970-01-01 00:00:00)
3	Longitude East
4	Latitude North
5	Speed over ground (Knots)
6	Course over ground (Degrees)

The data are in ASCII format.

Magnetic Data

Magnetic field data were collected along some route segments using a Geometrics G-886 towed magnetometer. The G-886 uses proton precession to measure the strength of the earth’s magnetic field. A proton precession magnetometer measures the absolute value of the earth’s magnetic field by measuring the proton precession frequency and converts that frequency into values that are used to represent the earth’s magnetic field in gammas.

The magnetometer was towed on a cable ~100 m behind the ship. Upon deploying the magnetometer, the G-886 automatically sends data to the Display and Control Computer over the RS-232 serial interface with a delay time of a few minutes. Terminal communication software (probably PROCOMM) was used to observe and record the data coming from the G-886.

Prior to the deployment cruise, we compiled preexisting magnetic anomaly data, primarily from the National Geophysical Data Center, collected along ship tracks in our study area. From the resulting maps, we made determinations about when to deploy the magnetometer during our cruise. Specifically, if any one of our transit legs did not have good preexisting magnetic field coverage and the leg was long enough to warrant the deployment and recovery of the magnetometer given the additional time these required, we deployed it. Prior to the start and end of each magnetometer-recording transit leg, approximately 20 minutes were required to deploy it and approximately 20 minutes to recover it while the ship was traveling at about 10 knots.

While the magnetometer was in the water, watchstanders on duty kept track of ship speed and were ready to notify the bridge if the ship slowed to lower than 8 knots. In addition, the watchstanders were ready to warn the computer technician if the depth of the magnetometer exceeded 30 m. Data were recorded in files corresponding to deployment leg. Each file contains the UTC time stamp and magnetic field value.

Gravity Data

The ship’s Bell BGM-3 shipboard gravimeter (Serial #224) made gravity measurements during the entire cruise. The raw BGM-3 data were collected at a rate of 1 sample/sec and timestamped by the acquisition system. Gravity ties were performed on 5/11/2010, 6/18/2010 and 8/30/2010. The results from these ties were used to calculate observed gravity.

Tie Date	BGM-3 Slope	BGM-3 Offset
2010-05-11 14:36:00	4.9826266	855320.35444
2010-06-18 17:08:00	4.9826266	855320.65644
2010-08-30 21:02:00	4.9826266	855320.889421

The raw observed gravity, GPS latitude, GPS speed over ground and GPS course over ground data were low-pass filtered over 2-minute time series durations, then decimated to a sample rate of 1 sample/minute. Observed gravity values were calculated using the gravity tie data. Theoretical gravity was calculated using the IGSN-71 (GRS67) formulation and filtered latitude. The Eotvos correction was calculated from the filtered latitude, speed, and course. The resulting 1 sample/minute time series gravity file (“mv1010.gravity”) has the following format:

Data Column	Contents
1	UTC timestamp (yyyymmddhhmmss)
2	UTC timestamp (seconds since 1970-01-01 00:00:00)
3	Longitude East
4	Latitude North
5	Speed over ground (Knots)
6	Course over ground (Degrees)
7	IGSN-71 Observed gravity (mgals)
8	IGSN-71 theoretical gravity (mgals)
9	Eotvos correction (mgals)
10	Free-air anomaly (mgals)

The data are in ASCII format.

Multibeam Bathymetry Data

Prior to this cruise, the seafloor bathymetry at many of the OBS locations was already known from low-resolution altimetry-based measurements; therefore higher-resolution multibeam bathymetry data collection was an integral part of the ALBACORE mission. Not only did it directly aid in the placement of OBS instruments in relatively flat, horizontal locations, but it also made possible new high-resolution mapping of seafloor. Due to the need to place the OBSs in a geologically stable environment, the ability to survey the local bathymetry at or near the site of OBS deployment was a crucial step during each OBS drop. The real-time bathymetry data alerted scientists that some predetermined OBS sites were in fact unstable locations characterized by steep gradients in topography. Additionally, although primary viewing of the data was in 2D, the real-time bathymetry data could be viewed in 3D for a more thorough analysis of specific features, both during deployments and during seafloor surveys.

Multibeam Hardware and Software

Bathymetry data was collected using Melville’s Kongsberg EM122 multibeam echosounder system using sound speed corrections applied with Expendable Bathythermograph data collected once daily during the cruise. The EM122 transceiver is equipped with 64 transmitting and 16 receiving transducers (EM120 Series) in which the transmitting array is aligned along the keel of the ship and the receiving array is oriented perpendicular to it. Each of the 64 transmitting transducers sends out a signal at a different frequency centered on 12 kHz. (For example, one of the transmitting transducers may send out a signal at 12.1 kHz and another at 11.9 kHz.) Each of the 16 receiving array transducers then measures the arrival time of the transmitted frequencies, where the difference in time for these measured frequencies yields the depth and location of the reflection of the transmitted signal along the seafloor. The advantage of having the transmitting and receiving arrays oriented perpendicular to one another, otherwise known as "out of phase" installation, is that the signals are correlated to minimize the uncertainty in the reflection location. The processed acoustic signals come from those areas of the seafloor where the transmitting and receiving beams overlap.

The resulting time series recorded during the cruise have variable period and there are gaps when the instrument was secured. The time series bathymetry file ("mv1010.em122") has the following format:

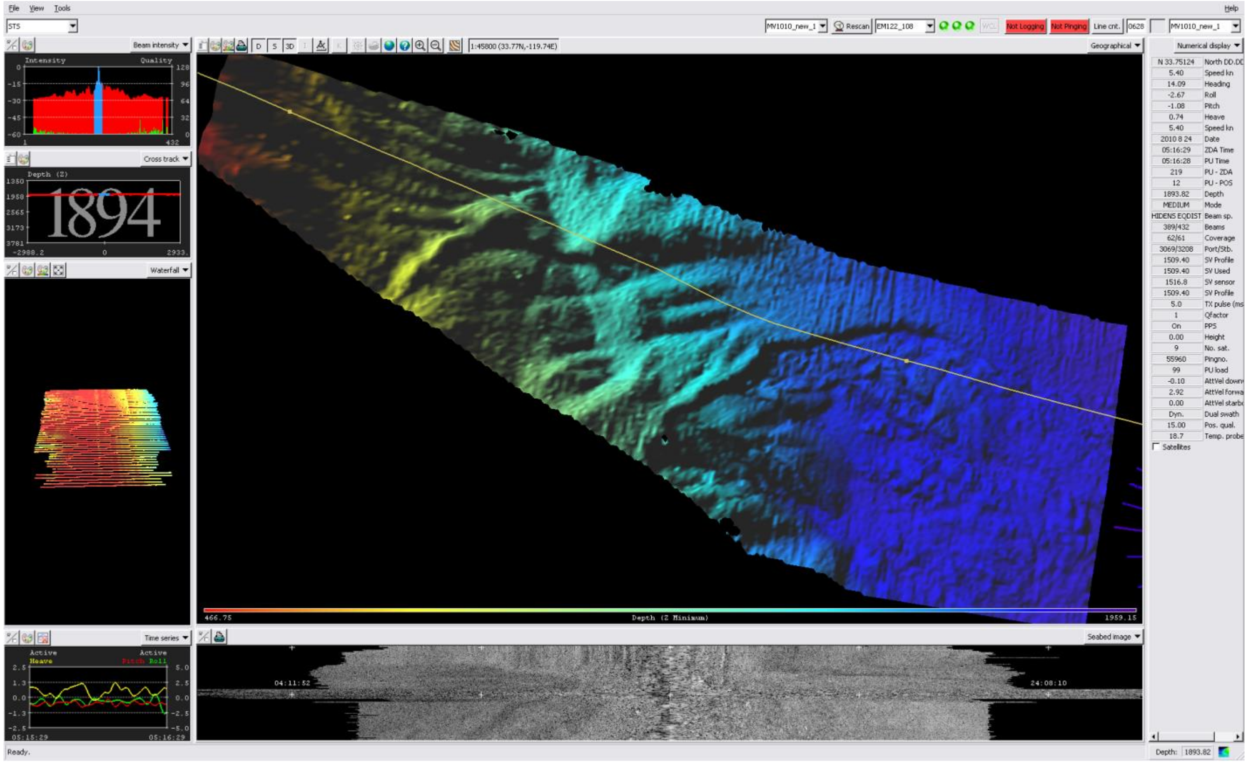
Data Column	Contents
1	UTC timestamp (yyyymmddhhmmss)
2	UTC timestamp (seconds since 1970-01-01 00:00:00)
3	Longitude East
4	Latitude North
5	Speed over ground (Knots)
6	Course over ground (Degrees)
7	Depth (meters)

The data are in ASCII format.

During the cruise the real-time bathymetry processing and imaging software used was Seafloor Information Systems (SIS) version 3.6.4 (Fig 4.). To ensure a high-quality data set, a calibration cruise to measure the pitch, roll, and heave bias for this ship using a Motion Reference Unit equipped with three gyroscopes oriented in the x, y, and z directions was performed prior to this cruise. The navigation calibration data was applied prior to real-time processing to allow for greater accuracy in the data. The sea state affects the quality of the multibeam data in part because the pitch and roll at any one point produce cavitation (the collection of water bubbles) on the transducer. The distribution of water bubbles across the transducers results in an impedance of the transmitted pulse which cannot be corrected.

Multibeam data collection continued at all times except at OBS deployment sites, during periods when the system was undergoing a "self-test" of the EM 122 transceiver, or the software needed to be restarted. The "self-test" ensured that the transducers were working properly and that the transceiver was sending and receiving signals. It also accounted for background noise measured in the receiver. The multibeam was turned off at the OBS deployment sites so as to avoid interference between the RDF transmitter/receiver and the OBS. Furthermore, since the multibeam was synchronized with the echosounder throughout the course of the survey, when the multibeam was turned off, the echosounder was off as well.

As a result of inaccurate onboard software information provided to us during and after the pre-cruise meeting, processing of underway data was delayed. At the pre-cruise meeting, we were told that the latest version of MBSystem (version 5.1.3 beta 1862) was installed, and that multibeam data processing and imaging could be completed during cruise. The latest version was, in fact, not installed. Jon Meyer (who could not make it to the pre-cruise meeting) installed it during the second day of cruise but *mbprocess* had not been tested and did not work correctly. We were also told during the pre-cruise meeting and in follow-up emails that our pre-cruise-produced bathymetry images in any common format could be read into Seafloor Information System (SIS) to underlie real-time rendered images. This turned out to be less than straightforward. It took several cruise days to figure out how to convert previous images to the one required format (GeoTIFF), read them into SIS, and reduce their size such that SIS would not crash. Several times SIS crashed or stopped rendering correctly in real time, possibly due to the presence of the underlying image and/or possibly due to accumulated underway bathymetry data.



N 33.75124	North DD.DC
5.40	Speed kn
14.09	Heading
-2.67	Roll
-1.08	Pitch
0.74	Heave
5.40	Speed kn
2010 8 24	Date
05:16:29	ZDA Time
05:16:28	PU Time
219	PU - ZDA
12	PU - POS
1893.82	Depth
MEDIUM	Mode
HIDENS EQDIST	Beam sp.
389/432	Beams
62/61	Coverage
3069/3208	Port/Stb.
1509.40	SV Profile
1509.40	SV Used
1516.8	SV sensor
1509.40	SV Profile
5.0	TX pulse (ms
1	Qfactor
On	PPS
0.00	Height
9	No. sat.
55960	Pingno.
99	PU load
-0.10	AttVel down
2.92	AttVel forwa
0.00	AttVel starb
Dyn.	Dual swath
15.00	Pos. qual.
18.7	Temp. probe

☐ Satellites

Figure 4. Screenshot of Seafloor Information Systems (SIS) real-time bathymetry imaging of a possible undersea landslide. This image encapsulates the usefulness of the multibeam when surveying and deploying OBSs. This image also illustrates the 3D capabilities of SIS.

The quality of the multibeam data was excellent during the cruise but the value of the data varied depending on location. Because the width of the swath analyzed by the multibeam is a function of the depth of the water column directly underneath the ship, the multibeam was more useful in deep water. The multibeam was most widely used for depths between 100 and 4500 meters, covering a maximum swath width of up to 16 kilometers with good resolution.

Quality of Multibeam Data

Some error was encountered when working with the multibeam system. Water temperature calibration attempts to correct for local conditions, but other errors also occur. First, depths shallower than 80 meters yielded noisy reflected pulses recorded at the receivers, and the system itself has a depth perception error of approximately +/- 30 meters. Second, the dynamics encountered by the ship such as the roll, pitch, and heave dictated by the local sea state play a major role in the accuracy of the data.

The quality of the data is also limited somewhat by the projection angle. The maximum allowed projection angle for the swath width is 75 degrees, but to allow for maximum output of high quality data, 65 degrees was chosen for this cruise. Although the multibeam is capable of processing data at a projection angle of 75 degrees, the greater swath width for a given center beam depth at this angle causes the data points to be distributed over a greater distance. As a result, the data at the outer beams of the swath become increasingly poor. Another contributing factor to poor quality data at the outer beams of the swath is that sometimes the reflected pulse does not reaching any of the 16 receivers, in which case it becomes “oblique energy.”

Multibeam Noise Control and Post-processing

During the cruise, editing of the multibeam data was done with *mbedit*, a program in the MBSystem Package which was installed on the ship’s main computer as well as on the PIs’ computers. Noise control was done by editing the swaths using *mbedit* in which the following were eliminated: i) Outlier points resulting from bad pings; ii) Ping data resulting from the pitch and roll and not from the seafloor topography. These types of points were confirmed by using the ‘info’ option in the program to look up whether the location on the map corresponded with an area of higher or lower elevation. Also, the values of pitch and roll were checked in the watchstander’s log. Finally, iii) Poor ping data at the outer beams of the swath data which produced artificial changes in slope; other inconsistencies between swaths or pings were also removed.

XBT: Expendable Bathythermograph

XBTs produced by Sippican, Inc. were used to measure temperature as a function of depth in the water. The results were fed directly into the EM122 multibeam system to provide real-time calibrations to sound velocities as a function of depth. Once every 24 hours, a probe was dropped from a hand-held launcher off Melville’s stern. The probe measured temperature as it fell through the water to a maximum depth of 1000 m. Two small wires transmitted temperature data to the XBT data acquisition system where it was recorded. The XBT records resistance as a function of time, which is related to the change in temperature. The rate of descent is assumed to be 1000 meters in three minutes from previous experiments; this value may vary by salinity or density of water.

Echosounder Sub-bottom Profiler

Melville’s echosounder system consisted of a Knudsen 320 B/R 3.5 kHz system, and provided information about the depth and sediment conditions on the seafloor. The echosounder was synchronized with the ship’s navigation system and multibeam, and was used during some of the bathymetry surveys. The use of the echosounder was especially important just before an

OBS deployment; it gave estimates of the gradient, sediment thickness, morphology, etc. of the drop site. Because it was synchronized with the multibeam, the echosounder was turned off during some legs of the cruise to allow for higher signal-to-noise in the multibeam bathymetry mapping.

The Knudsen system consists of 16 transducers placed in a grid pattern under the ship. It sends out sound waves and as the sound waves reflect off the ocean floor, it measures the returning waves as a function of time. It converts the time to depth in meters assuming that the speed of sound in water is 1500 m/s. When the echosounder is used over shallow waters, there is sometimes a second, artifact seafloor layer seen at twice the depth of the actual sea floor depth. This is due to the initial sound wave reflecting off the ship back down to the sea floor and back up again to the receivers. The parameters of the echosounder that the watchstanders and computer technician changed according to local conditions throughout the cruise were:

- Tx Pulse: Measured in milliseconds, the Tx pulse describes the length of the sound bit being transmitted by the transducers. The Tx pulse ranges from 0.0625 ms to 64 ms. A higher Tx pulse corresponds to a stronger return. For most of this cruise, the Tx pulse was under 10 ms.

- Tx Power: Tx power corresponds to the power level of the transmitted pulse. Tx power ranges from 1 to 4 with 4 being the maximum power. A higher power also results in a stronger return.

- Gain Value: The gain value can only be controlled when the echosounder is set to the manual gain mode. The gain value controls the analog gain of the incoming data. The gain ranges from 0 dB to 96 dB; on this cruise the gain was set to below 15 dB. A higher gain created a darker echosounder image.

- Process Shift: The process shift controls the digital gain. It amplifies the data but it does not clip the analog data. It ranges from 0-13. For most of the cruise, the process shift was set to below 5. A higher process shift also resulted in a darker echosounder image.

- Range: This is approximated to the length of the water column below the echosounder. For example, if the range is set to 500, the echosounder would only collect data for a select 500 meters. For this cruise, the maximum range is 1000 because the SEG-Y files cannot log for a higher range.

- Phase: The phase can be set to auto or manual mode. For most of the cruise, the phase was set to manual mode since the auto mode had not yet been fully tested. The phase value sets the minimum and maximum depths for the water column.

- Depth limits: The depth limits (minimum and maximum) are the limits in which the phase can be set.