Cruise Report

COAST: Cascadia Open-Access Seismic Transects

W. Steven Holbrook, Graham M. Kent, and Katie Keranen, Co-Chief Scientists
Anne Trehu and Paul Johnson, Onshore co-PI's

R/V Marcus G. Langseth *cruise MGL1212*
Astoria, Oregon - Astoria, Oregon
July 12-24, 2012

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Cruise Summary

During COAST (**C**ascadia **O**pen-**A**ccess **S**eismic **T**ransects), we collected geophysical data on the Cascadia subduction margin on cruise MGL1212 of the R/V *Marcus G. Langseth*, from July 12-24, 2012. The purpose of the cruise, which was funded by the NSF Marine Geology and Geophysics program, was to acquire a grid of 2D seismic reflection profiles and associated geophysical data in a high-priority GeoPRISMS corridor off Grays Harbor, Washington. An important secondary goal was to conduct an open-participation, open-access cruise, with an organized shipboard education and training program, and immediate, full release to the community of all geophysical data. The COAST data will provide benchmark seismic images to address key scientific issues regarding the location, physical state, fluid budget, and associated methane systems of the subducting plate boundary and overlying crust. These include (1) determining the location of the offshore plate boundary beneath a segment of the Cascadia margin that ruptures in very large, infrequent earthquakes, (2) constraining sediment subduction and plate boundary roughness, (3) estimating pore fluid pathways, (4) determining controls on methane distribution, and (5) imaging compressional and extensional structures that may pose geohazards on the Cascadia margin.

Overall the cruise was a success. While we did not acquire all of our planned data, we acquired some data on all of our planned transects, and achieved nearly complete seismic coverage of the deformation front and Pleistocene accretionary wedge. Coverage of the upper slope and shelf is incomplete, due to marine mammals and fishing activity. The cruise faced several challenges, including abundant marine mammals, encounters with fishing boats and long lines, and shipboard mechanical and electrical failures. The first two challenges are endemic to working in the offshore Cascadia region; while vexing, they can be overcome with good planning, sufficient contingency time, pro-active offshore logistical support, and sound at-sea decisions. The mechanical/electrical problems were less anticipated, and were more numerous than should be expected in a 12-day cruise.

Initial observations include the following: (1) The Pleistocene accretionary wedge is well imaged and shows landward-vergent thrust faulting throughout our survey area. An outboard series of ramp-and-thrust structures gives way to a region characterized by folds that separate "oases" of undeformed sediment. (2) The oceanic basement reflection is strong and clear outboard of the deformation front but becomes much weaker beneath the Pleistocene wedge. At this stage of processing it is not clear whether this reflects inaccurate processing, loss of energy by scattering off a complex surface, or (more intriguingly) a physical change in the plate boundary structure. (3) Where it is imaged beneath the margin, the top of oceanic crust appears nearly flat or gently dipping beneath the Pleistocene wedge, then bends into a steeper inclination beneath the Miocene wedge. (4) A widespread methane hydrate system, indicated by bottom-simulating reflections, exists in the outer wedge and upper slope of our area. The BSR's are strongest in tilted sediments, suggesting that fluid flow along bedding planes contributes to the hydrate system. (5) As indicated in previous studies, the Melange and Broken Formation (MBF) is acoustically transparent. An abrupt drop in frequency content beneath the top of the MBF suggests high attenuation within the formation.

The open-participation aspect of the cruise was a great success. From a group of about 60 applicants, the PI's selected 17 participants from 14 institutions, comprising thirteen graduate students, two postdocs, and two faculty. The focus on introducing this diverse group of scientists to the science conducted aboard the U.S. National Marine Seismic Facility resulted in an empowered, highly motivated shipboard science party that was actively involved in all phases of shipboard operations, data processing, and analysis. Shipboard seismic data processing was conducted primarily by the "newbies," most of whom had little or no previous experience with marine seismic reflection processing. LDEO greatly assisted the open-participation effort by making every berth on the ship available; we sailed with 55 people aboard, including a visiting science party of 20.

Cruise Objectives

Scientific Objectives

The Cascadia margin is the site of active subduction, with the Juan de Fuca plate subducting under the North American plate at a rate of ~35 mm/yr. This system is of great scientific and societal interest, as it is capable of very large (Mw~9) earthquakes, creates volcanic hazards in the Cascades, and hosts periodic episodic tremor and slip (ETS) episodes. Despite evidence that the system has generated large megathrust earthquakes, limited seismicity creates large uncertainties in the position, structure, and physical state of the plate boundary. The COAST project conducted an open-access, open-participation 2D seismic survey of the Cascadia subduction margin off Grays Harbor, WA, that will provide benchmark seismic images to address key scientific issues regarding the location, physical state, fluid budget, and associated methane systems of the subducting plate boundary and overlying crust.

The Grays Harbor region of the Cascadia subduction zone is a high-priority area for future 3D seismic imaging of the plate boundary. This 2D survey will provide background information critical for optimally siting and planning any future 3D work on this part of the margin.

Our specific scientific objectives include the following:

(1) Where is the offshore plate boundary in the Cascadia subduction zone?

Virtually every important question regarding subduction processes, earthquake nucleation and hazards in the Cascadia subduction zone requires knowledge of the location of the plate boundary. Due to low background seismicity, however, the plate boundary in our study area is poorly located. Modern seismic reflection data will provide images of the plate boundary, traceable from the downgoing plate in the trench, and will enable new fundamental hypotheses regarding plate asperities/roughness and the role of sediments and fluids to be addressed.

(2) Downdip variations in character of subduction thrust associated with seismic rupture

The location of the seismic rupture zone on the subduction thrust is a critical factor in earthquake hazard for great earthquakes. An important potential definition of the seismogenic zone is through changes in the character of the subduction thrust reflection from aseismic creep near the deformation front, to the locked zone that ruptures in great earthquakes, to the aseismic deeper zone (e.g., Nedimovic, 2003; Bangs, 2004). Our proposed survey has the potential to identify the critically-important transitions in plate boundary reflectance in the Cascadia subduction system that is located near a major urban center.

(3) Character of the subduction interface

Our data will address key questions regarding the subduction channel, including: Is sediment subducted between the upper and lower plates at all sediment-rich margins? What effect do these sediments, if subducted, have on the properties of the plate interface? At what depth does dewatering of the sediment create a zone of fluid pressure at the plate boundary? What variability exists in the thickness of the subducted sediment channel along the margin, and what effect does this have on seismogenic margin segmentation?

(4) Quantification of pore fluid pressure, fluid budgets, and upstream inputs to the ETS zone.

Fluids have a strong impact on seismic velocities [Yuan et al., 1994] and reflection character on the plate interface and can be identified and interpreted from variations in those properties (e.g., [Bell et al., 2010; Ranero et al., 2008]). Sediments along the Cascadia margin likely contain high volumes of fluid, as rapid deposition from Pleistocene glaciation would have trapped fluid near and outboard of the trench before it could escape. Cascadia is also a primary study site for the phenomenon of episodic tremor and slip (ETS), which is hypothesized to be related to fluid-rich, overpressured zones on the plate boundary [Calkins et al., 2011; Ito and Obara, 2006]. By constraining the amount of sediment being subducted, it should be possible to estimate the amount and distribution of water flux into and escaping from the "subduction conveyor" along this segment of the margin.

(5) Geological controls on methane distribution in an accretionary margin.

Our survey will image the geological controls on an actively venting methane system, including the source, migration pathways, and controls on venting. Archive industry seismic profiles show numerous direct indicators of gas in the area (bright spots, flat spots, BSRs), as well as features that may contribute to gas migration and concentration, including listric normal faults, mud diapirs, and turbiditic channels. Our data will address the following issues: Are the sources of methane gas on the shelf and slope linked or are they distinct systems? How are methane vents on the margin controlled by structural elements, such as faulting, or stratigraphic architecture?

Operational Objectives

Our operational objectives on MGL1212 included the following:

- Acquire 2D multichannel seismic reflection data on nine cross-margin transects and two north-south tie lines using the *Langseth's* 8-km-long streamer and the full 36-gun, 6600 cu. in. airgun array.
- Acquire ancillary geophysical and oceanographic data, including multibeam bathymetry, gravity, magnetics, 3.5 kHz subbottom profiles, acoustic Doppler current profiler (ADCP), and water-column temperature and salinity data (XBT/XCTD).
- Coordinate operations, to maximum extent feasible, with onshore teams (Trehu/Abers) deploying portable seismometers for recording onshore-offshore data, and with the team (Tolstoy/Allen) aboard R/V Thompson recovering ARRA ocean-bottom seismometers.

Education and Outreach Objectives

A major goal of MGL1212 was to conduct the first open-participation, open-access seismic cruise in U.S. academia. Students and early-career scientists applied to sail on MGL1212 via an open application process, aboard the *Langseth* to gain experience in seismic acquisition and processing. This project thus provided a "dry run" of the open-participation model for *Langseth* cruises, which NSF has supported through its sponsorship of the 2010 seismic community workshop (http://www.steveholbrook.com/mlsoc/workshop_report.pdf).

The open-access approach that is captured in the COAST project name will allow for immediate public access to the data acquired in this important focus site. The raw geophysical data and cruise report will be advertised and made available online immediately after the cruise for public use without restriction. We anticipate making these announcements in the GeoPRISMS and UNOLS newsletters and with a short article in *Eos*. Our PI group will process the 2D lines at no cost quickly during and after the cruise, for the purpose of identifying targets and for siting any potential future 3D surveys, in preparation for submission of an open-access, 3D acquisition proposal. Post-stack migrated seismic lines and other shipboard geophysical data will also be freely available to the community, again without restriction. We will particularly encourage the rapid and timely use of the data by PIs of proposals for other programs, including GeoPRISMS.

Cruise Assessment and Recommendations

Cruise Assessment

On the whole, MGL1212 was a successful cruise. Although we did not acquire all of our planned data, we acquired some data on all of our planned transects, and achieved nearly complete seismic coverage of the deformation front and Pleistocene accretionary wedge. Seismic data quality is generally acceptable for standard post-stack migration products (though marginally acceptable for pre-stack migration, as detailed below). The EM122 multibeam worked very well, and we believe that the multibeam bathymetry and backscatter will become very widely used products of this cruise. The seismic data provide beautiful images of structures in the Pleistocene accretionary wedge, including landward-vergent thrusting, widespread bottom-simulating reflections indicating an active methane hydrate system, extensional faulting on the continental shelf and slope (including recently active faulting), and submarine landslides at the deformation front. The top of the subducting slab is weak but present on many lines; we are hopeful that prestack depth migration will produce improved images of the plate boundary.

The co-PI's would like to extend their gratitude to the Captain and entire crew of the *Langseth* for their high level of professionalism and constant communication throughout our cruise. In particular, we would like to bring attention to Dave Martinson, Jay Johnstone and Chief Al Karlyn for helping overcome some fairly serious ship problems (e.g., ship power and propulsion issues) so that our cruise could continue and ultimately succeed (more on that below). We are pleased with the personnel that LDEO has hired and trained on the technical support staff. Those of us who sailed on the *Langseth* in 2008 were very gratified to see both the professional development in individuals we had previously sailed with, as well as some very strong new hires, at all levels of the technical staff. It is a pleasure to sail and work with individuals who are so knowledgable, enthusiastic, and professional.

We did encounter more challenges and problems than should reasonably be expected in a 12-day cruise. Some of these challenges (marine mammals and fishing activity) are endemic to the Cascadia margin and will have to be dealt with by any seismic cruise that conducts future work here. However, as outlined below, some of the challenges we faced were mechanical or electrical failures of ship equipment. In the first 48 hours of our cruise, we experienced a complete loss of electrical power in the main lab (which cost a night of shooting), a partial loss of propulsion in the port engine (which limited us to ~50% power in that engine and apparently threatened a complete shutdown for the remainder of the cruise), a complete breakdown of the level wind on streamer reel #3 (which delayed a mid-cruise recovery and repair of the streamer after its encounter with a tenacious fishing long line), and the breakdown of the Knudsen 3.5 kHz instrument.

Below we offer our frank assessment of the issues we encountered, as well as suggestions for improvements in *Langseth* operations. This analysis is based on conversations with Dave Martinson, Jay Johnstone and Chief Al Karlyn; we have attempted to describe the known issues as accurately as possible. The PIs would also encourage the Marcus Langseth Science Oversight Committee (MLSOC) to review these issues and encourage NSF funding to address fixes where appropriate.

Recommendations

- *Stabilize clean lab power*. During our cruise we experienced a total power failure in the main lab -- something that should never happen during a seismic cruise. The lab typically receives conditioned power through motor generator (MG) sets; in principle, this design should decouple lab power from the engine room. Apparently, while in port (Astoria) there was an earlier failure of the MG sets that caused complete power loss throughout the lab. Nearly a week later, the MG sets failed again early in our survey (Line 1). Because this occurred at night, not only did the scientific crew have to recover from a very serious issue, but shooting could not resume until morning due to IHA limitations. It appears that the poor state of power conditioning in the lab (prior to this failure) may have also led to issues such as premature aging of UPS batteries, etc. The stopgap solution on MGL1212 was to bypass both MG sets and hook the lab directly to "dirty" ship power, with the advantage that a complete power failure would then be unlikely. However, this arrangement appears to be sending too much current to the streamer, causing noisy traces, as well as other issues with lab equipment. Clearly this cannot be a long-term solution. We understand that NSF/LDEO have already approved a high end installation of a UPS/Power conditioner that will effectively isolate the lab and streamer systems from ship's power. This will be a huge improvement and **needs to be installed before either DCPP or SONGS cruises this fall**.
- *Propulsion Issues*. Near or around July 12th we were informed of a serious issue with the port side engine involving some degree of overheating that limited power to about 45% of max. Work since then has provided further evidence for a friction problem likely associated with a faulty bearing (shoe) that may need replacement in port. From what we understand, this repair may range from minor to serious and will await analysis by technicians that await the *Langseth* onshore in Astoria, Oregon. Shortly after the power outage, we also were informed by the Chief of issues with clutching due to a drop in air pressure (a small faculty device was ultimately bypassed). The Chief is hoping to bypass this device altogether through redesign in the near future. We hope that future cruises, especially those that will be towing the full 3D regalia, will be able to **count on full, reliable power from the engine room**.
- *Improve seismic streamer data quality*. The state of noise on the 8 km streamer is problematic at best, and by the end of MGL1212 became unacceptable. After catching a "long line" part way through the cruise, we used that opportunity to swap out some offending sections with short offsets, which helped to a certain degree. Nevertheless, by the end of the cruise, some 80 out of 636 channels — more than 12% of the streamer — had to be killed in processing due to noise issues. For many post-stack migration imaging schemes, this level of noise can be mitigated through editing and/or alpha-trim stacking approaches. In the prestack domain, however, these traces will have to be edited and likely trace interpolated (at great expense of CPU and user time) before any prestack migration and demultiple approaches are attempted. The principal source of the noise appears electrical, as it is characterized by noise bursts that occur simultaneously along the streamer (as shown in a later section of this cruise report); we understand that the issues with lab power contributed to this noise. In the future it is hoped that some of the 40+ km of spares can be brought to bear on this situation (and time will be allocated for this chore before future cruises). Given the state of the streamer, the future of streamer upgrades for the Langseth is becoming a pressing issue. We are aware of efforts being undertaken by the LDEO Marine Office to explore various options for upgrade paths, though we expect funding constraints may hamper some of the options. The ~42 km of spare streamer sections recently acquired by Lamont will help prolong the useful life of the current system, though we note that the condition of those sections is currently unknown. **We recommend that LDEO fully address lab power issues as they relate to streamer noise,**

and that they assess the quality of the "new" 40+ km of streamer sections. This is especially critical before any future 3D cruises are attempted.

- *Repair the Knudsen 3.5 kHz*. The failure of the Knudsen early in our cruise was a blow to our objectives, particularly vis-a-vis the imaging of faults that cut the seafloor. **LDEO should determine the source of the Knudsen failure and take appropriate steps to avoid similar failures in the future**.
- *Additional seismic processing workstations and software licenses*. The *Langseth* should, unequivocally, maintain a shipboard seismic data processing capability that befits her status as the National Marine Seismic Facility. We understand that, historically, the focus on both the *Ewing* and *Langseth* was on data acquisition, with the processing being the sole responsibility of the PI. However, in this era of inexpensive Linux workstations and free academic licenses to packages such as ProMax and Echos, there is no excuse for the *Langseth* to have only one workstation with seismic processing software (proc1) and a second for multibeam processing (proc2). This requires either that the PI's bring their own workstations or accept a minimally productive shipboard processing environment. We have moved beyond the time when PI's wish to ship their own workstations to sea -- this causes unnecessary expense and risk of damage, and it also creates substantial work shipboard for the IT expert (which the Marine Office currently does not have; we sailed without one), who must get the PI's workstations talking to the ship's network, with PI disks cross-mounted to fserve and proc1, etc. And for any cruises that hope to provide open participation, open access, and shipboard processing training, the current setup is just unworkable. **We recommend that LDEO provide four Linux workstations, with one new processing lab table, to create a true processing "station" in the main lab**. This would be a low-cost, high-impact action. There is plenty of room in the spacious main lab to develop a processing "alcove" for future cruises.
- *Improve internet bandwidth to the ship*. In the ever changing digital world we live and work in, it would seem that High Seas Net has probably outlived its usefulness. With effective download speeds much less than dial up, and some 55 folks aboard the ship, downloads were reduced to a crawl. Prior to the lab power outage, the High Seas Net unit required several reboots per day (though ironically that problem seemed to right itself after the lab power failure). Representatives from the PG&E and Edison expressed a willingness to help replace the unit (from what we gather it is about a $50,000 upgrade). We would definitely encourage this win-win move. **We recommend that LDEO investigate upgrade paths to improve the usefulness and bandwidth of shipboard internet**.
- *Improve shipboard networking*. Currently it is not possible to mount cruise-specific folders (e.g., MGL1212proc) using smb mounts. This makes it inconvenient to conduct some processing and analysis on user laptops, since data must first be copied over using *scp*. This should be rectified.
- *Mid-water-column recording module for the Kongsberg EM 122*. We were hoping to record the mid-water column backscatter data from the EM122 (we could see a display of it in the lab, but the license "dongle" had not yet arrived). We understand that the "dongle" is under acquisition; LDEO should install and test this at the earliest opportunity.
- *Creature comforts: address plumbing and cleanliness problems in cabins*. While the Langseth has made great strides over the past few years in general appearance and creature comforts, some work remains to be done. In particular, several leaks and clogged drains occurred. A persistent leak (cause unknown to us) resulted in a wet deck in the long passageway leading between the mess deck and the XBT room; this was covered with a bathroom towel for the duration of our cruise. In addition, we noticed a water leak on the deck of the passageway outside the library. We also heard persistent reports of clogged drains in

the heads and showers. This is reflected in the post-cruise survey of our participants; the only negative things they had to say about the *Langseth* were consistently along these lines:

> *"And the bathroom/showers could use some work (there was a tile missingin ours, and water was dripping through into our room), and some cleaning between cruises would be great."*

> *"Barriers [are needed] in the shower basin floor so water doesn't leave the shower basin and slosh around the head for 3 days until the ship rolls at just the right angle to guide the flow into the drain."*

> *"My only complaint is that common areas are pretty dirty and the cabin I was given was in sorry shape (lots of little broken latches, shelves, leaks etc.) with a very unclean bathroom from the start."*

Survey Maps

Survey Plan

Our original survey plan included nine cross-margin lines, extending from just outboard of the deformation front to approximately the 100 m isobath on the continental shelf, and two north-south tie lines. In addition, we were tasked with acquiring a line on the shelf (labeled “Abers/Trehu”) that represented a landward extension of the Carbotte/Carton Cascadia survey acquired on MGL1211. Shots from all of our lines were also recorded on portable seismometers deployed onshore by Anne Trehu and Geoff Abers.

The map below shows the acquisition plan. Arrows show the direction of acquisition decided upon at sea, after the initial problems were encountered on Lines 11 and 1.

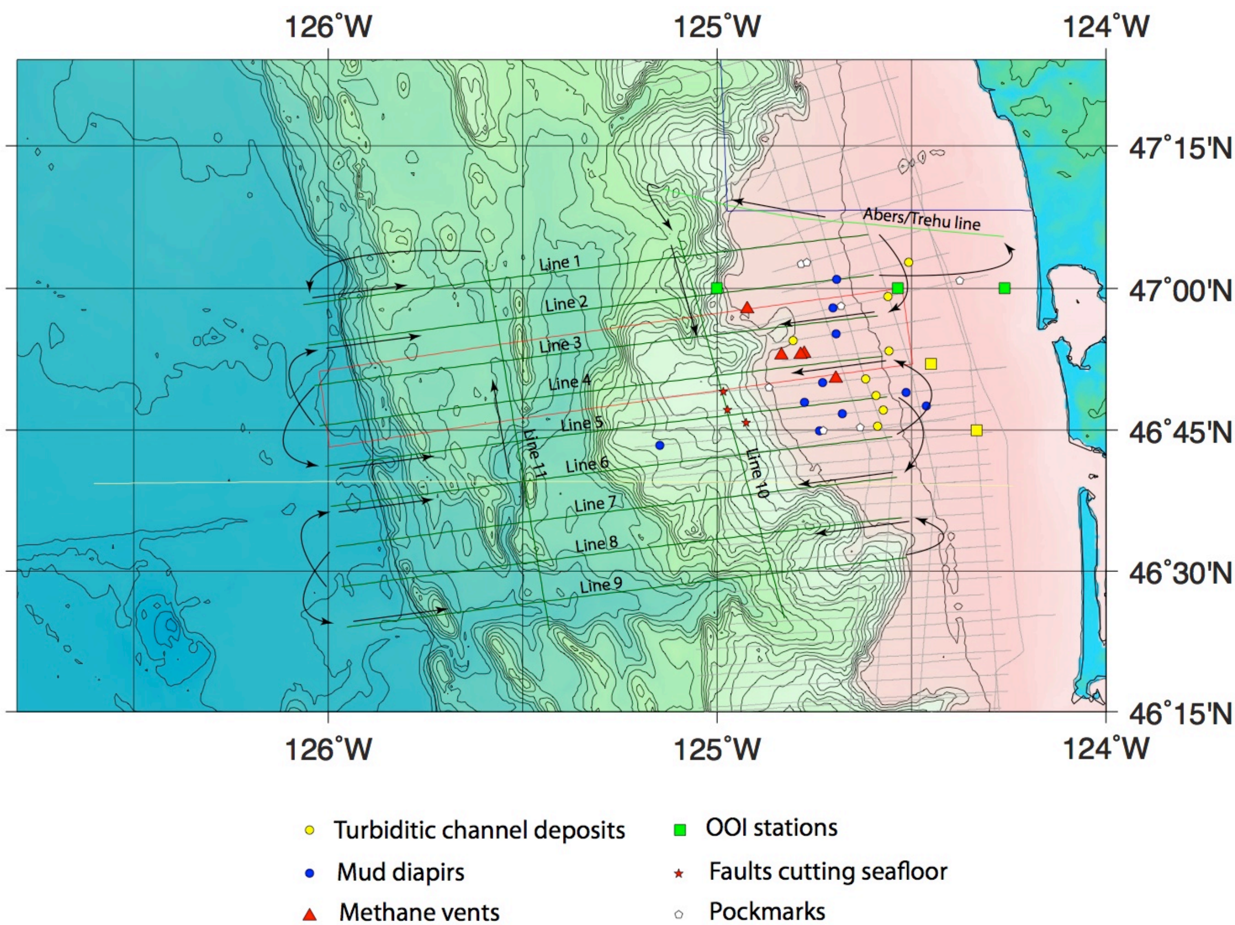


Figure 1. Location map of intended track lines. Arrows show the direction of ship travel during line changes.

Actual Acquisition Map

Our acquisition did not go entirely according to plan, due primarily to mechanical/electrical failures, fishing activity, and abundant marine mammals (which caused rampdowns, shutdowns, and early line terminations to avoid humpbacks reported ahead by the M/V *Northern Light*). In addition, we decided at sea to move Line 10 from its original position on the upper slope, where our data showed little continuous sediment, to a more seaward position through a continuous sedimentary section in the Pleistocene accretionary wedge.

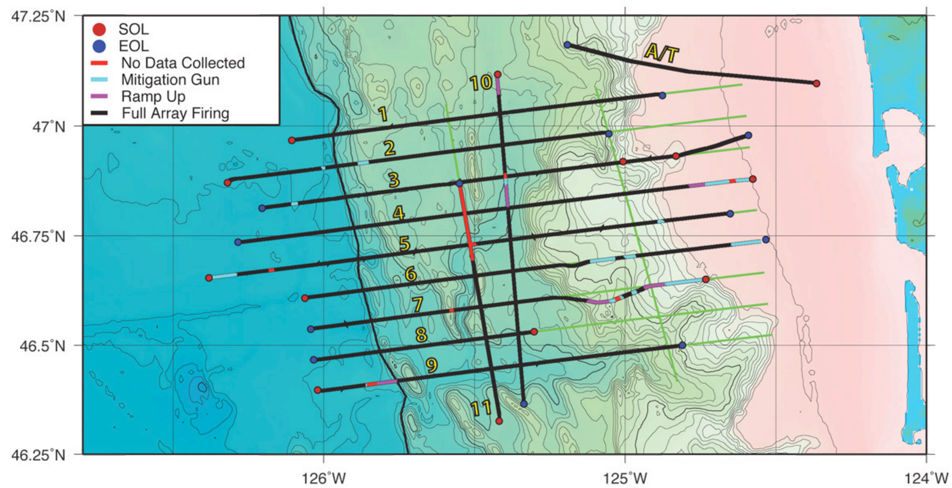


Figure 2. Map of actual track lines, along with indications of gun array status during shooting. This map provides an "at-a-glance" look at survey completion, by comparing thick black lines (full array shooting) to green lines (original plan).

Cascadia Array OBS Map

During our survey, scientists aboard the R/V Thompson were in the same area, recovering the "Cascadia Array" ocean-bottom seismometers. We were in continuous communication with those scientists (including Doug Toomey, Maya Tolstoy, and Richard Allen), both before and during the cruises. Many of the OBS's on the map below were left in place as long as possible in order to maximize recording of our airgun shots.

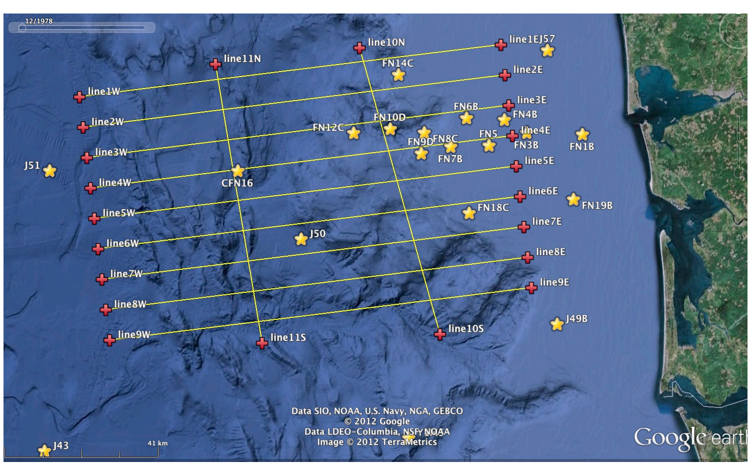


Figure 3. Map of planned track lines, plotted with positions of Cascadia Array ocean-bottom seismometers.

Shotpoint Maps

The maps below show shotpoint numbers for north-south and east-west lines.

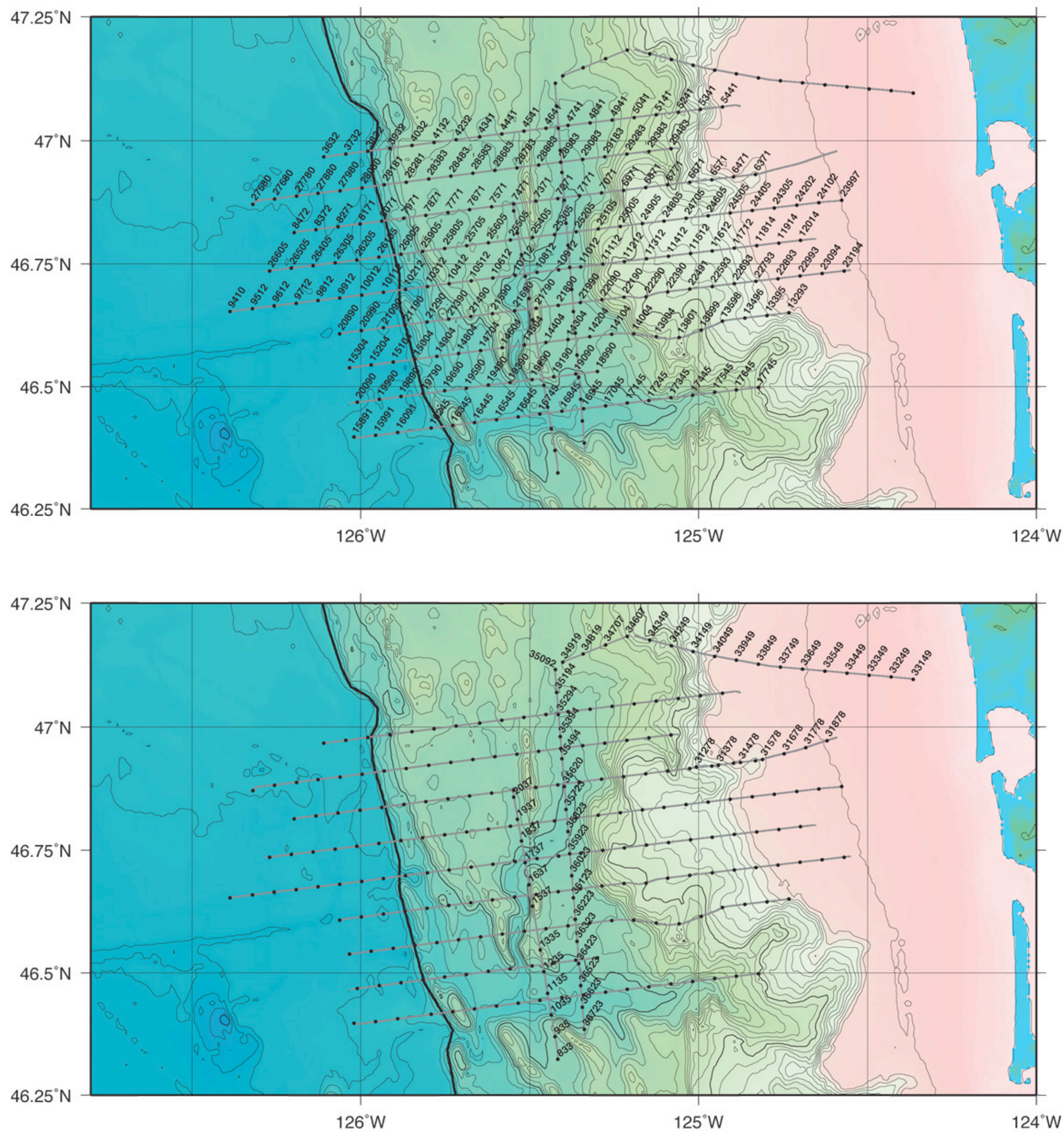


Figure 4. Map of actual track lines, along with indications of gun array status during shooting. This map provides an "at-a-glance" look at survey completion, by comparing thick black lines (full array shooting) to green lines (original plan).

Cruise Participants

R/V *Langseth* Crew List

James E. O'Loughlin	Master
Stanley P. Zeigler, Jr.	Chief Mate
David H. Wolford	2nd Mate
Zachary D. Lemite	3rd Mate
Jason J. Woronowicz	Bosun
Peter C. Piscitello	AB
George G. Cereno	AB
Douglas Hodgson	AB
Jeromiel J. Webster	OS
Lakia M. Jordan	OS
Albert D. Karlyn	Chief Engr.
Ryan P. Vetting	1st Engr.
Chrisse A. Guilas	3rd Engr.
Cameron H. Ruth	3rd Engr.
Philip D. Neis	Electrician
Jerald F. Chase	Oiler
William R. Buchanan	Oiler
Denise Y. Mendoza	Oiler
Michael G. McCoy	Steward
Ricardo Rios	Cook

R/V *Langseth* Technical Staff

Jay D. Johnstone	Science Officer	LDEO
David Martinson	Science Officer	LDEO
Grady C. Henley	Navigator	LDEO
Michael C. Martello	Navigator	Consultant
Bernard K. McKiernan	Science Tech	LDEO
Lisa K. Hawkins	Science Tech	LDEO
Carlos D. Gutierrez	Lead Gunner	LDEO
Weston B. Groves	Gunner	LDEO
Michael P. Tatro	Gunner	LDEO
Christopher T. Francis	Gunner	LDEO

Protected Species Observers

Heidi E. Ingram	Lead PSO	RPS
Meagan J. Cummings	PSO	LDEO
Katherine M. Douglas	PSO	RPS
Emily M. Ellis	PSO	RPS
Tatiana A. Moreno	PSO	RPS

Science Party

W. Steven Holbrook	Chief Scientist	University of Wyoming
Graham M. Kent	Co-Chief Scientist	University of Nevada
Kathleen M. Keranen	Co-Chief Scientist	University of Oklahoma
Kate E. Allstadt	Scientist	University of Washington
Robert E. Anthony	Scientist	New Mexico Tech
Shahar Barak	Scientist	Stanford University
Jeffrey W. Beeson	Scientist	Oregon State University
Janine S. Buehler	Scientist	Scripps Institution of Oceanography
Jacqueline Caplan-Auerbach	Scientist	Western Washington University
Brian M. Covellone	Scientist	University of Rhode Island
Brady A. Flinchum	Scientist	University of Nevada
Ashton F. Flinders	Scientist	University of New Hampshire
Will F. Fortin	Scientist	University of Wyoming
Dalton W. Hawkins	Scientist	University of Oklahoma
Anna M. Kell	Scientist	University of Nevada
Dara K. Merz	Scientist	Western Washington University
Emily C. Roland	Scientist	USGS-Anchorage
Marie S. Salmi	Scientist	University of Washington
Danielle F. Sumy	Scientist	USGS-Pasadena
Harold J. Tobin	Scientist	University of Wisconsin

Preliminary Findings

Accretionary complex structure

- *Contrasting wedge structures.* The Cascadia forearc off Washington comprises two distinct phases of accretionary complex development with contrasting structural age, thickness and internal structure: an outer Pleistocene complex, and an older Miocene complex beneath the upper slope and shelf (McNeill, 1999; Adam et al., 2004). The incoming Juan de Fuca plate carried about 2 seconds TWT of sediment at the deformation front. The Pleistocene complex, which lies immediately inboard, is 40-50 km wide in our study area and is dominated by a series of landward-vergent thrust sheets, as is typical for the northern Oregon and Washington margin (Silver, 1972; Seely, 1977; MacKay, 1995; Flueh et al., 1998; Adam et al., 2004). It has a bathymetric surface taper angle of nearly zero over that width, forming a deep plateau marked by elongate trench-parallel ridges partially to completely buried by slope basin sediment ponds. In the seismic data this complex appears to have a nearly constant “thickness” in two-way travel time, except for local thrust- and fold-thickened regions (though it may also generally thicken landward if velocity increases with distance from the deformation front). Structurally the Pleistocene complex is characterized by folds with wavelengths of 5-10 km, which are often separated by “oases” of virtually undeformed, flat-lying sediments. Some of the folds appear to be fault-cored, while others may be cored by diapirs or other flow structures, as suggested by Fisher et al. (1999). We expect that pre-stack depth migration will greatly improve resolution of these structures.

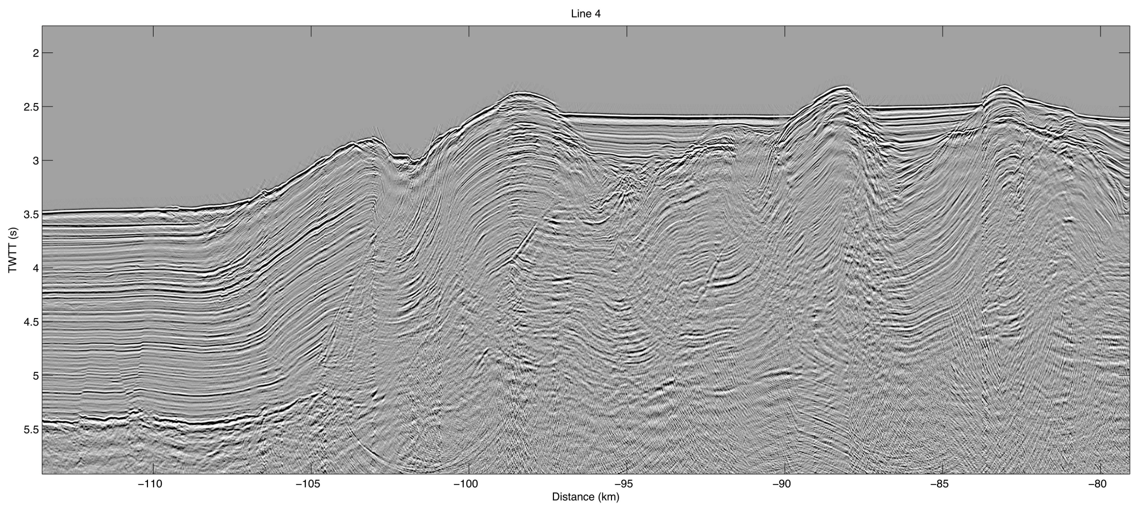


Figure 5. Deformation front imaged on Line 4, near the center of our survey.

In contrast, the Miocene accretionary complex is internally transparent, with only occasional hints of coherent structures — as expected for the Melange and Broken Formation (MBF; McNeill, 1999). We note two observations that suggest that the MBF is internally weak. First, reflections from within the MBF have much lower frequencies than reflections from the overlying section, indicating strong attenuation. Second, listric faults tend to sole out in detachments at or within the top of the MBF (see below), suggesting a strong contrast in internal friction there.

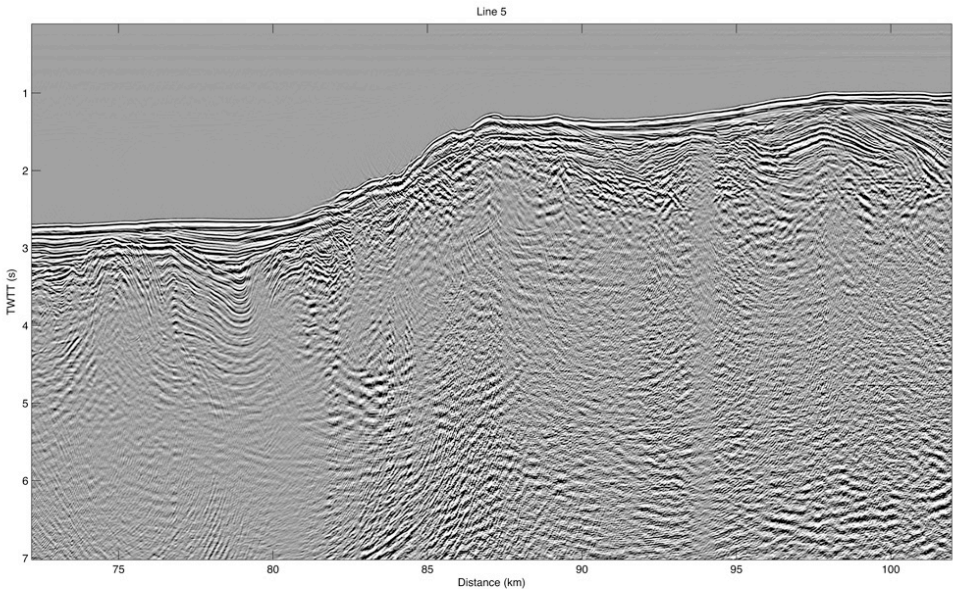


Figure 6. Transition from Pleistocene to Miocene accretionary complexes, across the continental slope. Note the low-frequency reflections that return from the MBF.

• *No clear evidence in current images for subducting sediment.* We cannot yet identify any unambiguous detachments above oceanic crust. At the deformation front across all of our lines, the frontal thrust soles into an apparent décollement either at or very close to the top of oceanic basement reflector. With initial processing, it is hard to evaluate whether that décollement lies at or above basement beneath the outer accretionary wedge. We are optimistic, however, that further processing will reveal more detail about the structure at the base of the accretionary complex.

Plate boundary structure

• *Low impedance contrast on top of downgoing oceanic crust*. The top of oceanic crust is a strong, clear reflection in the incoming Juan de Fuca plate. Beneath the accretionary wedge, however, the top of oceanic crust is weak and intermittent. At this stage of processing it is not clear to what extent this loss of signal is due to processing, out-of-plane scattering, greater signal attenuation through absorption, or intrinsic loss of impedance contrast . However, 2D stacks from other margins (e.g., Nankai – Park et al., 2002) show that the top of oceanic crust can be imaged as a strong reflector beneath other complexly deformed accretionary prisms. If this observation holds up after further processing (including PSDM), it will pose a potential paradox for understanding the mechanics of this margin: the landward-vergent thrusting here is thought to require a low-stress plate boundary - which is easiest to explain by invoking high pore pressure fluids at the plate boundary. But such a fluid-charged plate boundary, whether at the top of the oceanic crust or at a higher level of the section, would be expected to produce a strong reflection, which is not yet observed in our data at this stage of processing.

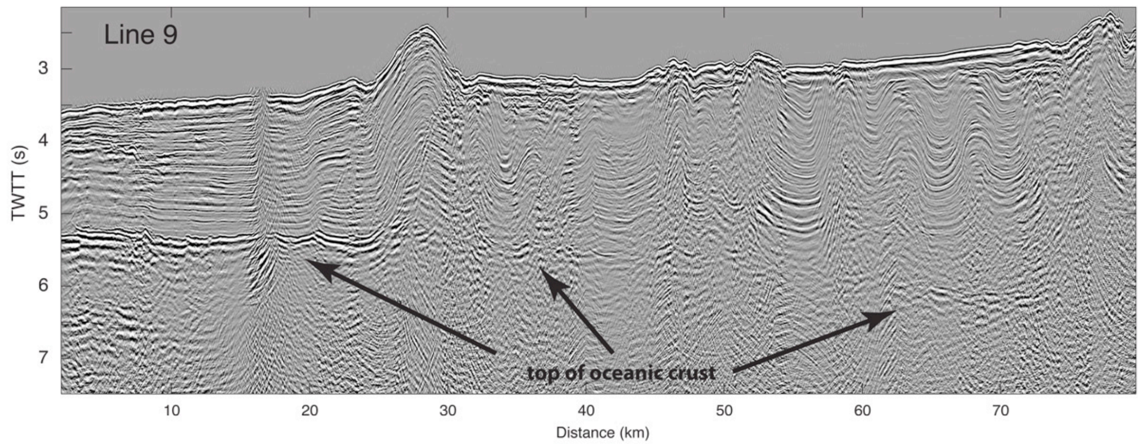


Figure 7. Portion of Line 9, showing likely plate boundary reflections.

Hinge point in downgoing slab. The slab appears to be very gently dipping - perhaps nearly flat - beneath the Pleistocene accretionary complex, which is 40-50 km wide in this area. The slab appears to bend abruptly beneath the outer slope, where it descends more steeply beneath the Miocene accretionary complex. This implies a substantial change on overall taper angle and mechanics of the accretionary wedge.

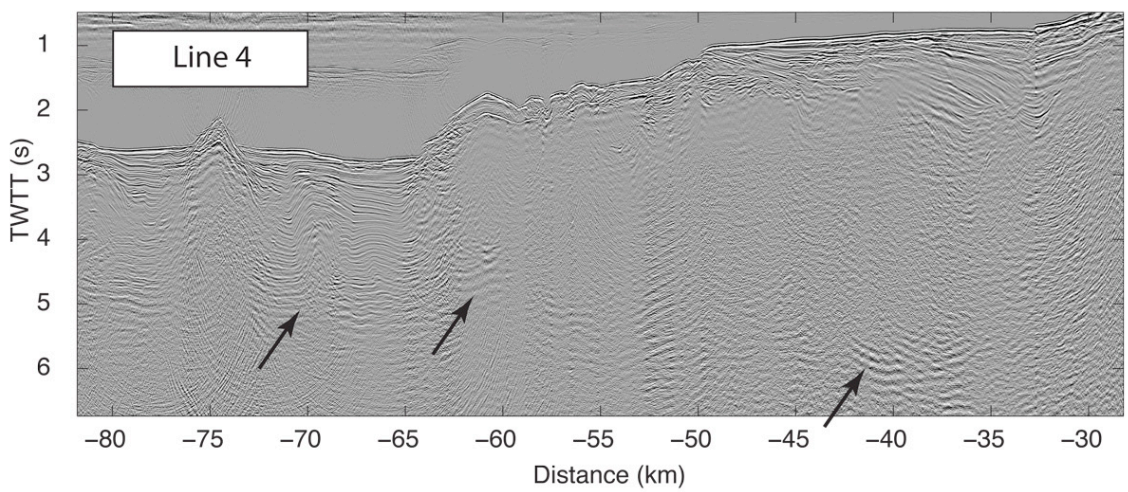


Figure 8. Portion of Line 4, showing likely plate boundary reflections. Note low frequencies.

Methane system

Our data document widespread occurrence of bottom-simulating reflections (BSR) that are indicative of an extensive methane hydrate system on the continental slope and in the Pleistocene accretionary prism.

- BSR's are concentrated on local highs and where beds are steeply dipping, suggesting that they are marking locations of fluid flow out of the accretionary complex.
- On Line 4 the BSR appears to strengthen away from the deformation front, becoming stronger on each successively landward ridge. This may be an indication of progressive compaction and enhanced fluid flow.
- Double BSR's are observed in several places on Line 2, suggesting a highly dynamic methane system.

Shelf extension

- As noted by McNeill et al., the shelf and parts of the upper slope appear to be under extension. Several listric normal faults exist; in most of these faults, the sediments of the hanging wall thicken and fan toward the fault plane, classic hallmarks of growth faults. On Line 3a we imaged a beautiful listric fault originally shown in McNeill et al. (1997) and confirmed her result that the fault plane appears to sole into a horizontal detachment plane. The sedimentary reflections above the fault plane are rotated to steep dips.

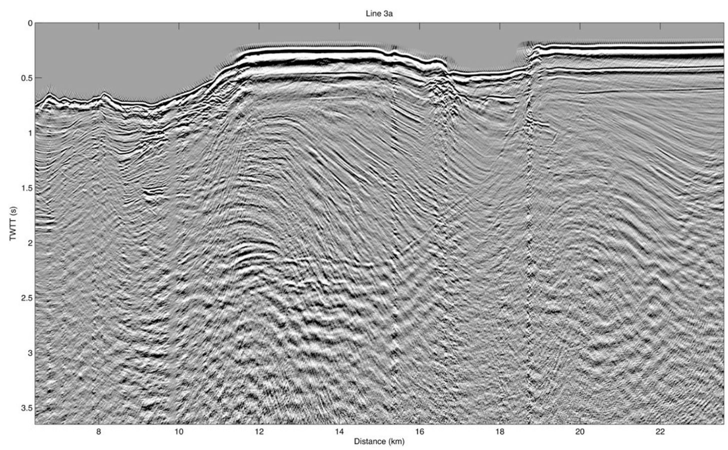


Figure 9. Portion of Line 3a, showing clear listric fault that appears to sole into a horizontal detachment. Note low-frequency reflections below the structure.

- At least one of the prominent listric faults shows displacement at the seafloor, indicating relatively recent activity. We imaged this fault on lines 4 and 5. On the multibeam data the fault shows up as a distinct, continuous, presumably young, scarp that extends at least 10 km along strike. The fault has an arcuate shape at the seafloor, with several changes in azimuth along its surface expression.

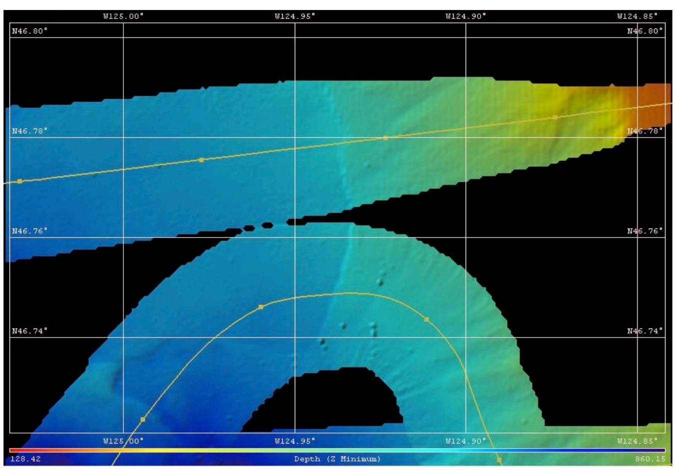


Figure 10. Screen grab of EM122 multibeam bathymetry, showing seafloor expression of normal faulting. The subsurface expression of this fault can be seen in Figure 8 (Line 4), at about x=33 km.

Slope Failures

- The multibeam data show evidence for many slope failures on the margin, from the deformation front to the upper continental slope. These are particularly abundant on the deformation front (figure below); many of the failures leave debris fields on the trench floor, but others do not. The largest of these features measure several km in diameter. The figures below show the abundance of slope failures on the deformation front, as well as the internal structure of a prominent failure crossed by seismic Line 5.

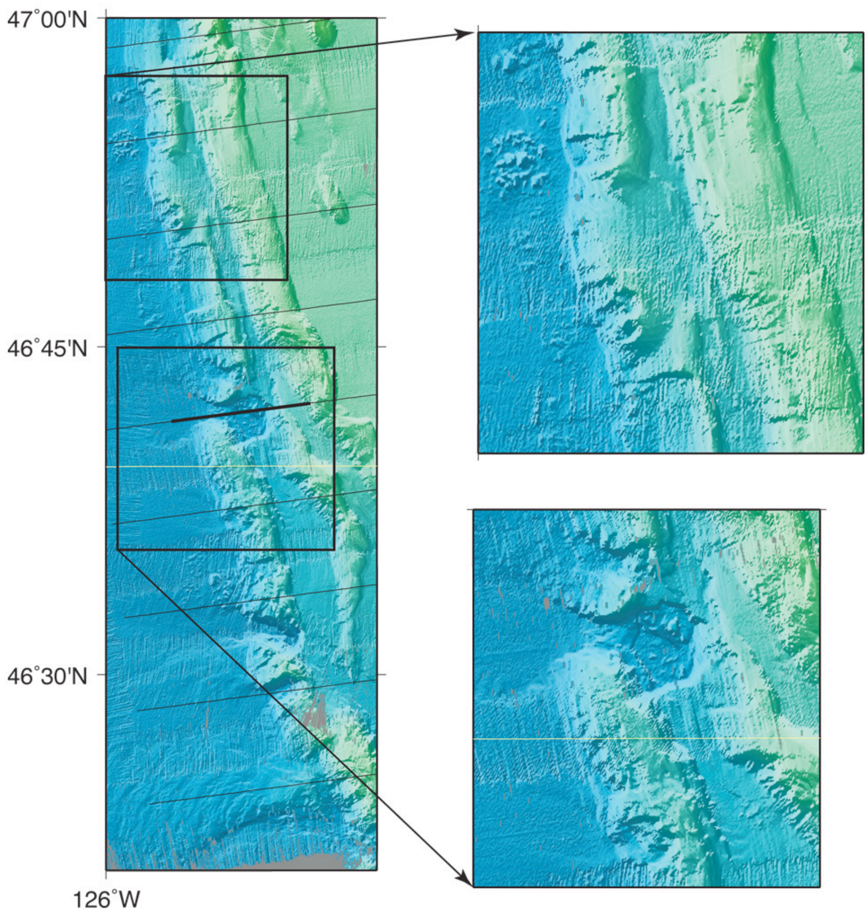


Fig. 11. Mutibeam bathymetry over the deformation front in our survey area. Seismic lines (1-9) are shown as thin lines. Bold line shows location of Line 5 seismic image in figure 12. Zooms of collapse features are shown top right.

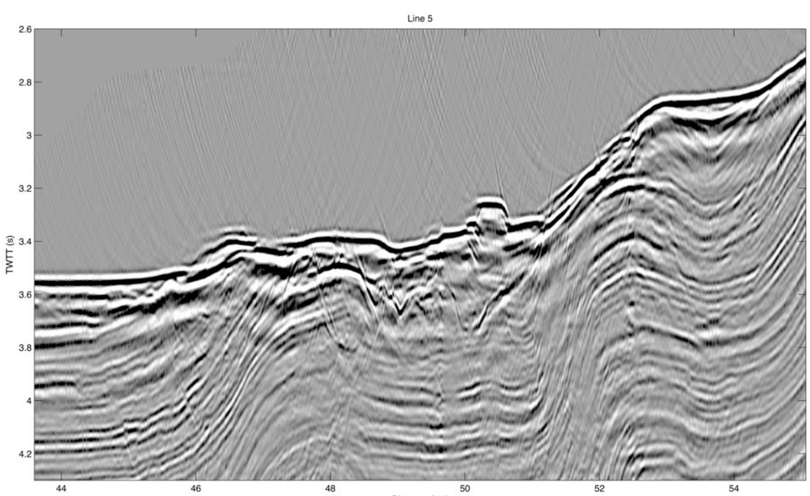


Figure 12. Portion of Line 5 seismic data showing structure within collapse feature. Much of the strata are missing from the decapitated ridge at 46-48 km; a bright, undulating reflector from 48-51 km likely represents the slip plane.

Narrative

NOTE: Unless otherwise indicated, times in this narrative are local time (LT), which is (GMT-7 hrs). i.e., 1200 LT is 1900 Z.

10 July 12 (JD 192) - Tuesday

Most of the science party arrived at PDX today; we drove in one-way rented cars to Astoria and checked in to our hotels. We received news that our IHA had been approved, so we would sail on Thursday morning as scheduled.

11 July 12 (JD 193) - Wednesday

The science party moved onto the ship after lunch. Orientation and tours were held in the afternoon. The PI's met with the *Langseth* technical staff to discuss plans. In the late afternoon we returned the three rental cars to the Hertz office at the tiny Astoria airport; Emily Roland shuttled us back from the airport in her personal car. We all enjoyed a last night ashore.

12 July 12 (JD 194) - Thursday

We woke early for a group photo on the dock at 0730, and we set sail on time at 0900 under gray skies. The pilot disembarked smoothly onto the deck of the pilot boat. After clearing the Columbia Bar (surprisingly smooth), we headed northwest toward the target point for beginning streamer deployment. We began streamer deployment at 1330, a mere 4.5 hours after leaving the dock; the outer two km of reel 1 were deployed first, then attached to the end of reel 3, giving 8 km of streamer.

During streamer deployment, we headed north with the intention of putting ourselves in position to start shooting on the landward side of the Abers/Trehu onshore-offshore line at first light on Friday. However, by late afternoon Meagan Cummings reported to us that an unusually high number of humpback whales had been observed on the transit and streamer deployment. It became immediately clear to us that the humpback population for this area had been seriously underestimated in our IHA: we were only authorized to "take" eleven humpbacks. Given the information at hand, we perceived the risk of encountering humpbacks to be greatest in shallower water, and thus decided that shooting the Abers/Trehu line first would pose an unacceptable risk given our low take limit; this is summarized in the email below:

From: *"W. Steven Holbrook" <steveh@uwyo.edu>*
Date: *Thursday, July 12, 2012 7:26 PM*
To: *Maya Tolstoy <tolstoy@ldeo.columbia.edu>*
Cc: *Trehu Anne <trehu@coas.oregonstate.edu>, Geoff Abers <abers@ldeo.columbia.edu>, Paul Johnson <johnson@ocean.washington.edu>, "rallen@berkeley.edu" <rallen@berkeley.edu>, Graham Kent <gkent@unr.edu>, Katie Keranen <keranen@ou.edu>, Will Fortin <wfortin@uwyo.edu>, Meagan Cummings <cummings@ldeo.columbia.edu>, Sean Higgins <sean@ldeo.columbia.edu>, Jeff Rupert <rupert@ldeo.columbia.edu>*
Subject: *Change in Langseth plans*

All:

Unfortunately we have hit our first snag on the cruise, and it's a potentially serious one. During our transit to our starting point, the MMO's on board have seen 17 humpback whales today. And by 2 pm today, the chase boat (M/V Northern Light) had seen 15 humpbacks. The problem is that our IHA only authorizes us to "take" 11 humpbacks in total for our entire cruise. (this was obviously based on a serious underestimate of the humpback population here). If the population density of these animals remains anything like what we've seen so far, we won't even finish a single line before we have to shut down the guns at the sight of every single humpback. As a result, we need to alter our plans to try to minimize the risk to our survey.

So far we know that humpbacks appear to be plentiful in the shallow water and upper slope. We don't know whether they are also plentiful in deeper water, but we are going to hope so and take our chances there. Therefore we have decided to begin the survey on the southern end of the seaward strike line (waypoint line11S in the attached figure). From there we will turn to the seaward end of Line 1 (waypoint line1W) and work our way landward, at which point we'll assess the humpback population density to inform future shooting decisions.

The upshot of this is likely to be that the Abers/Trehu line will not be shot until the end of our survey. I spoke to Geoff a little while ago, and he assured us that their onshore instruments should be able to record for our entire survey and thus can accommodate an end-of-survey schedule. We have also been in touch with the Lamont Marine Office, who have approved the change in shooting plan.

Meanwhile LDEO will be contacting NMFS to request a revised take limit for humpbacks — but any approval of that request would take several days at least (not counting the weekend).

We'll continue to keep you posted.

Thanks,
-steve

Happy gun strings. (photo: B. Covellone)

We learned of a problem with the port engine (a bearing on the shaft?), which means that it can't be run over 45% capacity (pitch angle). This won't be fixed until after our cruise. As a result, we can't pull gear at more than about 4.6 knots through water. This may cost us some time, as we were hoping to go a bit faster.

13 July 12 (JD 195) - Friday

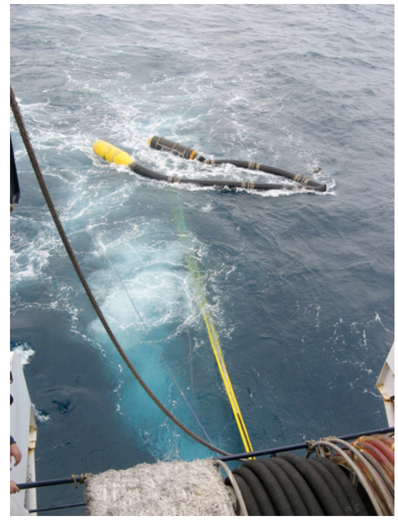
Friday the 13th struck the *Langseth* with a vengeance.

First, while shooting Line 11 from south to north in the early morning hours, we had a total failure of the Spectra recording system, resulting in a loss of 110 shots (a gap of >5 km). Next, in mid-morning a tow rope on gun string #1 broke, causing that string to drift into string #2, resulting in a first-class airgun tangle. In the ensuing effort to untangle the strings (each of which is probably 40 feet long and carries 10 guns), string #3 got caught in the streamer tow leader. All of this took about 12 hours to clear up, repair, and redeploy. As a result, most of Line 11 (our first line) will not be useful.

We turned onto line 1 at about 2200 LT; before we got very far down the line, at 2300 LT, the ship lost power. Emergency lighting came on in the lab within seconds, but all computers and monitors remained dark for 10-15 minutes. Because the ensuing shooting gap occurred at night and lasted (much) more than the 8-minute maximum defined in the IHA, we will have to wait until morning light to begin shooting again (once the PSO's give us the all clear to begin ramp-up). We thus lost the night of shooting. At 2335 we decided to turn around and re-shoot line 1 from the start, since we had only acquired ~6 km of data at the start of the line before the power failure.

Given the poor start and perceived risks to the program going forward, The PI's decided on an amendment to the shooting plan: rather than shoot the dip lines in order (1-9) from north to south, we will make longer turns and shoot the odd lines (1, 3, 5, 7, 9) first, then turn north to do the even lines (8, 6, 4, 2), then do Abers/Trehu, then finish on strike line 10. The thinking here is that, in the event that things continue to go poorly, we will at least get some coverage of the entire survey area on the odd-numbered lines, with the even-numbered lines considered as "infill."

In looking at shot gathers today, we noticed that the source signature for the array at 15 m depth is not very pretty. This is detailed in a separate part of the cruise report.



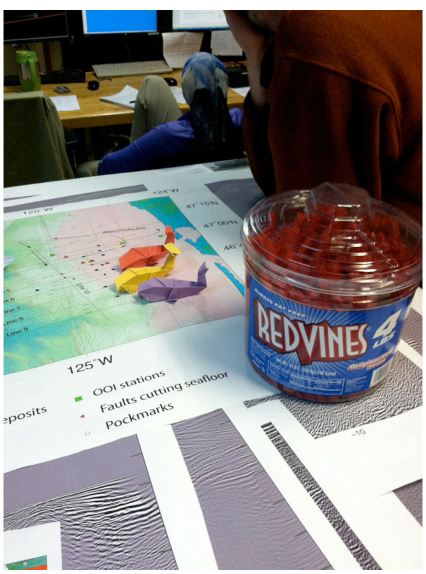
Unhappy gun string. (photo: Jackie)

14 July 12 (JD 196) - Saturday

We started Line 1 normally at 0610 LT. We are hoping for better luck today.

At 1030 LT we had our first daily meeting with the Captain, Lead MMO, Chief, and Science Officers. Much to discuss – mostly the fallout from yesterday's power failure, which was caused by a failure of the M.G. (motor generator) set, which supplies clean power to the lab. The Chief says that, while this type of power failure has been quite rare in the history of the *Langseth*, it has happened twice in the past two weeks, so we are taking a big chance by continuing to run on the current M.G. set – that is, a similar failure could occur at any time. The technical staff have been making contingency plans for future power outages, with the goal of ensuring that we can at least keep our mitigation gun running through an outage. In addition, they are preparing to turn off the M.G. entirely, so that the problem can't affect the lab again. (This will mean that the lab will then be running on dirty power, but Jay and Dave are not concerned about that – "It's not that dirty.")

The Captain expressed concern about long turns in shallow water due to risks of tangling with fishing gear. Rather than the plan we had proposed of shooting the odd-numbered lines first, he preferred a different plan that minimized the length of turns in shallow water. However, we prevailed upon him to keep the current plan in effect.



Temptation, thy name is RedVines.

We informed Heidi (lead MMO) that we were planning to switch to 9 m gun depths at some point during the cruise, due to the relatively poor source signature of the array at 15 m. This will not present a problem from the MMO perspective, since safety radii are explicitly included in the IHA for both 9 and 12 m depths.

A lingering problem from the power outage is that we still can't mount the seismic data file system on proc1 – so we can't yet process the data we're currently collecting. This is a consequence of the abrupt shutdown of the DNS and fileserver during the outage, so all the file systems are screwed up. (The RAIDS even experienced a brownout, but fortunately we did not lose any data.)

Meagan Cummings informed us at 12:45 LT that the Northern Light had not seen any humpbacks at the landward end of Line 1 today. They are heading in to port due to anticipated deterioration in weather.

Will Fortin continued his short course on seismic processing for the BYT's (Bright Young Things).

At around 19:30 LT, while on a line change between Lines 1 and 3 and running the mitigation gun, we received a call from the PSO tower that humpbacks were in the area and were about to enter the 60 m radius. Unfortunately this meant that they were already inside the 160 dB limit for the mit gun (~600 m), so we had just used two of our 11 takes for humpbacks. We shut down the mitigation gun just in time to avoid an impressive concentration of humpbacks that came near the ship (within several hundred meters). We decided to turn to join Line 3 at a point more seaward than intended, in order to avoid the area where the humpbacks appeared to be feeding. We managed to get beyond them (at the full safety radius of ~2 km for the full array) for 30 minutes before nightfall, just in time to begin ramping up the gun array for Line 3.

15 July 12 (JD 197) - Sunday

The winds and seas have picked up today. 15’ swells under gray skies.

Operations went smoothly during the night and morning, and we finished line 5 (our second cross-margin line) shortly after lunch. At that point, instead of turning onto the next line, we continued seaward to provide time for electrician Phil and the technical staff to complete the changeover from M.G. set power to “dirty” power in the lab. This involved pulling floorboards in the lab to access the power distribution system (photo). Altogether this task took about two hours. During this time, we attempted to keep the mitigation gun firing by running Digishot off the UPS. This worked for a while but ultimately we lost the shooting system. By the time we turned back onto the line, we were outside our IHA zone anyway, so we held off on the ramping up the array until we re-entered the IHA boundary.

We started Line 5 at about 1800 LT. We were so far out on the incoming plate that it took hours to reach the deformation zone. The extra line length on the incoming plate made Harold happy.

We learned from Sean Higgins that NSF had granted us an extra day of ship time if we need it. This is welcome news.

Graham Kent gave a lecture on seismic processing at our daily science meeting at 4 pm.

16 July 12 (JD 198) - Monday

The weather is improving, so hopefully people will sleep better. Last night was a sleepless one for many, especially those in the top bunks.

We continued shooting Line 5 through the early morning hours. Around 1000 LT, when we were five or six miles from the landward end of the line, we got a call from the M/V Northern Light that they had identified three humpback whales near their position at the end of the line. Because the 160 dB Level B Harassment distance in our water depth is 15.65 km, these sightings by the *Northern Light* immediately constituted “takes,” bringing our total up to five (out of 11 possible) takes.

At 1440 LT the Captain and Chief came round to report that around 1600 today we would have to take the port engine offline, due to the low air pressure on the clutch (now down below 5 kb). This would require taking the port engine off line for a while to fix the problem. Chief Al took the PI’s down into the engine room to show us where the problem was. At dinner time we learned that the repair worked; there was no impact to science operations.

Jeff Beeson gave us a lecture on the turbidite work that the Goldfinger group at OSU has been doing, and its implications for seismic hazards in Cascadia.

At the start of Line 7, we again saw several humpbacks again and also encountered porpoises, some of whom came over to play in the airguns. This of course triggered a complete shutdown. Much of the landward third or so of Line 7 was plagued by similar power-downs, shutdowns, and ramp ups, making this part of the line minimally useful. We considered circling but decided that, given the difficulties we have encountered so far, the more prudent course would be to live with the gap in favor of preserving our contingency time.

17 July 12 (JD 199) - Tuesday

Swells picked up throughout the day, rising to ~16’ according to the estimate of 2nd Mate Dave Wolford.

Around 1700 LT, while shooting landward in ~1100 m on Line 9, our PSO's observed a humpback, bringing our takes to 7 out of 11. We went to the bridge and asked the Captain to call the Northern Light, who were ~14 km ahead of us in shallower water, to find out what they were seeing. Megan Meyer informed us that they were following two animals believed to be humpbacks, about 1 km north of them. At that moment we were in 1055 m of water. Given the distance to the animals, we would trigger two takes if we continued shooting the full array once we crossed the 1000 m contour. We called the lab and asked them to power down to the mitigation gun, which they did before we reached 1000 m. Given the likely occurrence of more mammals in the shallower water, as well as the approach of darkness (which posed the risk of a night without shooting if things did not go well for us), the PI's conferred and decided to end Line 9 early (by about 12 nm) and turn up to Line 8.

It is clear to us that planning for a 3D survey in this area will require sufficient contingency time to shoot infill on numerous gaps if mammals are as numerous in shallow water as they are now.

During our turn from line 9 to line 8, at around 1900 LT, we learned that the bridge had spotted a high flyer that marks the end of long line fishing gear. Given the trajectory of our turn, it is extremely unlikely that that the streamer will clear the long line (the high flyer passed only 10 m off the gun array). This could cause a major delay if the worst happens. We will have to monitor the situation.

2000 LT: The cable definitely caught on a long line, which it has been dragging for the past hour. At one point a section of the streamer was down at 50 m or a bit more. The SRD's are set to deploy at 40 m, so we probably have several of those fired.

This email summarizes the events:

From: "W. Steven Holbrook" <steveh@uwyo.edu>
Date: Wednesday, July 18, 2012 12:02 AM
To: Anne Trehu <trehu@coas.oregonstate.edu>, Geoff Abers <abers@ldeo.columbia.edu>, Paul Johnson <johnson@ocean.washington.edu>, Maya Tolstoy <tolstoy@ldeo.columbia.edu>
Cc: Sean Higgins <sean@ldeo.columbia.edu>, Graham Kent <gkent@unr.edu>, Katie Keranen <keranen@ou.edu>
Subject: Problems

All:

Tonight (Tuesday 17 July) we experienced two compounding problems that will result in delays to our plan. First, at around 1900 LT, while making an early line change (Line 9 to Line 8) to avoid humpbacks, we caught the streamer in some long line fishing gear. (We weren't even on the shelf when this happened — we were in 1100 m of water…) This pulled the streamer down to >50 m depth (probably deploying the SRD's) and damaged or removed several birds. After an hour of touch-and-go navigating to make sure we would not lose the streamer, we began pulling the streamer aboard, with the plan of replacing the lost or damaged birds, replacing a noisy streamer section or two while we were at it, and being ready to shoot again by morning. This would have cost us about 12 hours, or half of our remaining contingency.

*Almost immediately during streamer recovery (before the head buoy was even on board), the level wind on streamer reel #3 failed, making it impossible to bring the streamer on board. The level wind is, in Jay's word, "f**ked." As a result, we cannot pull the streamer in on its current reel. The plan devised by MGL's hard-working technical staff (it's all hands on deck, and they are doing their very best) is to (1) rig up a winch and wire to the reel 3 level wind to bring in the streamer to the first section, (2) collar off the streamer there and transfer it to adjacent streamer reel #4, (3) pull in as much of the streamer as we can fit onto reel 4, hoping that that will get us back to the problem sections, (3) swap out the bad sections and birds, (4) let out the streamer on winch #4, (5) transfer the streamer back to reel #3 and resume collecting data. Then, once we are collecting data again, they will cannibalize the level wind on winch #4 to fix the level wind on #3, so that we will be able to bring the streamer back on board at the end of the cruise. I understand that one risk in this plan is that the winch on reel #4 is in poor condition, but hopefully it will* *work long enough for this plan to work. If not, the guys have a backup plan involving reels #1 and #2, which I won't trouble you with. Needless to say, the technical staff has a long night ahead of them.*

Meanwhile, Dave Martinson tells me that the EM 122 has failed. I don't know when he'll have a chance to try to fix that, with all the other problems. A shame, too, since we were getting some lovely multibeam data and would have gotten full coverage in the deep water with our 8 km line spacing.

The upshot of all this is that our next moves are a bit uncertain. There seems to be little chance that we will be shooting in the morning. If all goes perfectly, we still have a chance of getting all our lines in. If not, we will adapt to the situation as it unfolds. It is almost certain that we will use the extra day (July 24) granted us by NSF.

We had a couple of good days there, but the return of our bad luck has prompted Science Officer Jay to say, "all I can think is, someone must have brought a horse on board." Will keep you posted. I certainly fear that the BYT's we have brought on board are not getting an accurate picture of how successful a seismic cruise can be.

-steve

18 July 12 (JD 200) - Wednesday

Streamer repair continued throughout the morning as we circled our way back toward a middle point on Line 8. We are hoping to get at least the seaward half of Line 8 before continuing on with the rest of the planned survey.

By the time repairs were completed, Jay, Bern, Dave et al. had replaced seven streamer sections and three missing birds. We came on line at 1455 LT; we will only get about the seaward third of Line 8.

Danielle Sumy gave us a presentation on her research in the Gulf of California at today's all-hands meeting in the movie theater.

We finished Line 8 around 2130 LT and made the turn onto the seaward end of Line 6, on very calm seas.

They are only smiling because this gear didn't completely sever the streamer. (photo: D. Merz)

19 July 12 (JD 201) - Thursday

Shooting continued on Line 6 relatively uneventfully until we approached the shelf break. We received a call that the Northern Light saw two humpbacks at about 12 km away from us. Given the new 9 m gun depth, these animals would enter our 160 dB radius and become "takes" at 12.2 km distance. We conferred and decided that, given the critical importance of determining whether we can image the plate boundary in the shallow water here, we decided to continue shooting, despite the possibility that these animals would soon add to our "take" count. (Our count at the time stood at 7 out of 11.) Shortly thereafter, we learned of two new (?) humpbacks ~4 km away. Our take count was now at 11, our limit. Then at 1358 LT we got a call from the PSO tower that we had exceeded our take limit, which was now at 12. From this point in the survey on, we will be immediately powered down whenever humpbacks come within the 160 dB radius.

Some thoughts summarized here:

From: "W. Steven Holbrook" <steveh@uwyo.edu>
Date: Thursday, July 19, 2012 2:11 PM
To: Sean Higgins <sean@ldeo.columbia.edu>

Subject: Humpbacks

Hi Sean,
We have exceeded our take limit for humpbacks (currently at 12). Can you please give us a frank assessment of our chances for getting a response from NMFS in time to make a difference for us?

At this point, it looks like any time we see humpbacks, we will be powered down to a useless gun size (mitigation gun). The best we can hope for in those situations is that the animals dive and disappear, so that we can start up again after 30 minutes. This procedure will result in huge gaps in our line. Just so you understand why this is critical for this project, we have been so limited in our shooting time on the shelf that we may fail entirely to determine whether it is possible to image the subducting plate boundary on the shelf — a necessity for being able to propose future 3D work in the area.

If we continue to see humpbacks on the shelf, we will likely have large gaps in the Abers/Trehu line, which is in the shallowest water of the cruise.
For the record, in future surveys that intend to use the full airgun array, I think it should be standard procedure for LDEO to request safety radii for 1 string, 2 strings, and the full array. Only being able to shoot either the full array or the 40 cu. in. mitigation gun leaves no flexibility. This is my fault for not making this request specific in the run-up to this cruise. But it would be a great help to future PI's, I suspect, for LDEO to include a range of array sizes as a matter of course.

thanks,
-steve

The landward end of Line 6 turned out to be a whale-watching tour. We had to power down at 1400 LT and were unable to ramp up at all before the end of the line. We decided to shoot the end of the line on the "mit" gun only, as we wanted to make our planned turn into the landward end of Line 4. During our transit, mammals entered the exclusion zone, forcing us to a total shutdown.

We saw the R/V *Thompson* pass by on their mission to recover the ARRA OBS's and deploy thermal blankets. The bridges and chief scientists communicated with each other during this transition.

At the beginning of Line 4 we again saw numerous whales, delaying our ramp up. We briefly discussed the possibility of circling around to time our arrival at the start of the line closer to darkness, but we decided this might violate the spirit (though not the letter) of the IHA, so we decided against changing our plan. We were able to begin ramping up at 1849 LT, in ~150 m of water, 16 km from the intended start of our line. So, we were not able to get a full line shot on the shelf in the center of our survey here. This is a significant scientific loss, as it will make it difficult to

know how well the *Langseth* array will image the plate boundary beneath the shelf.

20 July 12 (JD 202) - Friday

We finished Line 4 in the early morning hours and made the turn onto the seaward end of Line 2.

The M/V *Northern Light* reported quite a congregation of fishing vessels and gear about two-thirds of the way up Line 2. In consultation with the Captain we decided that it would not be viable to shoot the landward third of

Line 2. Instead, we will turn south two miles from the fishing vessels and head back down to Line 3 to shoot the landward portion that we were unable to finish on the first pass. This line has a beautiful listric fault that surfaces near the head of Grays Canyon, which we were unable to completely image earlier in the cruise. After shooting to the landward end of Line 3B, we will then transit over to the Abers/Trehu line firing only the "mit" gun, scheduling a first-light arrival, so that we can then ramp up and shoot the Abers line from landward to seaward in full daylight.

The initial processing of Line 4 shows that it will likely be the "poster boy" for our cruise. Spectacular structures, and a nearly continuous image of the plate boundary across much of the profile, including under the shelf. We are somewhat surprised that the 9 m gun depth has produced our best image of the plate boundary at depth so far. And with the 9 m depth we of course get superior resolution of the shallow structures in the accretionary wedge and slope/shelf. The beauty of this line has really raised spirits around the lab. We are almost giddy about it.

In planning for any future 3D survey, we discussed the need to test several configurations of the guns, including a two-string array, which is what would be used in an actual 3D shoot. We devised a plan, which ought to be doable in the remaining time, to re-shoot a 40-km-long section of line 9 three times, using (1) the current 4-string, 9-m array, (2) a 2-string, 9-m array, and (3) a 2-string, 15-m array. Combined with the first shooting of Line 9, with the full array at 15 m, this will give us a unique imaging comparison with four different source array configurations. The section of Line 9 selected has an apparent reflection from the top of the downgoing plate. This comparison will give us valuable information to select the best source array for any future imaging.

Just after getting up on the shelf on the Line 3 re-shoot, the bridge reported a fishing vessel in the path of the intended line. We diverted to the north of the line, and the rest of the line was finished off the planned track.

21 July 12 (JD 203) – Saturday

At 0145 LT we decided to end Line 3B ~ 5 km early, upon crossing the 100 m contour. Given the fact that we were shooting toward land, and since the Level B harassment contour becomes much larger at that water depth, it seems prudent in terms of protected species impacts to use discretion while approaching the coast at night. We will now shoot the mitigation gun only until turning onto Abers/Trehu just after sunrise.

We came on line for A/T in the early daylight and began ramping up after the 30-minute observation period by the PSO's passed. Amazingly, given the shallow water (which results in a much larger exclusion zone), we were able to shoot the entire A/T line without a single incident – no power-downs, no diversions for fishing vessels. We finished the line at about 1345 LT and began a turn toward our N-S strike line – Line 10, shooting a transition line (MCST08) in between.

We moved Line 10 seaward from its originally envisioned position, in order to catch more of the stratigraphy in the accretionary wedge. We came online on Line 10 at 1700 LT. On both T08 and Line 10 we had a few power-downs (and one shutdown) for porpoises and whales. During this time we reached our take limit on right whale dolphins – so now whenever any are seen within the 160 dB radius, we will have to power down.

Harold Tobin gave us a presentation on the Nankai seismic and drilling results at our daily science lecture.

We've enjoyed relatively calm seas for the last several days, which has contributed to both good data quality and high spirits around the lab. I'm very pleased with the esprit de corps and sense of friendship that has developed during this cruise among the science party; this was not a foregone conclusion in a visiting science party of 20 people (nearly IODP numbers!). The long table in the aft part of the lab has become the social center of the team; at any given time, 8 or 9 people are seated there, cheek by jowl, working on their laptops and shooting the breeze. Even when people aren't on watch, they want to hang out in the lab. We have lucked out in having selected a great team of shipboard students, postdocs, and faculty from among our ~60 applicants for the cruise. As an example of the camaraderie that has developed among this group, the team threw a surprise birthday party for Jackie today, complete with cake and coffee-filter hat.

The cruise blog has really come along well, too. At current count, we have 22 posts, some of which are very creative. The ability for the BYT's to post directly to the blog site, rather than going through a site mediated by the Chief Scientist, is key to giving the participants a feeling of ownership of the site. For this reason, the blog site at the Columbia Earth Institute is not well suited to blogging during the cruise, since non-LDEO people can only post there as "guest blogger" (as far as we understand).

22 July 12 (JD 204) – Sunday

We had a relatively quiet night and reached the south end of Line 10 at about 0400 LT. We began our turn back onto Line 9 for the source array comparison shooting. The first line will be conducted with the full array at 9 m depth.

At our daily 1030 LT meeting with the team leaders, Jay reported that the current best estimate for finishing the shooting of the three source array comparison lines was 0800 LT on Monday. Given the 6 hours needed to pull in the gear and the 4 hours needed to fill the multibeam gap, we will be unable to come in to Astoria on the 23rd. So we will use that extra day NSF gave us after all.

Kate Allstadt gave us a talk on two topics – repeating ice-quakes on Mt. Rainier, and seismic forensics on a giant landslide on Mt. Meager in British Columbia.

23 July 12 (JD 205) – Monday

We finished seismic work this morning, completing Line 9C (the 15-m, two-string re-shoot) at 0900 LT. The tail buoy was aboard by 1300 LT and we headed back toward Line 8 to begin filling in holes in the multibeam data set.

24 July 12 (JD 206) – Tuesday

We filled the main hole in our multibeam set and headed up to Line 3 to try to re-do a part of that line that had very noisy multibeam data during the seismic shoot (due to poor weather). We broke off the multibeam survey at 01:13 LT, in order to head back toward Astoria. The pilot came aboard at 0930 and guided us in to the dock at Astoria, where we tied up around noon LT.

Thanks, Langseth.

Open-Participation Program

Shipboard Education Program

by Jackie Caplan-Auerbach

A major focus of cruise MGL1212 was to expand the user community of the R/V *Langseth* by educating students and early career scientists in marine operations and active source science. This took place through a variety of channels, both formal and informal and at levels from introductory to advanced, including the following:

- Formal lectures each day, including ones on seismic acquisition and processing
- Hands-on experience in seismic processing on freshly acquired lines, from raw data to migrated image
- Hands-on experience (for a subset) in processing multibeam data
- Hands-on experience with streamer operations
- Watch-standing
- Informal discussions on interpretation of seismic data, tectonics of subduction margins
- Additionally, participants are leaving with complete processing flows for Focus and ProMAX, and tools for using the data in Matlab and GMT

Of twenty members of the science party, including one of the PI's, eight had never been aboard a research vessel, and an additional five had never participated in a marine seismic reflection survey. Thus, many of the science party experienced their first introduction to shipboard life: standing watch at all hours, interacting with the ship's crew and navigating the corridors in high seas. Science party members took turns standing 6 hours watches over the geophysical equipment, logging data on missed shots, changes in course and protected species sightings. The science party participated in deck operations: they learned to launch XBT's and contributed to the deployment and recovery of streamers and birds.

It was the goal of the PI's to have all of the seismic data preliminarily processed before our return to shore. All members of the science party were trained in the use of the Paradigm processing software Echoes (formerly Focus), and each spent two hours per day (outside of regular watch hours) engaged in data analysis. This analysis includes processing line geometry, sorting data into common midpoint gathers, picking stacking and interval velocities, picking mutes, identifying bad traces and stacking and migrating seismic lines. Some of the participants also learned to use Promax software. A subset of the science party learned to edit and process multibeam data using MBSystem. Because not all of the participants have access to seismic processing software at their home institutions, everyone was provided with SEGY files of processed data and MATLAB scripts for reading and plotting them. In theory all participants should walk off of the ship with the ability to plot the processed files and perform at least an introductory level of analysis of the tectonics illuminated by the data. Of particular note is that most of the software training in use of Focus and MBSystem was led by graduate students.

Nightly seminars were held in which members of the science party presented their current or past research. Ten members of the science party presented research lectures on topics ranging from the details of seismic processing to seismic oceanography, seismic refraction, the seismicity of oceanic transform faults and the mechanics of accretionary prisms. Not only were these lectures informative, they provided an additional jumping-off point for discussions about active source seismics, subduction tectonics and earthquake science. Several of the presentations were made by graduate students.

While the formal training and seminars were immensely beneficial to all participants, perhaps the most important aspect of shipboard education was simply the informal discussion that went on in the main lab. Nearly all members of the science party spent their off-watch hours in the main lab, and discussions around the lab tables were ubiquitous. These discussions often focused around printouts of recently processed data, or on journal articles focused on Cascadia tectonics. The diverse backgrounds of the science party ensured that many different areas of expertise were represented in these discussions.

Feedback on the Program

At the end of the cruise, we solicited feedback from the participants on the at-sea education and training program (as well as other aspects of the cruise). Here are some representative excerpts from their responses:

"The people were the largest asset on this cruise. Having an open-access format brought together people from different backgrounds with interest in the region for a variety of reasons. Discussions and questions around the seismic images produced were impressive in both depth and breadth due to input from specialists in a different fields… Processing capability needs to be improved. As a national facility there needs to be adequate computing power to handle data efficiently and effectively at the facility. Having all processing routed through only one machine causes much too significant delays in work."

"The best aspect of the cruise for me was probably being able to see this whole process and get a better understanding for the problems one can encounter at sea. I also really enjoyed having the daily lectures and being able to talk with the other scientists and crew and just get a feel for what they do in the geosciences… The processing training I thought was a really good idea, having the two processing packages was cool. I think more work stations and licenses would be better."

"Certainly the format (if that's not too vague) was my favorite thing about this cruise. The presumption from day 1 that this would be a learning/training experience, opened the door right away for careful explanations of the process, and encouraged lots of questions from participants. This included a range of issues from specifics of logistics on the Langseth to theory behind marine reflection seismology. A great, hands on way to learn, and I learned a ton… I'd say the shipboard "education" was very effective. Way easier to learn/retain this stuff when we're exposed to the actual process 30 yards away. In terms of improving upon this, I'd say my only idea would be to share even more of the PI's decision making process with the group. This might be difficult, as everything can't be done in a town-hall meeting type environment (anyway, the crew would get totally frustrated), but could it work to have a PI 'shadow' rotation, something like that? Sci. party participants could help make decisions during one of their watches... once during the cruise."

"It was very nice to see the software, learn to data process, and see images of data that we collected. More work stations would be great (or getting the software to run on our laptops). At first it was a bit hard for me to connect the processing steps that are needed since I could not go through all of them myself… [The cruise] was really a great experience! I enjoyed all the things mentioned above, and the people from all over the place."

"The best aspect of the cruise is meeting all of the other cruise participates and learning about all the different kinds of science they do. Often times you are pigeon holed into thinking like everyone else in your lab (or about the same questions), being with another more diverse group 24 hours a day for two weeks really expands the way you not only approach questions you may already have but opens you up to questions you may have never thought of… I really enjoyed the shipboard lecturers; they were a great way to learn about the theory and purpose of each data processing step. The lectures from other ship participants were also really valuable… enjoyed having the opportunity to process the data shipboard. It made me feel more "connected" to the data we collected. Also it was a great way to experience something that I may not experience during my own graduate career, which was my motivation for participating in the cruise in the first place. More workstations would be helpful so more than one person can actively process data. "

"The daily lectures were awesome! Once again this [dis]plays the diversity, from oceanography, subduction zones, the San Andreas Fault zone and landslides. I learned a ton with the lectures. They were also selected at an appropriate time so that everyone could make it. I really liked how we were informed of operations before the lectures started… [The shipboard processing training] was extremely helpful. Although there was only one computer the experience was priceless. The software made visualization easy. This really helped tie a lot of concepts that I have learned in class together… I think the main lab needs more seating. Since it is command central this is where everyone seemed to hang out. There was only one bench out there and it was always packed full, unless it was 2AM. "

"[The best aspect was] learning and experiencing offshore seismic acquisition and data processing, and meeting other early-career scientists from other universities with different research projects and interests… [The shipboard processing training] was very valuable. It would be great to have multiple work stations that can run simultaneously."

"Best aspect of the cruise: Being introduced to active seismic methods and how research is conducted at sea and gaining ideas on how to incorporate such methods into my own research problems… Data processing: Was an excellent introduction and I feel like I have a good idea for how the data processing is done and why and I could probably do a rudimentary job processing a line myself, if not with complete confidence on how to pick velocities and mutes properly, though I think that probably just comes with time… Best aspect of cruise: getting to know a diverse group of other scientists, discussing research, the life of a scientist, and playing ping pong."

Appendices

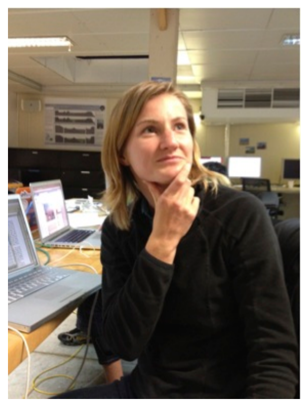
Photos: Scientific and Technical Personnel

**nicknames by GM Kent*

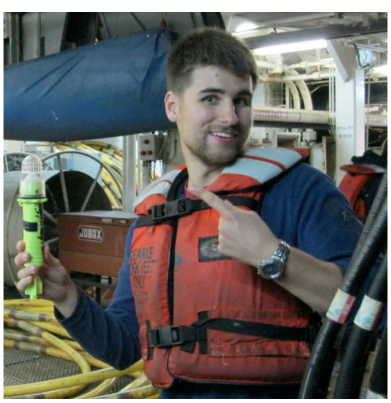
Steve "No Fear 2" Holbrook
Chief Scientist
University of Wyoming

Graham "Sleepy" Kent
Co-Chief Scientist
University of Nevada

Katie "Clutch" Keranen
Co-Chief Scientist
University of Oklahoma



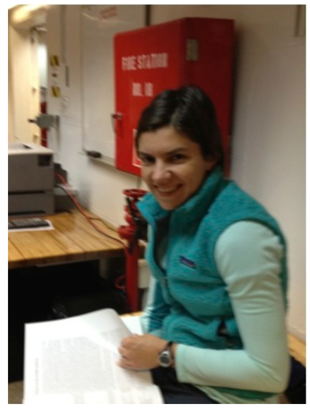
Kate "Kate Plus 8" Allstadt
Scientist
University of Washington



Rob "Caddy" Anthony
Scientist
New Mexico Tech

Shahar "Data" Barak
Scientist
Stanford University

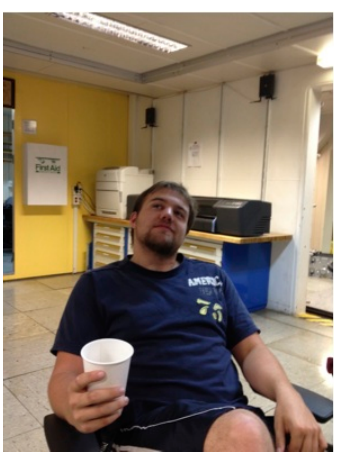
Jeff "Bennifer" Beeson
Scientist
Oregon State University



Janine "House of Cards" Buehler
Scientist
Scripps Institution of Oceanography

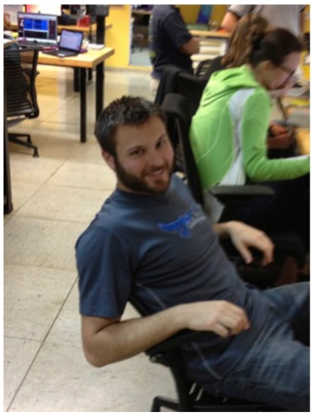
Jackie "Jackie O" Caplan-Auerbach
Scientist
Western Washington University

Brian "Oh Brian" Covellone
Scientist
University of Rhode Island

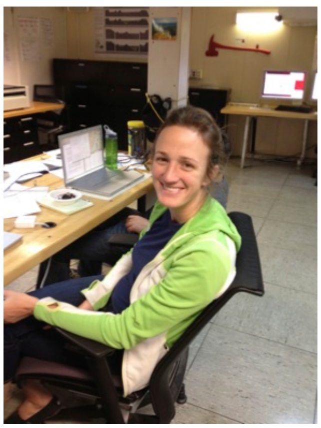


Brady "Wedding Planner" Flinchum
Scientist
University of Nevada

Ashton "Two and a Half" Flinders
Scientist
University of New Hampshire

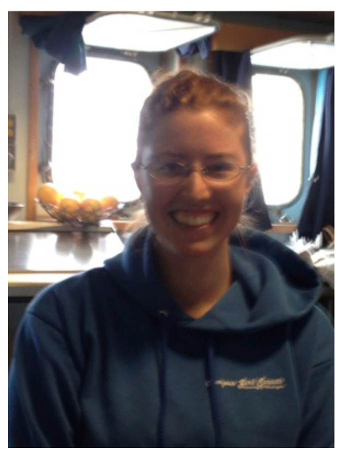

Will “Will.I.Am” Fortin
Scientist
University of Wyoming

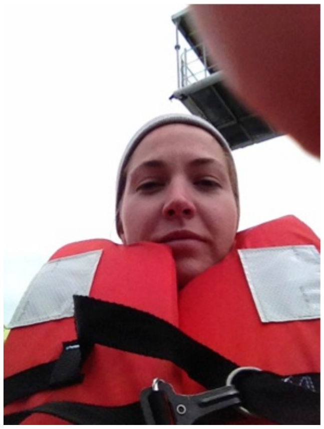

Dalton “Mario” Hawkins
Scientist
University of Oklahoma


Annie “Y’All” Kell
Scientist
University of Nevada

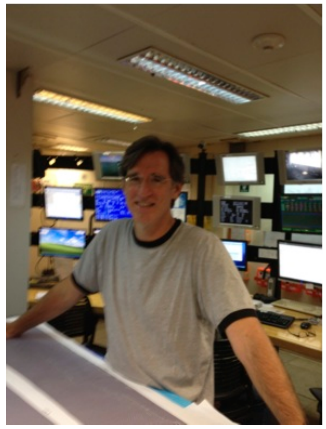

Dara “Needles” Merz
Scientist
Western Washington University


Emily “Ems” Roland
Scientist
USGS-Anchorage


Marie “Nightwalker” Salmi
Scientist
University of Washington



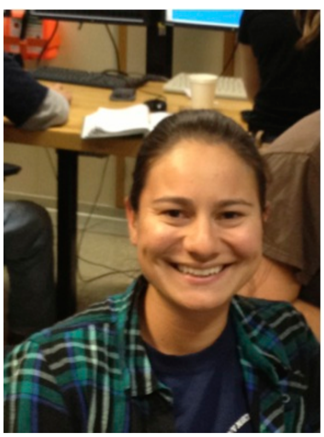
Danielle “Steele” Sumy
Scientist
USGS-Pasadena



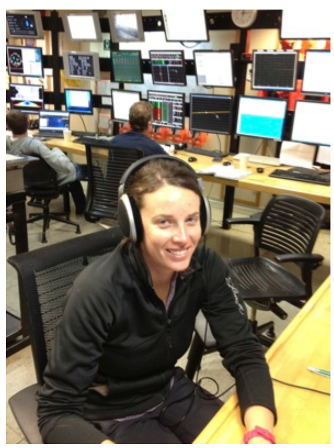
Harold “Drill Baby Drill” Tobin
Scientist
University of Wisconsin

Meagan Cummings
PSO

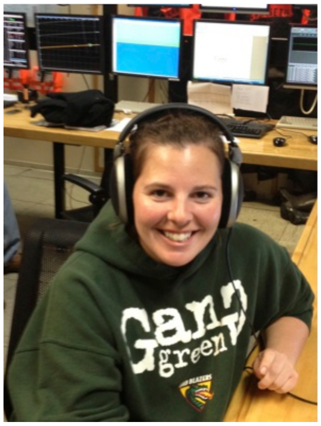
Katherine Douglas
PSO



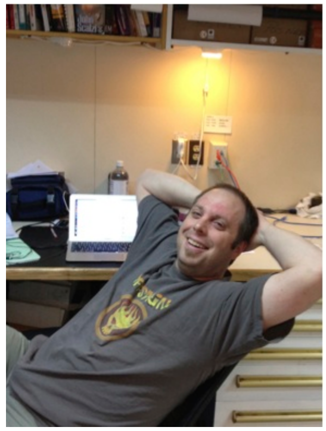
Tatiana Morena
PSO



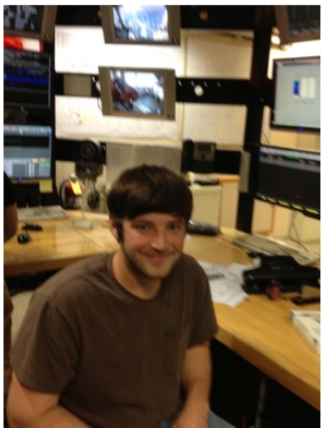
Heidi Ingram
Lead PSO



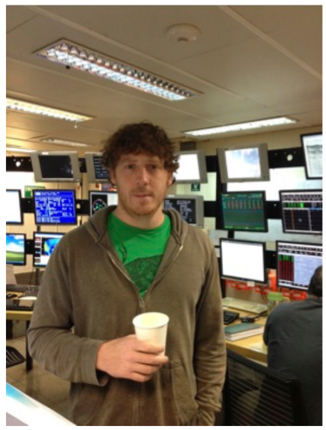
Emily Ellis
PSO



Jay Johnstone
Science Officer

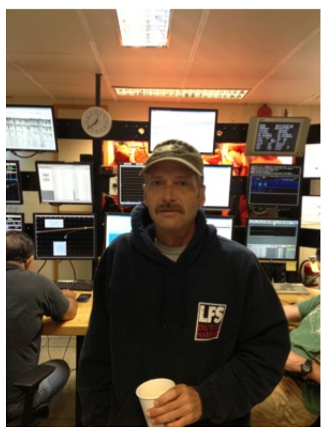


Wes Groves
Gunner



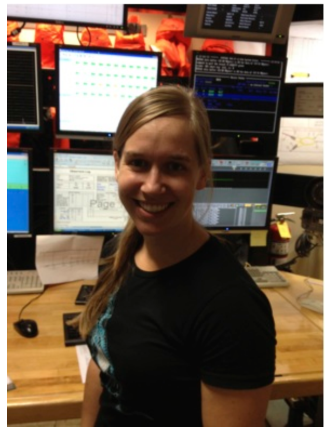
Michael Tatro
Gunner

Carlos Gutierrez
Lead Gunner



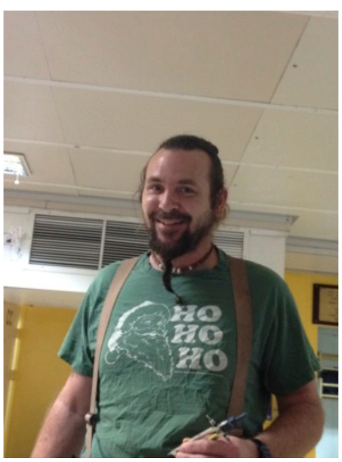
Christopher Francis
Gunner


Dave Martinson
Science Officer


Lisa Hawkins
Science Tech

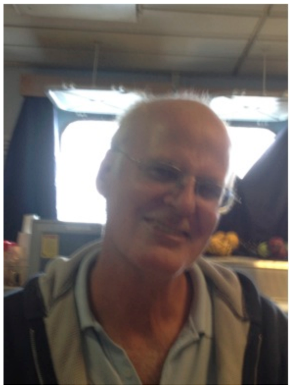

Grady Henley
Navigator

Mike Martello
Naviguesser



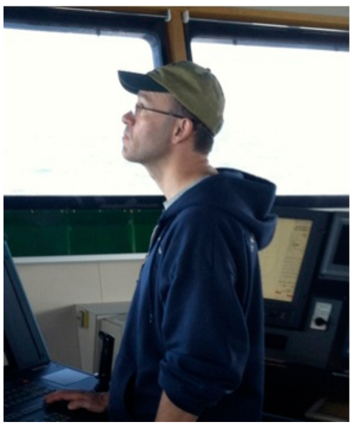
Bern McKiernan
Science Tech

Photos: Ship's Crew

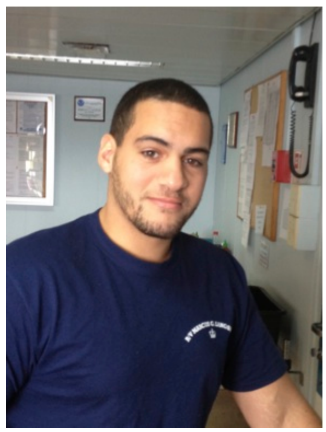


James O'Loughlin
Master

Stanley Zeigler
Chief Mate



David Wolford
2nd Mate

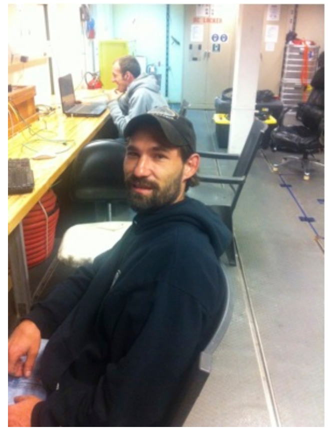


Zachary Lemite
3rd Mate

George Cereno
AB

Douglas Hodgson
AB

Peter Piscitello
AB



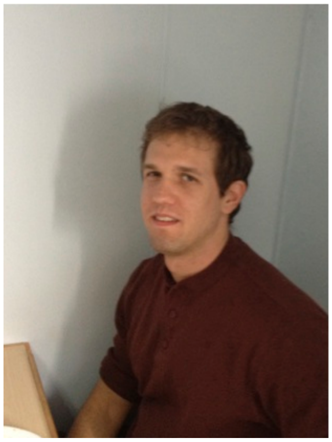
Jason Woronowicz
Bosun

Jeromiel Webster
OS

Lakia Jordan
OS

Albert Karlyn
Chief Engineer

Ryan Vetting
1st Engineer

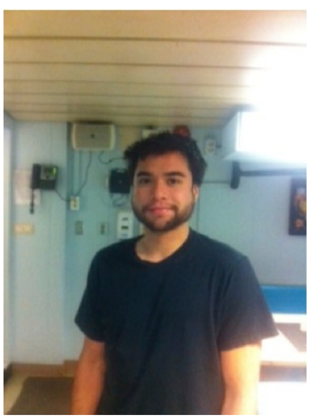


Cameron Ruth
2nd Engineer

Chrisse Guilas
3rd Engineer

Philip Neis
Electrician

Jerald Chase
Oiler



William Buchanan
Oiler

Denise Mendoza
Oiler

Michael McCoy
Steward

Ricardo "Ricky" Rios
Cook

eLog

A sample of the ship's eLog, which is the electronic log kept by watchstanders in the main lab, is appended below. The entire eLog is available upon request.

==
$@MID@$: 1
Date: Thu, 12 Jul 2012 16:00:56 +0000
Record time: 2012-07-12T15:55
Author: dmm
Type: Comment/Event
Subject: Sailing away
Attachment:
Encoding: HTML
==
<p>Depart Astoria for Holbrook cruise.</p>
$@MID@$: 2
Date: Thu, 12 Jul 2012 16:22:38 +0000
Record time: 2012-07-12T16:21
Author: Janine Buehler
Type: ADCP
Subject: started ADCP, 16:20
Attachment:
Encoding: HTML
==

$@MID@$: 3
Date: Thu, 12 Jul 2012 17:28:15 +0000
Record time: 2012-07-12T17:27
Author: dmm
Type: Comment/Event
Subject: Pilot away
Attachment:
Encoding: HTML
==

$@MID@$: 4
Date: Thu, 12 Jul 2012 18:01:31 +0000
Record time: 2012-07-12T17:47
Author: Annie Kell
Type: TSG
Subject: TSFG online and recording
Attachment:
Encoding: HTML
==

$@MID@$: 5
Date: Thu, 12 Jul 2012 18:02:37 +0000
Record time: 2012-07-12T17:53
Author: Annie Kell
Type: Knudsen
Subject: Knudssen 3.5 khz online and recording
Attachment:
Encoding: HTML
==

Shipboard Seismic Data Processing

Data storage and conversion

Data originated from the Syntrak recording system and were written into Seisnet internal files. All data were automatically replicated from Seisnet to individual SEG-D shot files (.RAW extension) on digital 'reels', stored on the fserve with RAID backup. Each reel of .RAW files included 240 shots (5 GB of data). Each shot gather consisted of 636 traces of 16.382-second record length, recorded at 2 ms sample rate, generating 32244 bytes/trace. The fserve drive is also mounted onto a server (proc1) with Echos and ProMAX seismic processing software. On the proc1 server, the SEG-D data were converted to one SEG-Y file for each line, in the shot domain, using a script calling sioseis (see example below). All .RAW files and .segy files were backed-up on multiple external hard drives by the science party after each line was acquired.

Example .csh file for SEG-D to SEG-Y conversion:

```
#! /bin/csh
#
#   Remember to run script "init_script" (sioseis-seisnet daemon)
#
#if( $#argv < 2 ) then
#    echo "Usage: stack line-number plot-direction(ltr/rtl)"
#    exit 1
#endif
#set LINENO = $1
#set DIR = $2

set filein = listfile_line4.txt
set fileout = /data/seismic/MGL1212proc/seisdata/line4/line4

ls /data/seismic/MGL1212-segd/TAPE0079.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp1.txt
ls /data/seismic/MGL1212-segd/TAPE0080.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp2.txt
ls /data/seismic/MGL1212-segd/TAPE0081.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp3.txt
ls /data/seismic/MGL1212-segd/TAPE0082.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp4.txt
ls /data/seismic/MGL1212-segd/TAPE0083.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp5.txt
ls /data/seismic/MGL1212-segd/TAPE0084.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp6.txt
ls /data/seismic/MGL1212-segd/TAPE0085.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp7.txt
ls /data/seismic/MGL1212-segd/TAPE0086.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp8.txt
ls /data/seismic/MGL1212-segd/TAPE0087.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp9.txt
ls /data/seismic/MGL1212-segd/TAPE0088.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp10.txt
ls /data/seismic/MGL1212-segd/TAPE0089.REEL/R*.RAW | awk '{print $1}' > ! /data/seismic/MGL1212proc/seisdata/line4/temp11.txt

#ls /cr0/Data/MGL0804/TAPE0012.REEL/R*.RAW | awk '{print $1}' > ! /arenal1/wfortin/seisdata/scripts/temp#.txt

cat  /data/seismic/MGL1212proc/seisdata/line4/temp1.txt /data/seismic/MGL1212proc/seisdata/line4/temp2.txt /data/seismic/MGL1212proc/seisd
ata/line4/temp3.txt /data/seismic/MGL1212proc/seisdata/line4/temp4.txt  /data/seismic/MGL1212proc/seisdata/line4/temp5.txt /data/seismic/M
GL1212proc/seisdata/line4/temp6.txt /data/seismic/MGL1212proc/seisdata/line4/temp7.txt /data/seismic/MGL1212proc/seisdata/line4/temp8.txt
/data/seismic/MGL1212proc/seisdata/line4/temp9.txt /data/seismic/MGL1212proc/seisdata/line4/temp10.txt /data/seismic/MGL1212proc/seisdata/
line4/temp11.txt >! listfile_line4.txt

rm temp*

/opt/sioseis/bin/sioseis << eof

procs segddin diskoe end

segddin
  ftr 1 ltr 636
  fcset 1 lcset 1
  listpath $filein
  end
end

diskoe   # Write out disk file
 fon 0
 opath $fileout.segy end
end
```

end
eof

Seismic Data Processing

Both the Echos (formerly FOCUS) and ProMAX processing packages were used to process data onboard the ship, with Echos used for routine processing of each line. Will Fortin (UWyoming) led the main shipboard processing efforts. Each member of the science party participated in processing in rotating shifts around the clock. A migrated image was available for each line within the first 12-24 hrs after being acquired. The processing flow consisted of the following steps:

- Assign geometry
- Data input
- Sort data – shot domain to CDP domain
- Kill bad traces
- Define NMO velocity functions (200 or 256 CDP increment)
- Top and bottom mute (same CDP increment as velocity function)
- Stack CDP gathers
- Bandpass filter (6-40 Hz for 15-m guns; 6-70 Hz for 9-m guns)
- Kirchoff post-stack time migration (migrating the top 9 seconds of data, using Echos default parameters). No maximum dip, maximum frequency, or maximum aperture parameters were set in Echos (default values were not modified).

Top mutes eliminated NMO-stretched data and high-amplitude direct arrivals. Bottom mutes were picked to suppress the water bottom multiple by muting the near traces from just above the first WB multiple.

One problem encountered onboard was that Echos and ProMAX would crash the server if both were running at the same time, by consuming and not releasing all 24 GB of RAM on the server. The server was rebooted many times as a result. Because of this conflict, Echos was used as the primary processing package. A complete flow was run in ProMAX for Line 5 to generate a flow for participants who have access to only ProMAX following the cruise. This flow sequence was placed as a zipped archive on the public fserve.

Seismic Reflection Data: Lines, Shot Numbers, and Reels

This table shows the "reel" or "tape" numbers associated with all the lines acquired in the COAST survey.

Seq#: The sequence number of the line (i.e., the order it was shot in the survey)
Tapes: The "reel numbers", or folders into which the raw SEGD shot files are written
Line: The line number we gave to the line (i.e., just a name)
fsp: First shot point
lsp: Last shot point

Note that the first and last shot points may have slight discrepancies between the observer log (obslog), the OBSIP shotlog file (obsip), and the list of shots in the merged segy files (lsd).

seq#	tapes	Line	obsip fsp	obsip lsp	obslog fsp	obslog lsp	lsd fsp	lsd lsp	comments
1	1-5	11	833	2063	833	2064	835	2065	
3	8	1	3226	3435	3226	3433	n/a	n/a	
4	9-16	1A	3632	5517	3632	5517	3632	5517	our processed line 1 is named A1 in the ship's logs
5	17-25	3	6371	8484	6371	8484	6371	8484	
6	26-37	5	9410	12085	9419	12085	9410	12086	
8	40-49	7	13293	15320	13293	15320	13293	15320	
10	52-59	9	15891	17766	15891	17766	15891	17767	
11	60-64	8	18990	20127	18994	20127	18993	20127	
13	67-76	6	20890	23250	20890	23250	20890	23251	
15	79-89	4	23997	26627	23997	26627	23997	26627	
17	92-100	2	27580	29524	27580	29524	27580	29525	
18	101-103	3A	31278	31923	31278	31923	31278	31924	
20	106-111	NT01	33149	34425	33149	34425	33149	34425	our processed line AT is named NT01 in the ship's logs
22	114-121	10	35092	36775	35092	36775	35092	36771	
23	122-126	9A	40465	41497	40465	41497	40465	41480	
24	127-131	9B	42244	43268	42244	43268	42244	43203	
25	132-135	9C	45630	46500	45630	46500	45630	46501	
Turn Lines:									
2	6-7	T01	2843	3292					
7	38-39	T02	12346	12633					
9	50-51	T03	15530	15788					
12	65-66	T04	20222	20482					
14	77-78	T05	23503	23769					
16	90-91	T06	27021	27283					
19	104-105	T07	32006	32341					
21	112-113	T08	34607	34928					

The table below shows the GMT time of the first and last shot in each line acquired during the COAST survey.

seq#	tapes	Line	obsip fsp	obsip lsp	Date fsp	Time fsp	Date lsp	Time lsp
1	1-5	11	833	2063	7/13/12	9:36:51	7/13/12	17:26:27
3	8	1	3226	3435	7/14/12	4:41:28	7/14/12	6:04:56
4	9-16	1A	3632	5517	7/14/12	13:10:27	7/15/12	0:42:44
5	17-25	3	6371	8484	7/15/12	5:15:14	7/15/12	18:37:33
6	26-37	5	9410	12085	7/16/12	1:00:40	7/16/12	17:30:38
8	40-49	7	13293	15320	7/16/12	21:02:05	7/17/12	10:38:15
10	52-59	9	15891	17766	7/17/12	13:00:54	7/18/12	0:15:00
11	60-64	8	18990	20127	7/18/12	22:32:05	7/19/12	5:28:51
13	67-76	6	20890	23250	7/19/12	7:44:32	7/19/12	22:02:21
15	79-89	4	23997	26627	7/20/12	0:18:41	7/20/12	15:11:29
17	92-100	2	27580	29524	7/20/12	17:08:53	7/21/12	4:09:19
18	101-103	3A	31278	31923	7/21/12	5:08:45	7/21/12	8:48:17
20	106-111	NT01	33149	34425	7/21/12	12:57:33	7/21/12	21:42:59
22	114-121	10	35092	36775	7/22/12	0:19:41	7/22/12	11:11:31
23	122-126	9A	40465	41497	7/22/12	15:25:40	7/22/12	21:47:22
24	127-131	9B	42244	43268	7/23/12	0:14:58	7/23/12	7:25:20
25	132-135	9C	45630	46500	7/23/12	10:42:18	7/23/12	16:03:43
Turn Lines:								
2	6-7	T01	2843	3292	7/14/12	00:26:46	7/14/12	3:33:18
7	38-39	T02	12346	12633	7/16/12	17:39:10	7/16/12	19:38:56
9	50-51	T03	15530	15788	7/17/12	10:55:15	7/17/12	12:46:22
12	65-66	T04	20222	20482	7/19/12	5:49:46	7/19/12	7:30:04
14	77-78	T05	23503	23769	7/19/12	22:09:45	7/19/12	23:51:14
16	90-91	T06	27021	27283	7/20/12	15:22:11	7/20/12	16:57:09
19	104-105	T07	32006	32341	7/21/12	8:59:18	7/21/12	11:34:19
21	112-113	T08	34607	34928	7/21/12	21:55:04	7/22/12	0:04:21

Shot time files in the OBSIP (OBS Instrument Pool) format were created shipboard by Jay Johnstone. These files have names keyed to the sequence number of each line, e.g., the shot file for Line 7 is called "Seq008_MGL1212MCS07.shotlog". These files are in ASCII format; an example of a few lines of one of these files is shown below.

```
0013293 2012-07-16 21:02:05.439866  46.651174 -124.728150  46.651142 -124.731260  376.3 MGL1212MCS07
0013294 2012-07-16 21:02:29.223865  46.651100 -124.728785  46.651099 -124.731902  381.0 MGL1212MCS07
0013295 2012-07-16 21:02:52.955870  46.651049 -124.729437  46.651054 -124.732556  382.7 MGL1212MCS07
0013296 2012-07-16 21:03:16.378866  46.651001 -124.730088  46.651007 -124.733204  375.1 MGL1212MCS07
0013297 2012-07-16 21:03:39.933873  46.650954 -124.730734  46.650956 -124.733850  375.0 MGL1212MCS07
0013298 2012-07-16 21:04:04.539872  46.650908 -124.731383  46.650886 -124.734497  371.6 MGL1212MCS07
0013299 2012-07-16 21:04:30.225871  46.650858 -124.732036  46.650849 -124.735149  369.6 MGL1212MCS07
0013300 2012-07-16 21:04:55.694864  46.650803 -124.732687  46.650791 -124.735800  360.0 MGL1212MCS07
0013301 2012-07-16 21:05:20.475868  46.650755 -124.733334  46.650737 -124.736448  352.8 MGL1212MCS07
0013302 2012-07-16 21:05:45.444870  46.650715 -124.733982  46.650689 -124.737093  343.0 MGL1212MCS07
0013303 2012-07-16 21:06:12.020870  46.650668 -124.734629  46.650626 -124.737742  331.8 MGL1212MCS07
```

The fields in this file are, from left to right, shot number, date, shot time to the nearest microsecond, latitude and longitude of the source array, latitude and longitude of the ship, and the line number.

Gun offsets, streamer configuration, and recording parameters

(All information in this section as provided by the *Langseth's* technical staff.)

The table below shows the record length, sample rate, gun depth, and source arrays used during MGL1212.

Sequence	line name	sp spacing	streamer length	sample rate	record length	source sub-array used	source depth	streamer depth	COS-CNG	comment
001	MGL1212MCS11	50	8000	2ms	16384	ALL	15	15	264	2D MCS
002	MGL1212MCST01	50	8000	2ms	16384	ALL	15	15	264	2D MCS
003	MGL1212MCS01	50	8000	2ms	16384	ALL	15	15	264	2D MCS
004	MGL1212MCS01A	50	8000	2ms	16384	ALL	15	15	264	2D MCS
005	MGL1212MCS03	50	8000	2ms	16384	ALL	15	15	264	2D MCS
006	MGL1212MCS05	50	8000	2ms	16384	ALL	15	15	264	2D MCS
007	MGL1212MCST02	50	8000	2ms	16384	ALL	15	15	264	2D MCS
008	MGL1212MCS07	50	8000	2ms	16384	ALL	15	15	264	2D MCS
009	MGL1212MCST03	50	8000	2ms	16384	ALL	15	15	264	2D MCS
010	MGL1212MCS09	50	8000	2ms	16384	ALL	15	15	264	2D MCS
011	MGL1212MCS08	50	8000	2ms	16384	ALL	9	9	264	2D MCS
012	MGL1212MCST04	50	8000	2ms	16384	ALL	9	9	264	2D MCS
013	MGL1212MCS06	50	8000	2ms	16384	ALL	9	9	264	2D MCS
014	MGL1212MCST05	50	8000	2ms	16384	ALL	9	9	264	2D MCS
015	MGL1212MCS04	50	8000	2ms	16384	ALL	9	9	264	2D MCS
016	MGL1212MCST06	50	8000	2ms	16384	ALL	9	9	264	2D MCS
017	MGL1212MCS02	50	8000	2ms	16384	ALL	9	9	264	2D MCS
018	MGL1212MCS03A	50	8000	2ms	16384	ALL	9	9	264	2D MCS
019	MGL1212MCST07	50	8000	2ms	16384	ALL	9	9	264	2D MCS
020	MGL1212NTMCS01	50	8000	2ms	16384	ALL	9	9	264	2D MCS
021	MGL1212MCST08	50	8000	2ms	16384	ALL	9	9	264	2D MCS
022	MGL1212MCS10	50	8000	2ms	16384	ALL	9	9	264	2D MCS
023	MGL1212MCS09A	50	8000	2ms	16384	ALL	9	9	264	2D MCS
024	MGL1212MCS09B	50	8000	2ms	16384	3&4	9	9	264	EVALUATION OF 09M DEPTH OF SOU
025	MGL1212MCS09C	50	8000	2ms	16384	1&2	15	15	264	EVALUATION OF 15M DEPTH OF SOU

Below are figures detailing the setback diagrams and gun array configuration during the cruise:

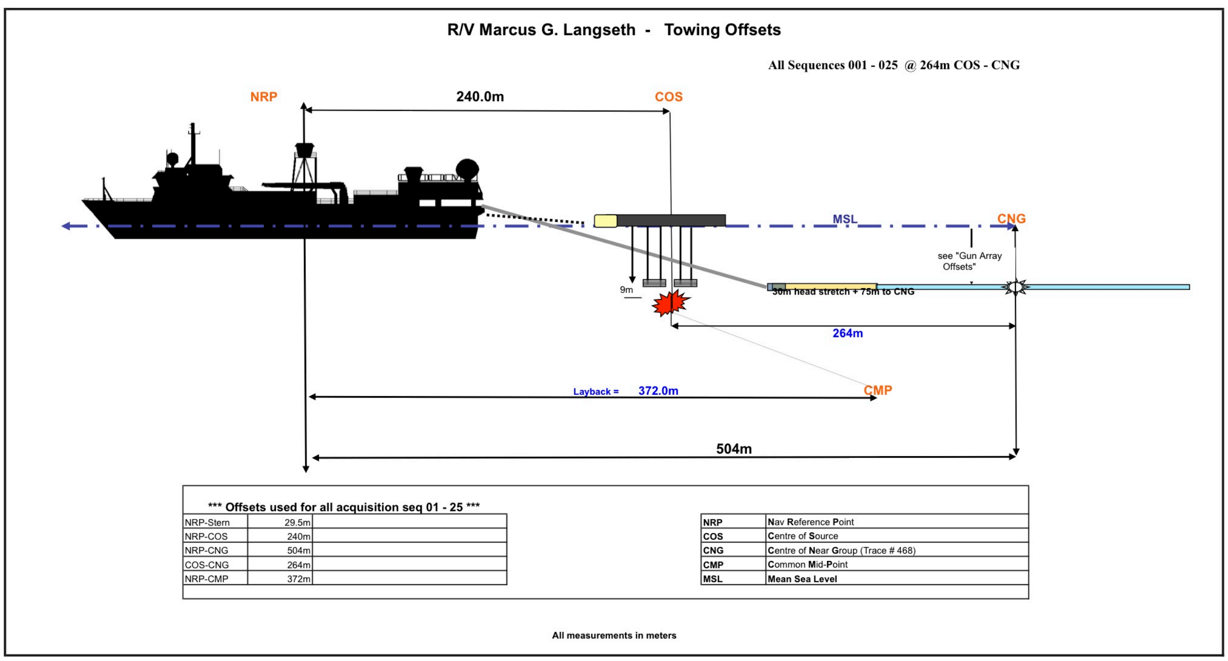


Figure 13. Setback diagram of MGL1212. Source-to-near-channel offset was 264 m.

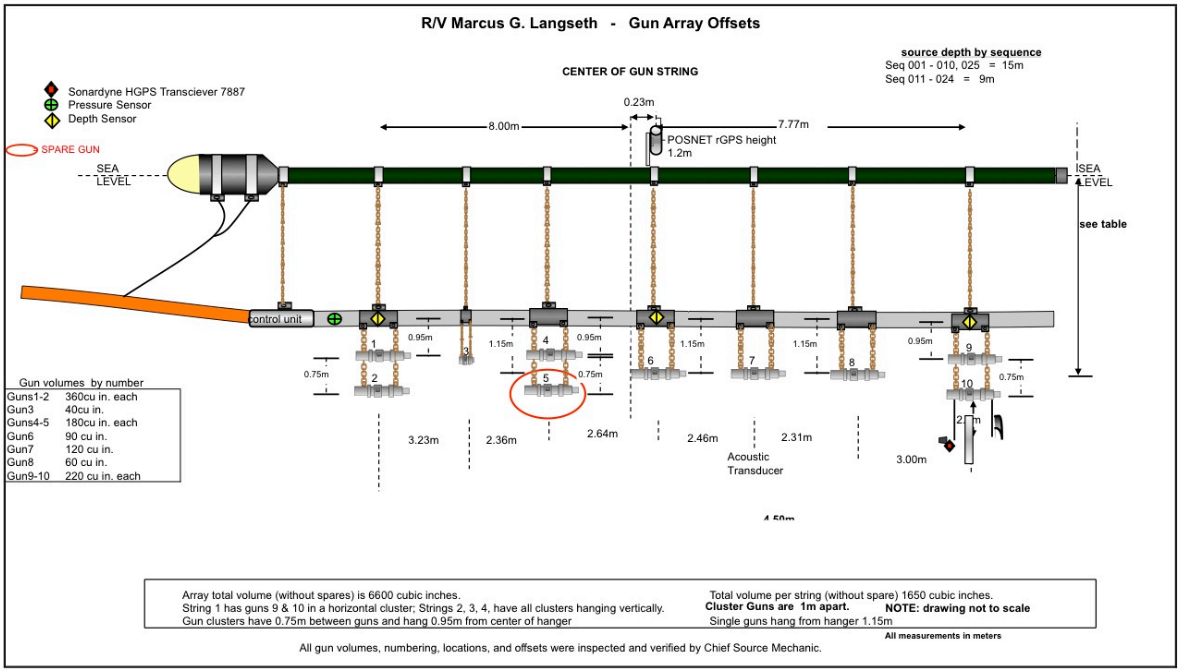


Figure 14 (above). Gun array offsets during MGL1212.

R/V Marcus G. Langseth "tow" configuratiion

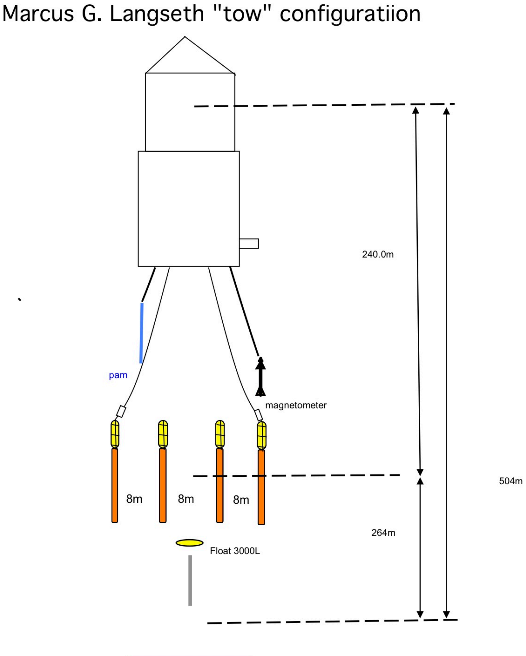
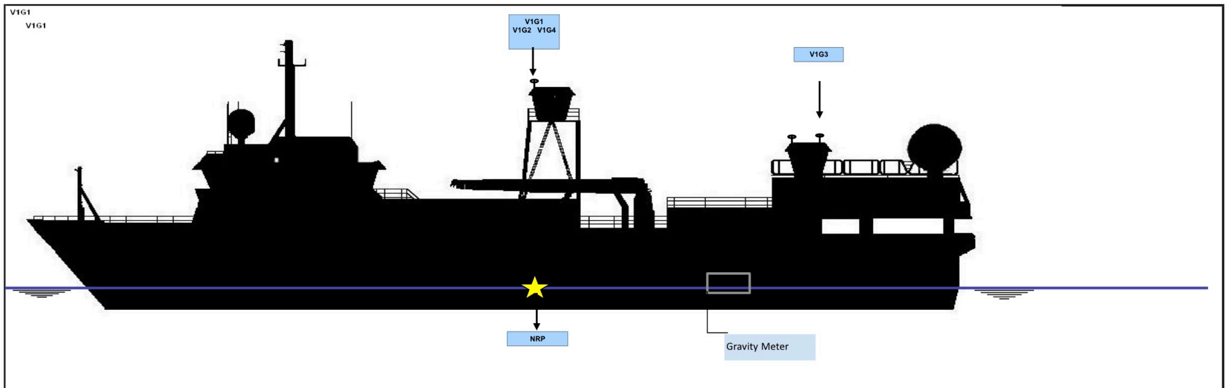
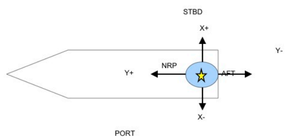


Figure 15 (left). Tow configuration of the gun strings during MGL1212.





Note: All Echosounders are used in Spectra with 6.6m ship's draft correction applied.

All measurements in meters

		STBD/PORT (X)	FORE/AFT (Y)	UP/DOWN (Z)
NRP	NAVIGATION REFERENCE POINT	0.00	0.00	0.00
V1G1	C-Nav 3050	0.00	0.00	-16.90
V1G2	SeaPath 200	0.00	1.50	-16.90
V1G3	C-Nav 2000	4.87	-15.27	-14.50
V1G4	Pos MV	-1.30	1.20	-16.90
V1R1	PosNet	-1.30	0.00	-16.90
EM122	Multibeam Transducer Array	0.00	20.20	7.49
MRU	Seapath MRU	2.30	-14.16	-4.30
BGM	Bell Gravity Meter	4.40	-13.10	-3.49

Figure 16. Antenna locations on R/V Langseth during MGL1212.

Seismic Reflection Data: Migrated Stacks of Lines 1-10

Here we present initial migrated stacks of Lines 1-10 from the COAST survey. These lines were all processed shipboard, principally by the student/postdoc/faculty participants. These images (and the corresponding SEGY files) are all open-access.

The processing flow for each of these lines included the following: geometry assignment, CMP sort, trace editing, velocity analysis at 200 CMP interval, alpha-trim stack, post-stack time migration, bandpass filtering, seafloor mute, and display AGC. Sections are displayed below using a matlab script that is available upon request.

Figure 17. Line 1 (15 m source and streamer depth; full source array)

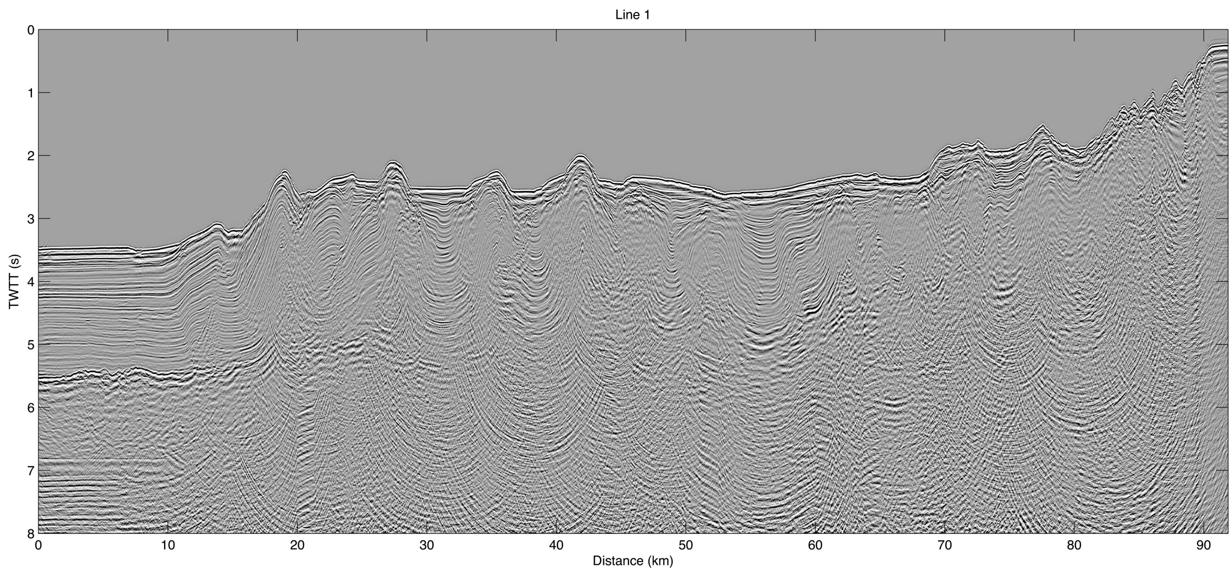


Figure 18. Line 2 (9 m source and streamer depth; full source array)

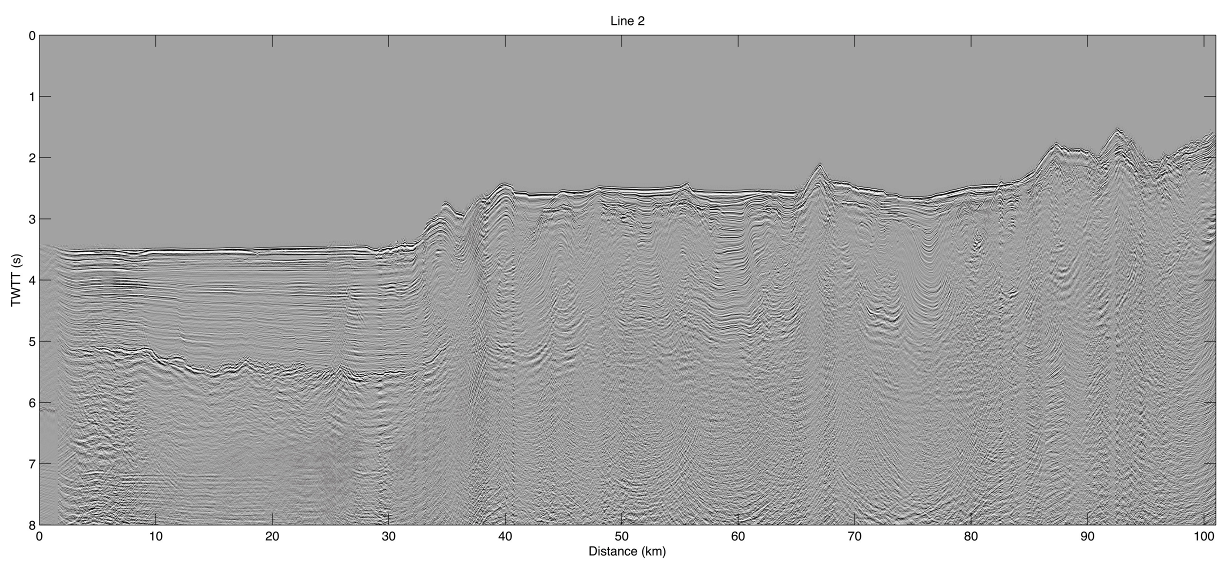


Figure 19. Line 3 (15 m source and streamer depth; full source array)

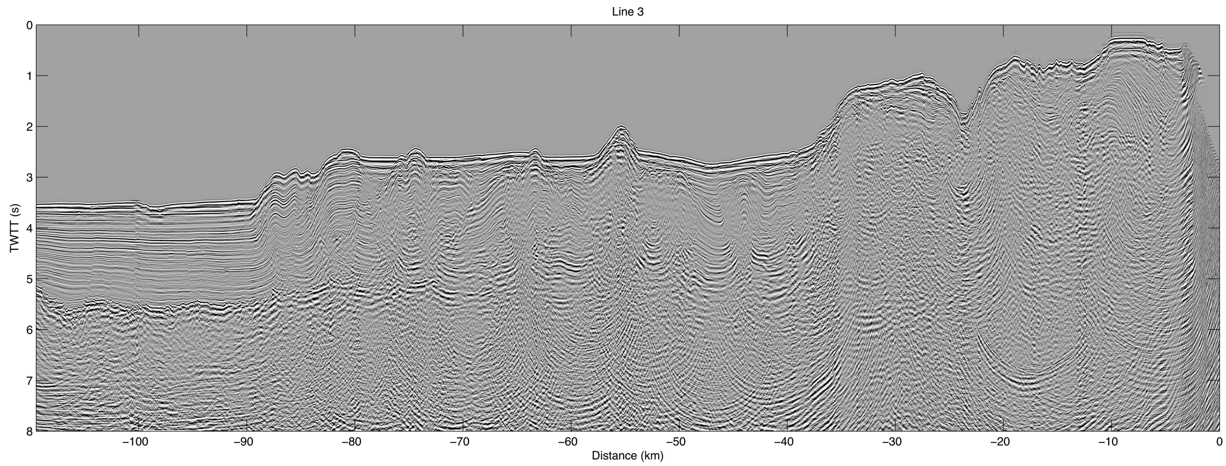


Figure 20. Line 4 (9 m source and streamer depth; full source array)

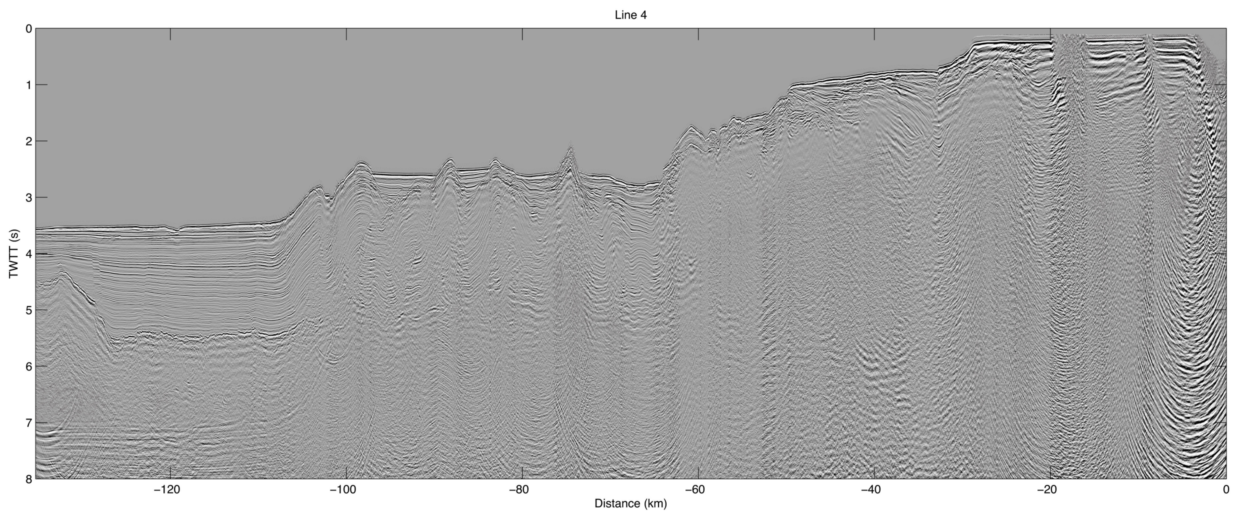


Figure 21. Line 5 (15 m source and streamer depth; full source array)

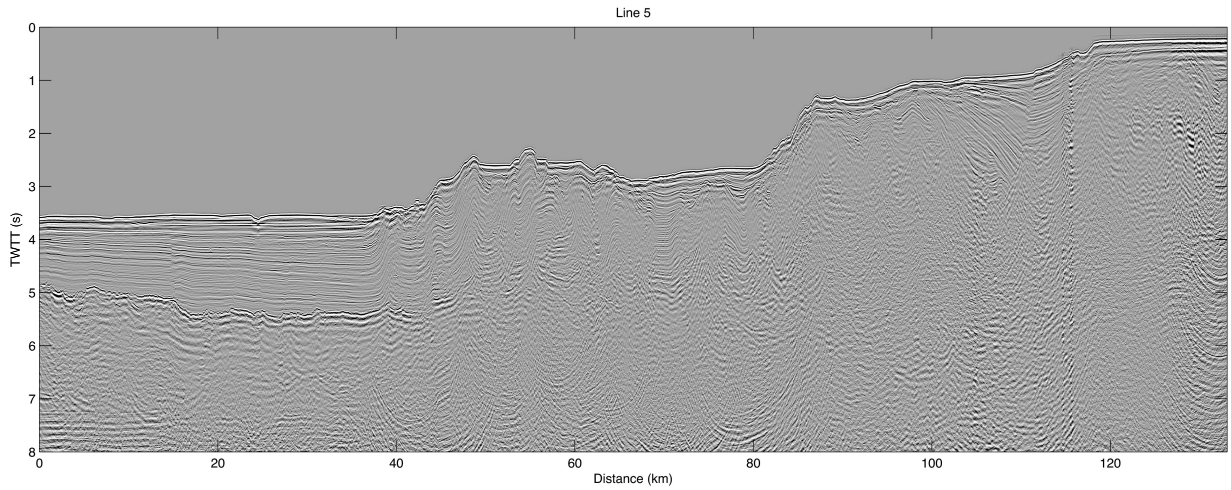


Figure 22. Line 6 (9 m source and streamer depth; full source array)

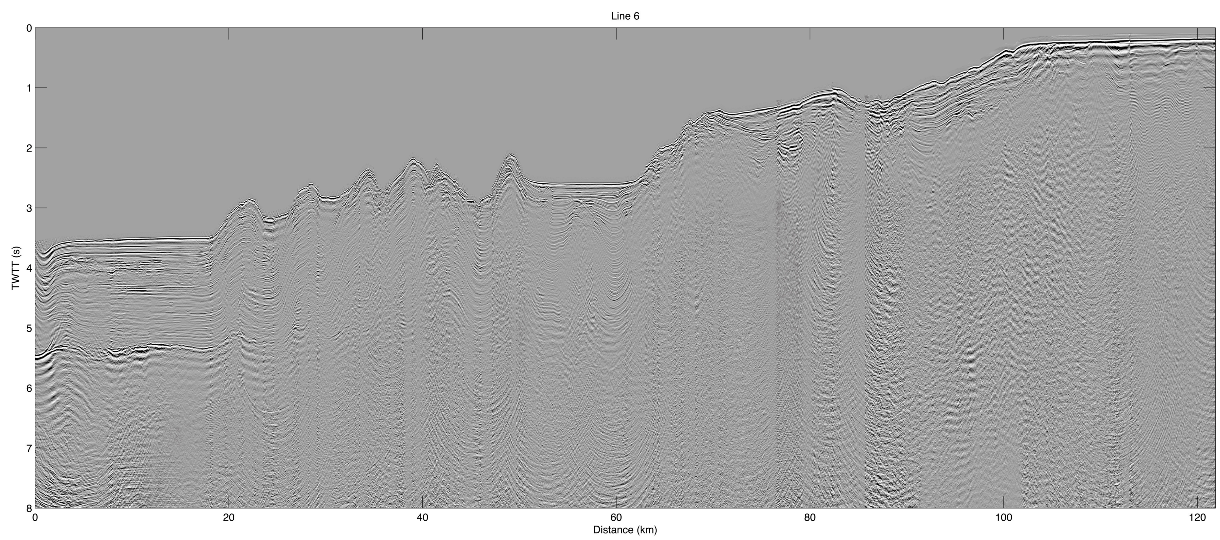


Figure 23. Line 7 (15 m source and streamer depth; full source array)

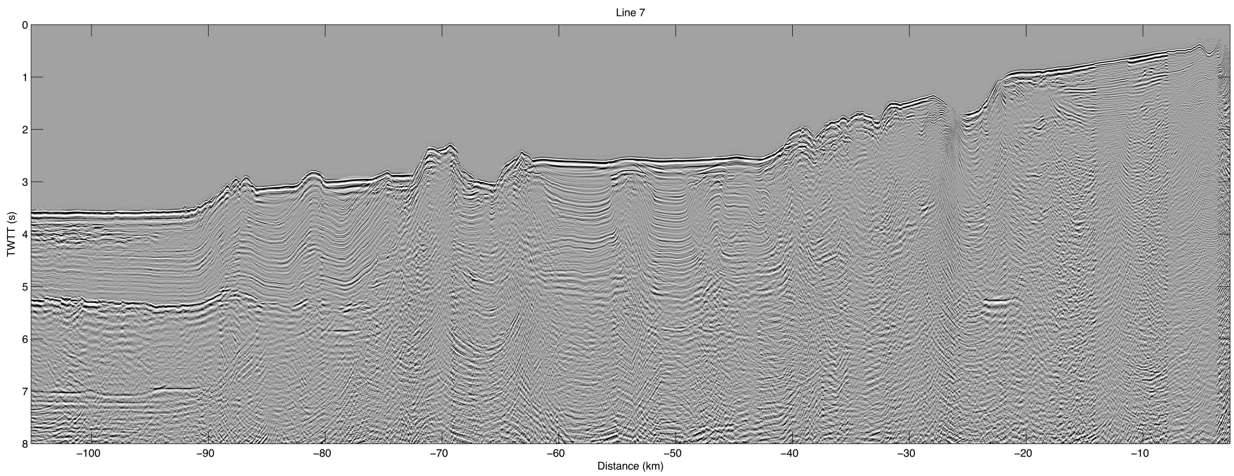


Figure 24. Line 8 (9 m source and streamer depth; full source array)

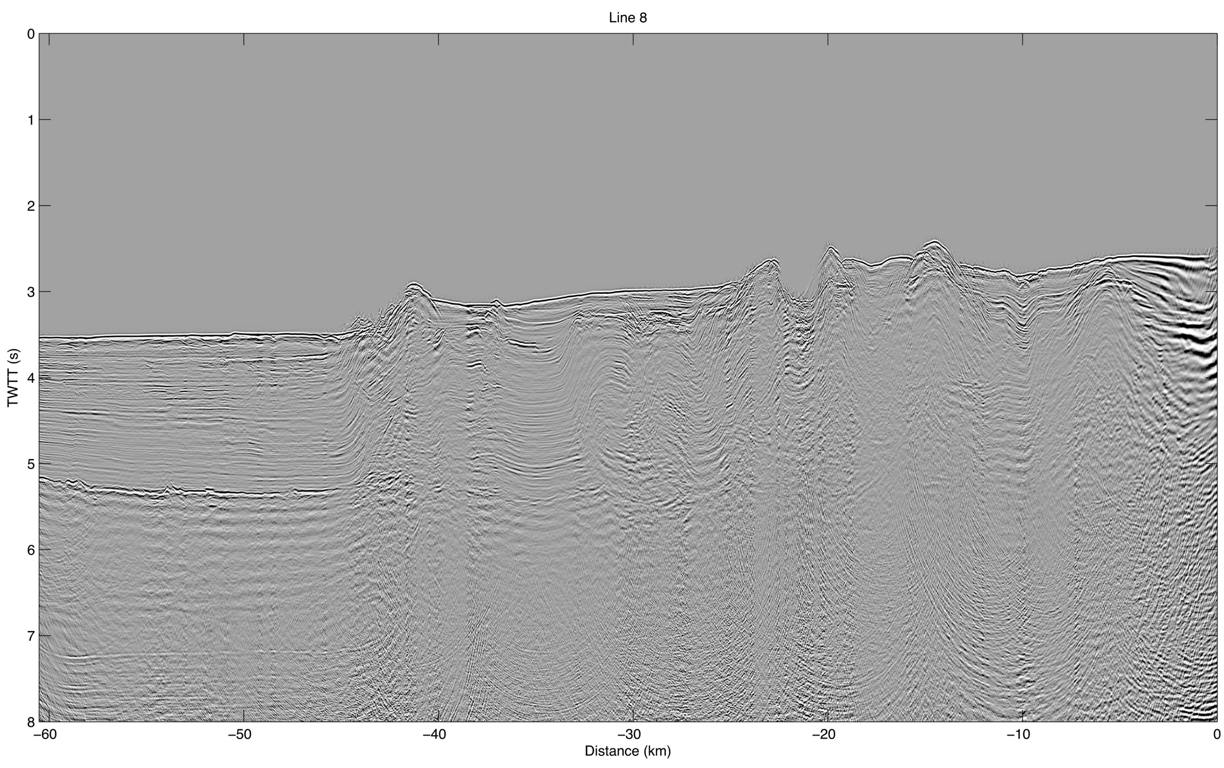


Figure 25. Line 9 (15 m source and streamer depth; full source array)

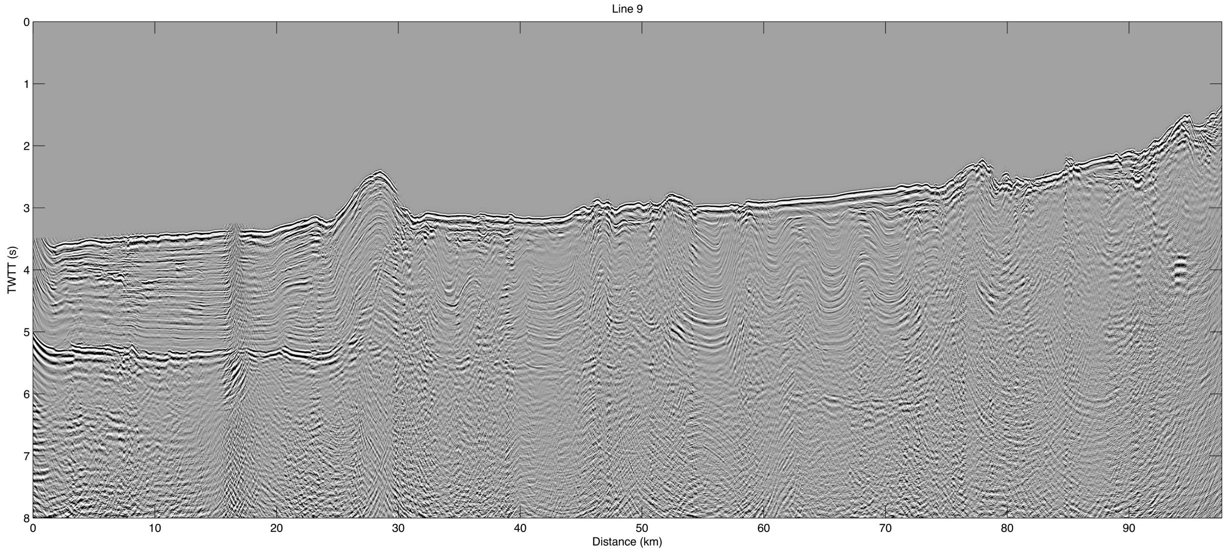
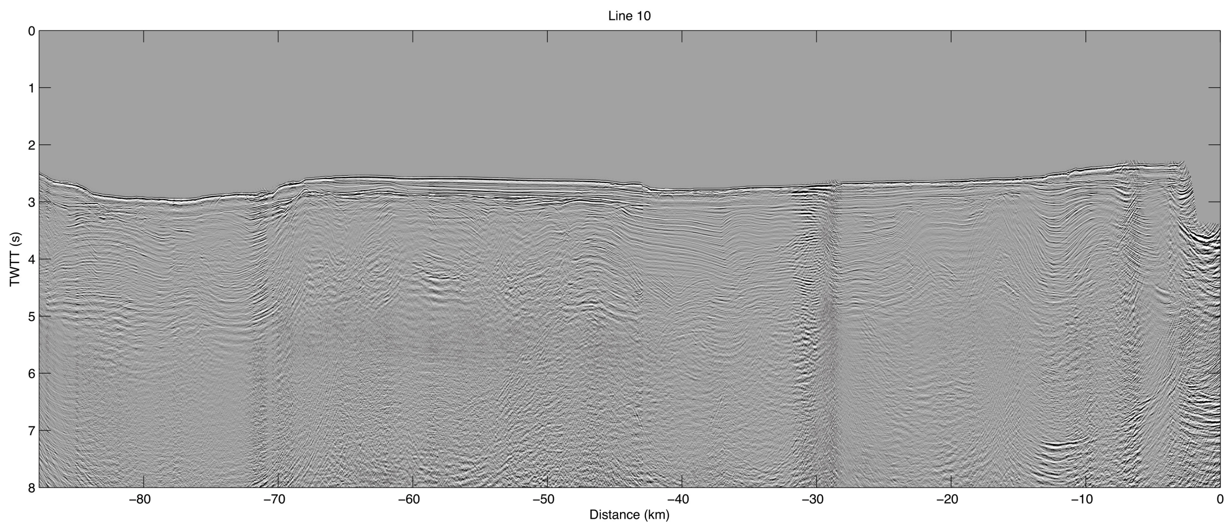


Figure 26. Line 10 (9 m source and streamer depth; full source array)



Source Signature Comparison

One of the purposes of MGL1212, as a site survey for possible future 3D work, was to test the suitability of several different source/streamer depths (and array volume) for imaging in the Cascadia forearc. We towed the gun array (and streamer) at two different depths during the cruise, 9 m and 15 m. On one line we also tested two gun strings (18 guns, 3300 cu. in.) versus four gun strings (36 guns, 6600 cu. in.). Preliminary results are shown here.

Appearance of source for 15-m and 9-m gun depths

Without a far-field hydrophone (towed or tethered), it is difficult to measure the source signature of an airgun array. However, an approximation of the source signature can be gleaned from looking at the seafloor reflection on shot gathers. These estimates of source signature will be affected by sub-seafloor reflections, but some indications can be gained, especially over simple geology. During all shooting, the streamer was towed at the same depth as the gun array, to keep the gun and streamer ghost notches identical (failing to do so creates the dreaded "fedora hat" wavelet, as John Diebold used to describe it).

On unfiltered data, the seafloor reflection at 15 m depth is fairly unsightly. A sharp first trough is followed by an asymmetric peak, and thereafter by higher frequency chop. This indicates to us that the source is not well tuned at 15 m depth. (As we understand it, this source array was designed to be optimally tuned at 6 m gun depth.) However, filtering the data with a passband of 10-40 Hz (inside the first ghost notch) provides an acceptable source signature (figure at bottom of page).

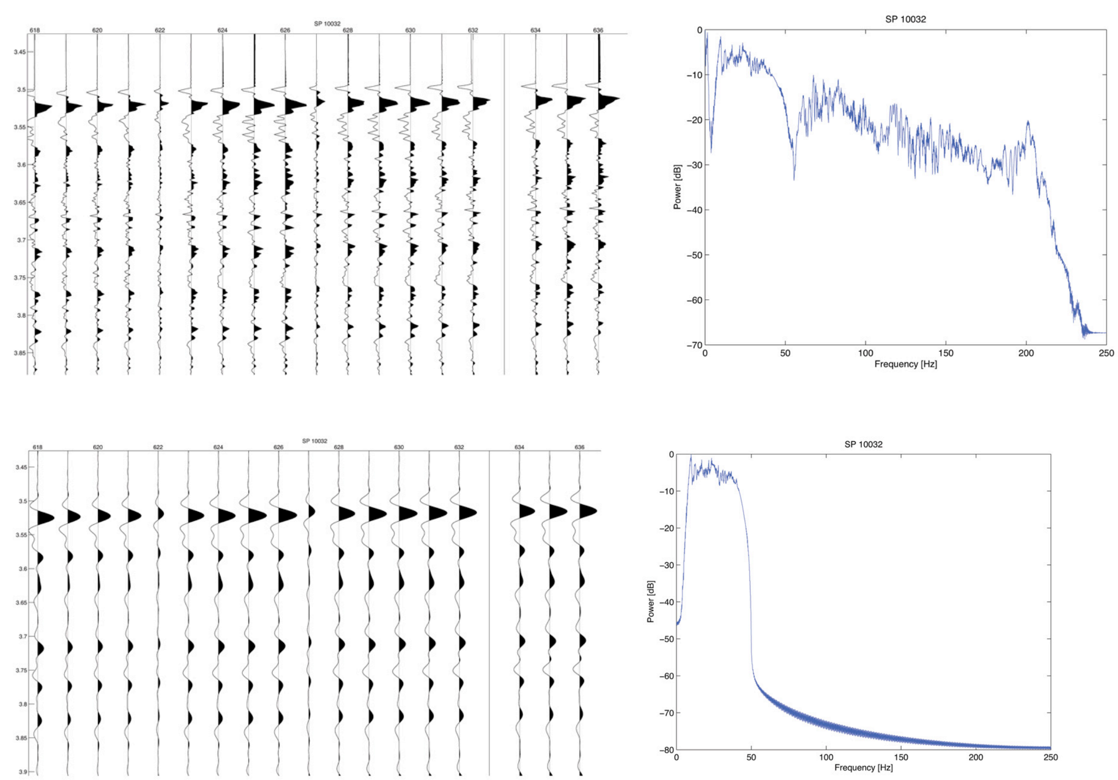


Figure 27. (Top left) Seafloor reflection on inner traces of shot gather from SP 10032, seaward of the trench on Line 5, when guns were at 15 m depth. (Top right) Frequency spectrum of shot gather, showing clear ghost notch at 50 Hz, as expected. (Bottom left) Same traces, filtered from 10-40 Hz. (Bottom right) Frequency spectrum after filtering.

At 9-m depth, the source array looks slightly better in raw form, and superior after filtering from 10-70 Hz:

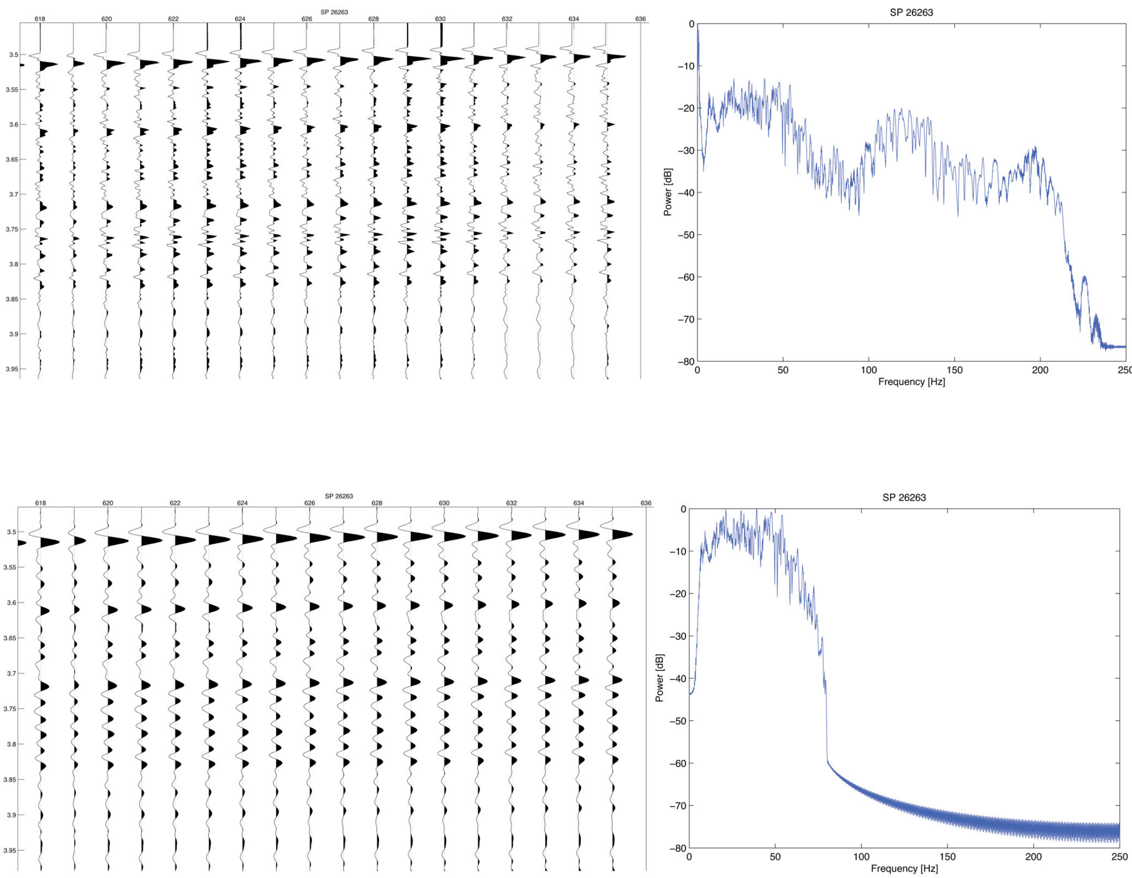


Figure 28. (Top left) Seafloor reflection on inner traces of shot gather from SP 26263, seaward of the trench on Line 4, when guns were at 9 m depth. (Top right) Frequency spectrum of shot gather, showing ghost notch at 83 Hz, as expected. (Bottom left) Same traces, filtered from 10-70 Hz. (Bottom right) Frequency spectrum after filtering.

<u>*Re-shoot of Line 9 with four different sources.*</u>

During shooting of the main transects on MGL1212 we used the full gun array (4 strings, 6600 cu. in.), in order to obtain the best possible data to address our immediate scientific goals. However, in any future 3D survey, the most likely source configuration will be a two-string array, due to the necessity of firing flip-flop source arrays to maximize the number of inlines acquired on a swath. Therefore, as the final seismic tasks of our cruise, we re-shot a portion of Line 9 three times, with a different source array each time. Combined with the original configuration on Line 9, this gave us a full comparison of 9-m vs. 15-m gun depths, and two-string vs. four-string volume:

- Line 9: 15-m depth, 4-string array
- Line 9a: 9-m depth, 4-string array
- Line 9b: 9-m depth, 2-string array
- Line 9c: 15-m depth, 2-string array

While all four transects were processed shipboard, different processing teams picked velocities individually on each line. The velocity functions thus differ slightly between the lines. In order to make a fully informative comparison, the lines should all be re-processed with a single velocity model. Meanwhile, preliminary results for the four lines are shown below.

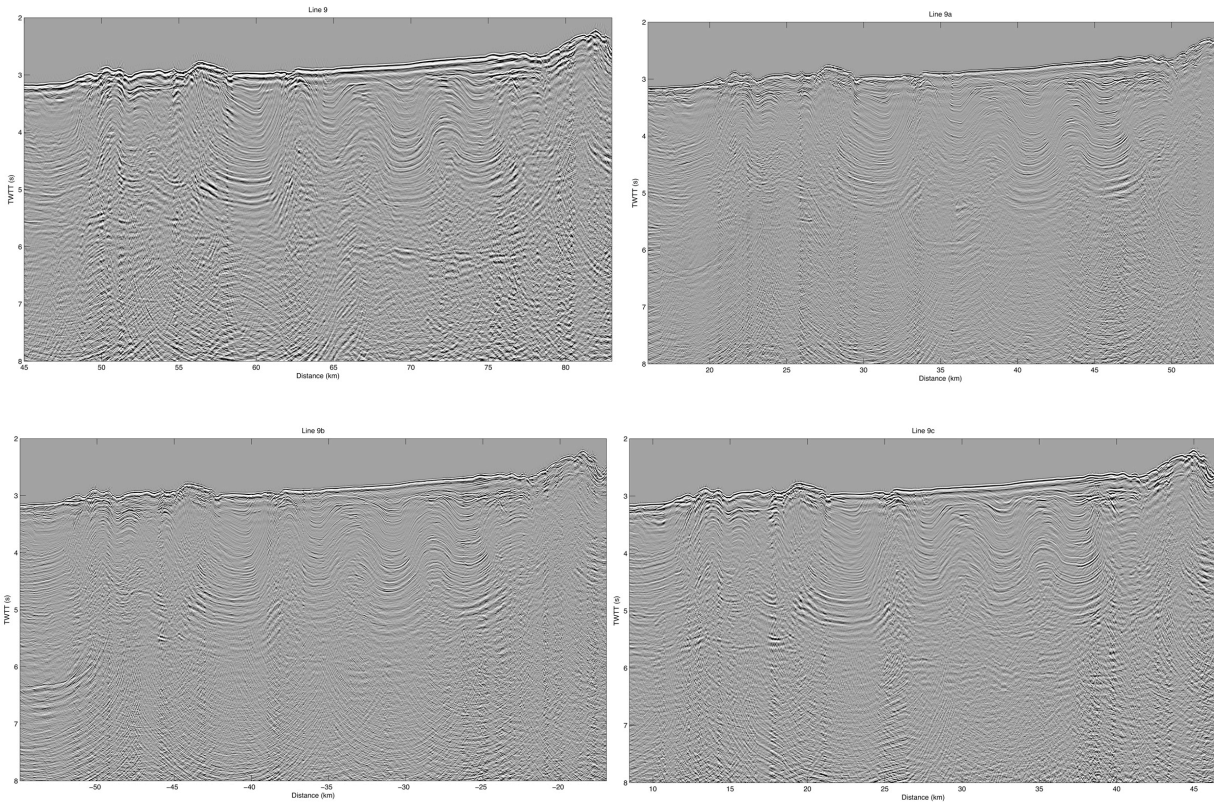


Figure 29. Comparison of same area shot with four different source configurations. (Top left) Line 9, full source array at 15 m depth. (Top right) Line 9a, full source array at 9 m depth. (Bottom left) Line 9c, half source array at 15 m depth. (Bottom right) Line 9d, half source array at 15 m depth.

A preliminary assessment indicates that the image of the plate boundary may be better imaged by the 15-m gun depth, while detail in the accretionary wedge is superior when imaged by the 9-m guns.

Noisy Streamer Sections

A significant, and unacceptable, amount of noise was present on the streamer during our cruise. This noise appears to be electrical in origin, given that it consists of simultaneous noise bursts along the streamer. We believe (but have not yet fully investigated) that this problem was exacerbated after the lab (and streamer) were put on "dirty" power straight off the ship's engine. By the end of our cruise, 80 of the 636 channels on the streamer — more than one in eight traces — had to be deleted in processing due to noise levels. This level of noise is particularly troublesome for any pre-stack processing that requires F-K or tau-p transforms, or for pre-stack depth migration.

On Line 4, we had to delete the following channel numbers (where channel 1 is at the far end of the streamer): 7-14, 18-24, 29-30, 92, 97, 100, 138, 141-144, 162-163, 173, 202-206, 221, 257-258, 260, 268-269, 343-344, 355-358, 361-364, 387, 393-401, 412, 427, 433, 445, 448, 474-478, 488-492, 555-558, 585-587.

An example of the appearance of this noise is shown below, from SP 26263:

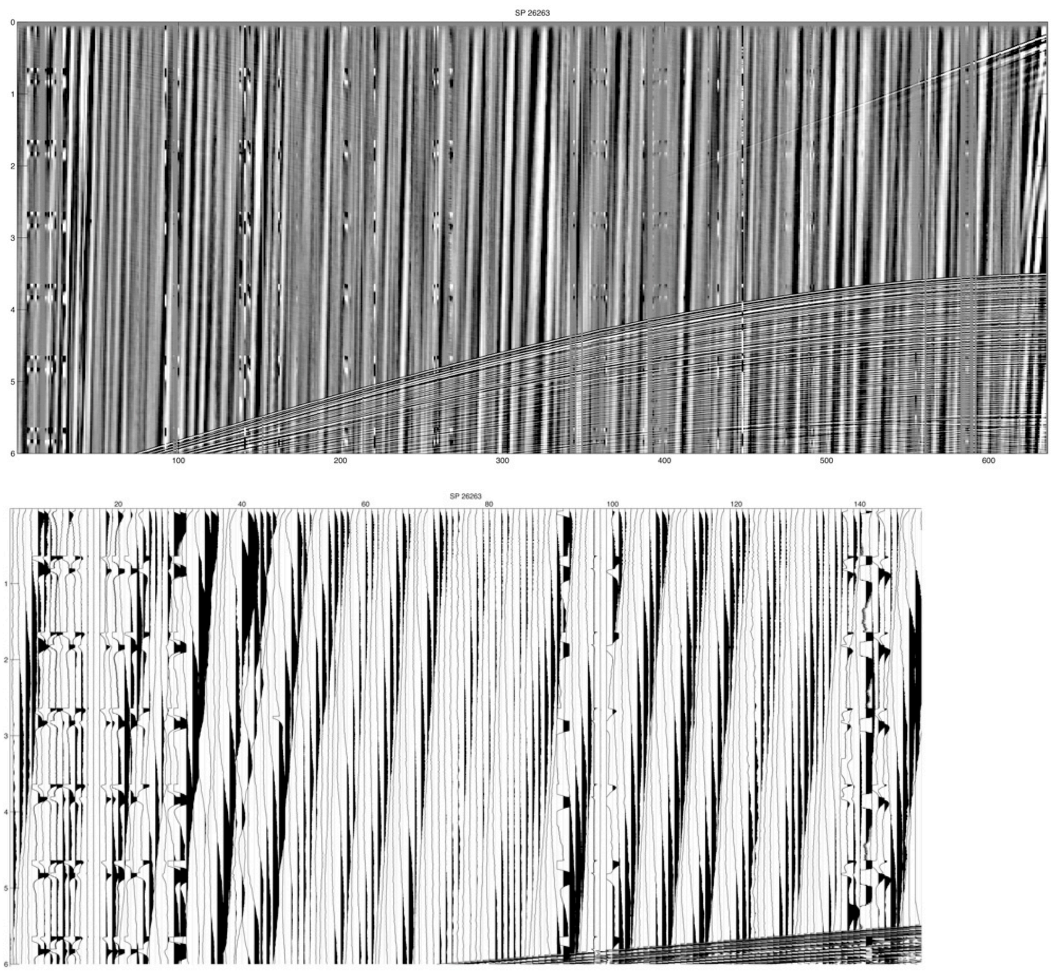


Figure 30. (Top) Raw, unfiltered data from Line 4, SP 26263, showing noise bursts. The noise is apparent as bright "glitches" that tend to occur at the same time on numerous traces. (Bottom) Zoom of outer portion of streamer, showing waveform of noise in wiggle-trace format.

Multi-Beam Processing

by Jeff Beeson and Ashton Flinders

The R/V *Langseth* is equipped with an EM122 transducer capable of collecting multibeam and sidescan data pertinent system modes for the EM122 are listed below (table 1). During the 2012 Cascadia Open-Access Seismic Transects (COAST) ~8855 km2 of multibeam/sidescan data was collected through the entirety of the cruise. Nearly all multibeam/sidescan data was collected at survey speeds of ~4.5 knots (8.3 km/hr). The EM122 data files contain attitude (roll, pitch, yaw, and heave) and sound velocity corrections. Sound velocity profiles were generated at minimum once per day using an XBT probe (expendable bathy thermograph). Each day the multibeam data was converted, edited, processed, and gridded. The location of raw and processed data can be found using table 2 (below). The primary software utilized for the processing and gridding of the multibeam data was MB System. A number of scripts were written for batch processing of the daily multibeam data (see appendices). Once grids were generated they were exported into Fledermaus, 3D visualization software, for inspection and exporting of geotiff files (figure 32). Vertical image drapes of some seismic profiles collected during the cruise were also imported into Fledermaus (figure 33). Geo-referencing of seismic images was done by adjusting bounds of the image to fit bathymetry.

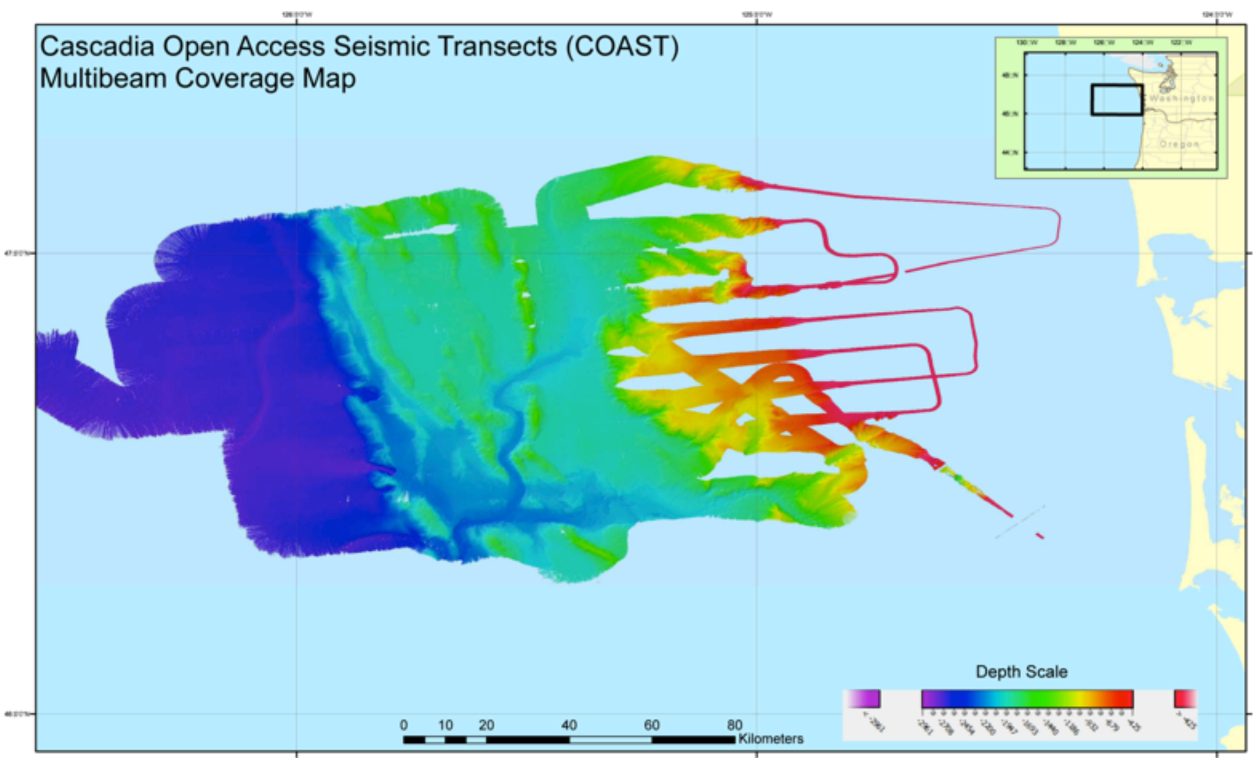


Figure 31: Coverage Map of bathymetry collected during COAST

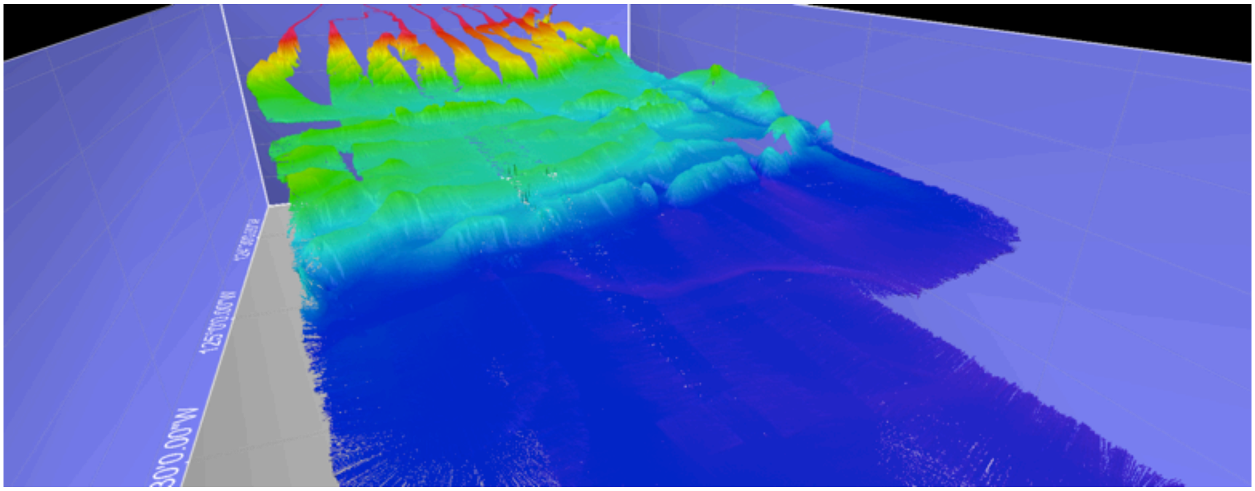


Figure 32: Exported 3D visualization of collected multibeam

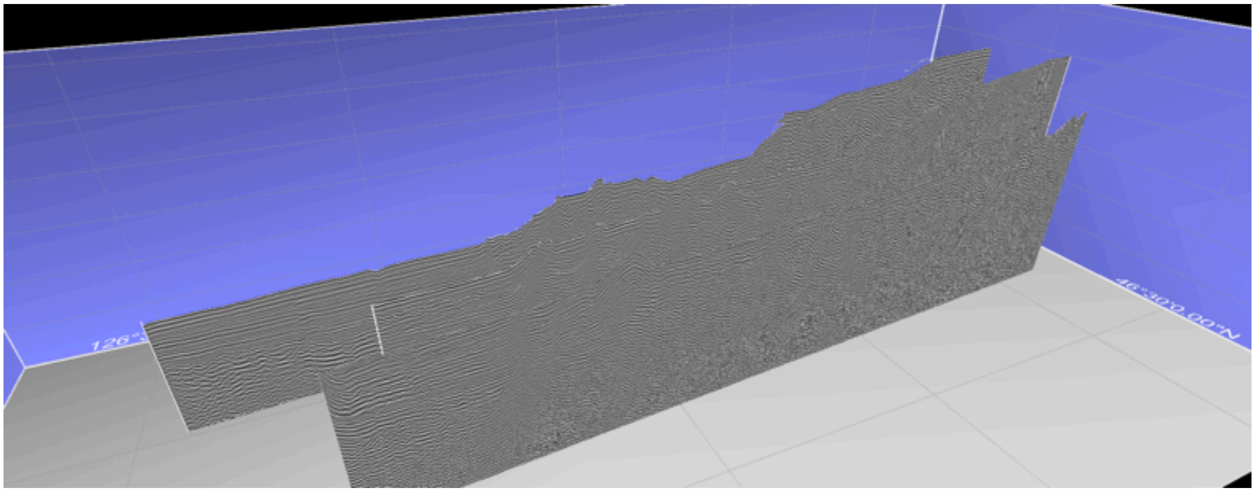


Figure 33: 3D visualization of seismic lines 3, 5, and 7

Table 1: Relevant Multibeam Settings

Multibeam EM122 Setting	Mode
Beam Spacing	Hidens Equidistant
Number of Beams	432 total beams
Angle cut off	70/70 degrees, port/starboard
Mode	AUTO
SVP	XBT (minimum once a day)

Table 2: Multibeam Processing File Summary

File Type	Directory	Produced by	Comments
.all	/MGL1212_MB/DATA/RAW/2012/07/DAY*	EM122	raw files logged by EM122
.mb59	/MGL1212_MB/DATA/MB_PROC/2012/07/DAY*	MBSystem (mbcopy)	Converted multibeam files to mbsystem format
p.mb59	/MGL1212_MB/DATA/MB_PROC/2012/07/DAY*	MBSystem (mbprocess)	Ping edited multibeam files
.grd	/MGL1212_MB/GRIDS/DAILY/BATH_"DAY"	MBSystem (mbmgrid)	processed daily grid files
.grd	/MGL1212_MB/GRIDS	MBSystem (mbmgrid)	processed grid of entire cruise
.csh	/MGL1212_MB/SCRIPTS	N/A	Scripts used for processing
.sd	/MGL1212_MB/DATA/MB_PROC/SCENE_FILES	Fledermaus	3D visuals of data
.scene	/MGL1212_MB/DATA/MB_PROC/SCENE_FILES	Fledermaus	Fledermaus scene files
.tiff	/MGL1212_MB/DATA/MB_PROC/GEOTIFFS	Fledermaus	Images of multibeam data
.grd	/MGL1212_MB /GRIDS/DAILY/SS_"DAY"	MBSystem	Side scan grid
.grd	/MGL1212_MB/DATA/COMPILE	MBSystem	Complete side scan grid
.abs	/MGL1212_MB/XBT	XBT's	XBT cast data

Shipboard Gravity

by Ashton Flinders and Jeff Beeson

Marine gravity data was collected using the ship's onboard Bell Aerospace BGM-3 gravimeter. The gravimeter logged continuously between departure (July 12, 2012) and arrival (July 24, 2012) at Astoria, OR. Raw serial data ,in gravimeter counts, was written as daily files—see file structure description, Table —and converted to gaussian filtered uncorrected gravity data, in mGals, using a ship-provided instrument specific conversion script. The filtered uncorrected data was co-registered in time with center beam bathymetry (Kongsberg EM120), and corrected navigation (C&C Tech. CNAV DGPS Receiver) using a routine provided by A. Flinders. This same routine down-sampled the gravity from a 1 s to 30 s sample rate, interpolating using an Akima spline. A compilation of all cruise uncorrected data was written to file (Table). Free-air anomaly data was created by calculating Etvos and latitude corrections and applying the Astoria, OR port absolute gravity value—980712.92 mGals, using a matlab routine provided by A. Flinders, Table #. A total of 2400 km of marine track-line gravity data was collected (ignoring turns). Simple Bouguer data was calculated using a crustal density of 2.6 g/cc and a water density of 1.05 g/cc.

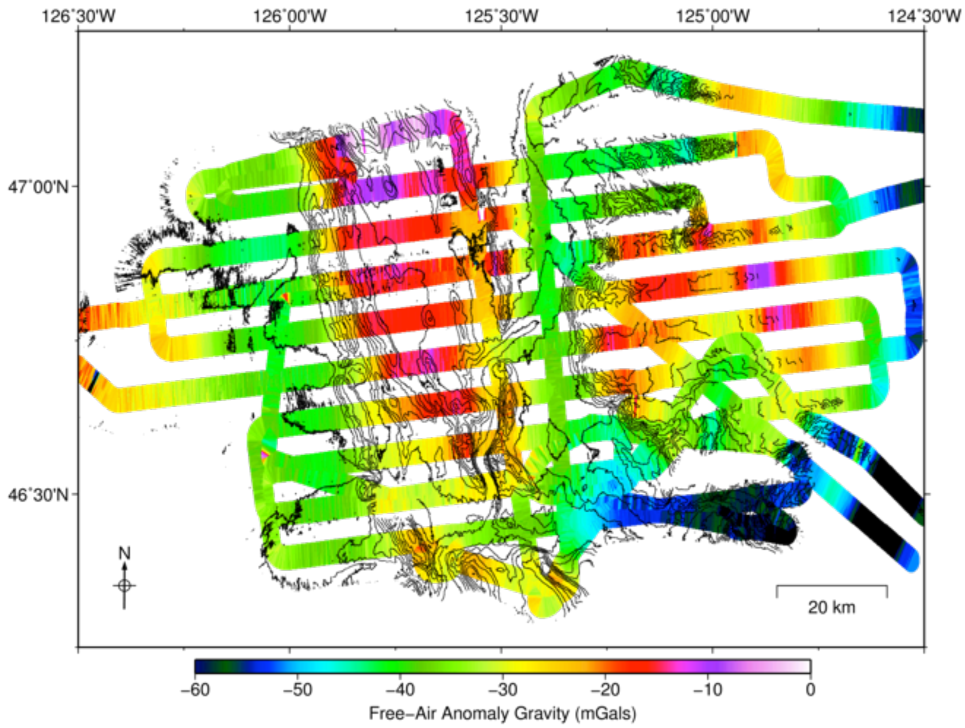


Figure 34. Free-Air Anomaly (mGals) Gravity of the Survey Region

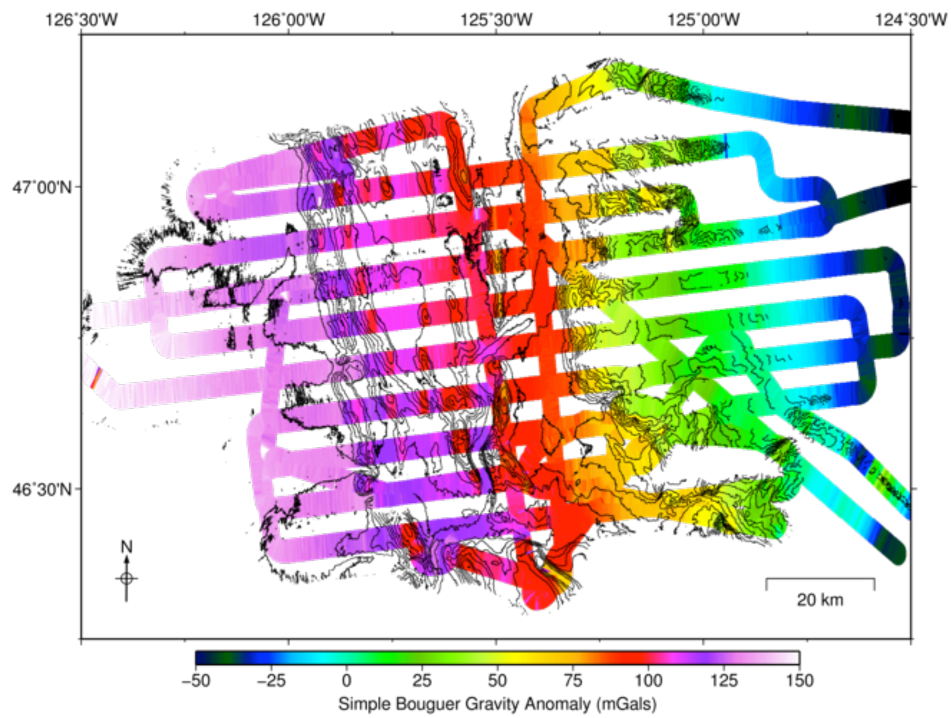


Figure 35. Simple Bouguer Anomaly (mGals) Gravity of the Survey Region

Towed Magnetics

by Ashton Flinders and Jeff Beeson

Marine magnetic data was collected using a cable-towed Geometrics 882 Magnetometer. Data collection was dependent on sea-state, with towed deployment typically restricted to sea-state 5 or below (< 3.5 m). The raw uncorrected data was co-registered in time with center beam bathymetry (Kongsberg EM120), and corrected navigation (C&C Tech. CNAV DGPS Receiver) using a routine provided by A. Flinders. This same routine down-sampled the magnetics from a 1 s to 30 s sample rate, interpolating using an Akima spline. A total of 1500 km of marine magnetic data was collected. This data is uncorrected for daily variations in the magnetic field.

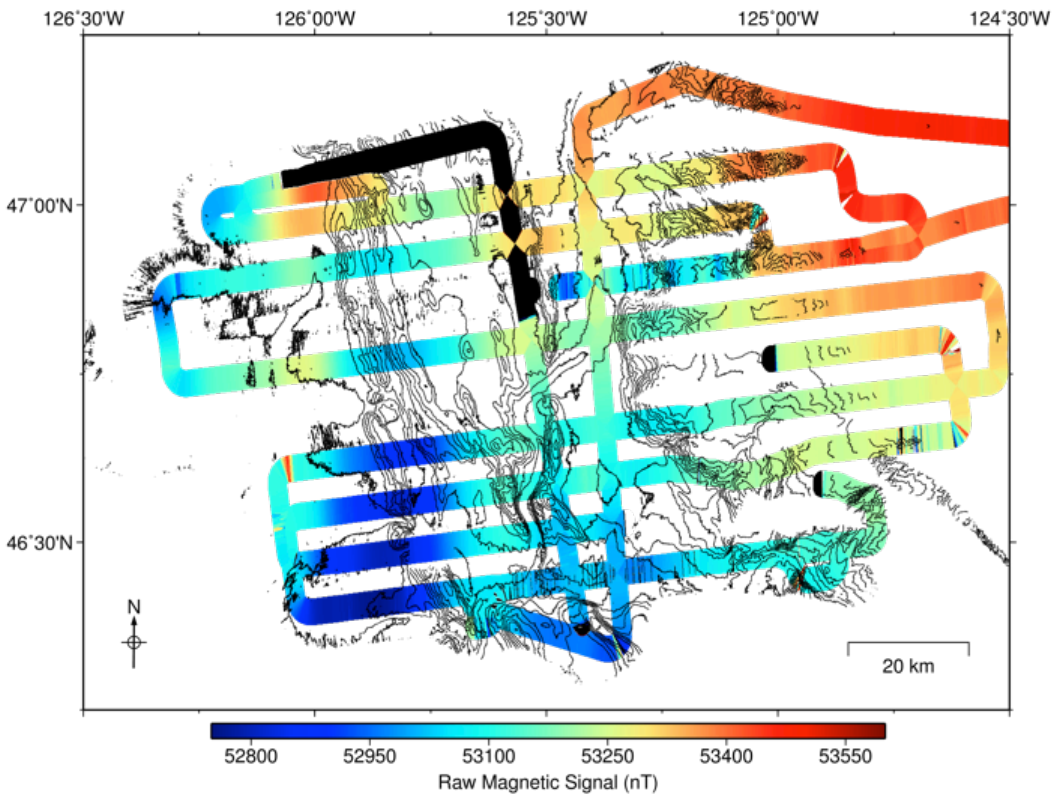


Figure 36. Uncorrected Magnetic Anomaly (mGals) of the Survey Region

Table: Marine Gravity/Magnetics File and Processing Summary

Gravity		
Filename	**Description**	**Produced By**
MGL-vc01.y2012d*	Bell Aerospace BGM-3 Gravimeter	serial
MGL-bath02.y2012d*	Kongsberg EM122 Center-beam Depth	serial
MGL-cnav3050all.y2012d*	C&C Tech. CNAV DGPS Receiver	serial
MGL-vc01_mGal.y2012d*	B.A. BGM-3 gravity converted to mGal	gravFilter.pl
dat.MGL1212.rgrav	Uncorrected gravity (mGal) combined with navigation and bathymetry	comb_nav_grav_bath.cmd
dat.MGL1212.faa	Free-air anomaly (FAA) corrected gravity (mGal)	makefaa.m
dat.MGL1212.sb	Simple Bouguer gravity (2.6 g/cc crustal density)	

Magnetics		
Filename	**Description**	**Produced By**
MGL-mag01.y2012d*	Geometrics 882 Magnetometer	serial
dat.MGL1212.rmag	Uncorrected magnetics (nT) combined with navigation and bathymetry	comb_nav_magy_bath.cmd

Specialized File Formats
dat.MGL1212.rgrav
long., lat., depth (+), raw gravity (mGals), Julian day, hour, min., sec.
dat.MGL1212.faa
long., lat., raw gravity, FAA, depth (-), obs. gravity, etovos, g0, vE, v, Julian day, hour, min., sec.
dat.MGL1212.sb
long., lat., simple bouguer (mGals)
dat.MGL1212.rmag
long., lat., depth (+), raw magnetics (nT), Julian day, hour, min., sec.

Sidescan Sonar (Backscatter) Data

During MGL1212 we recorded sidescan sonar data using the Kongsberg EM122 system. We created a GMT .grd file of the raw backscatter values shipboard. However, very little processing was done on these data. The figure below shows that backscatter values varied between transects, even in areas with geographic overlap. Regularization of these data will be required before full use can be made of them.

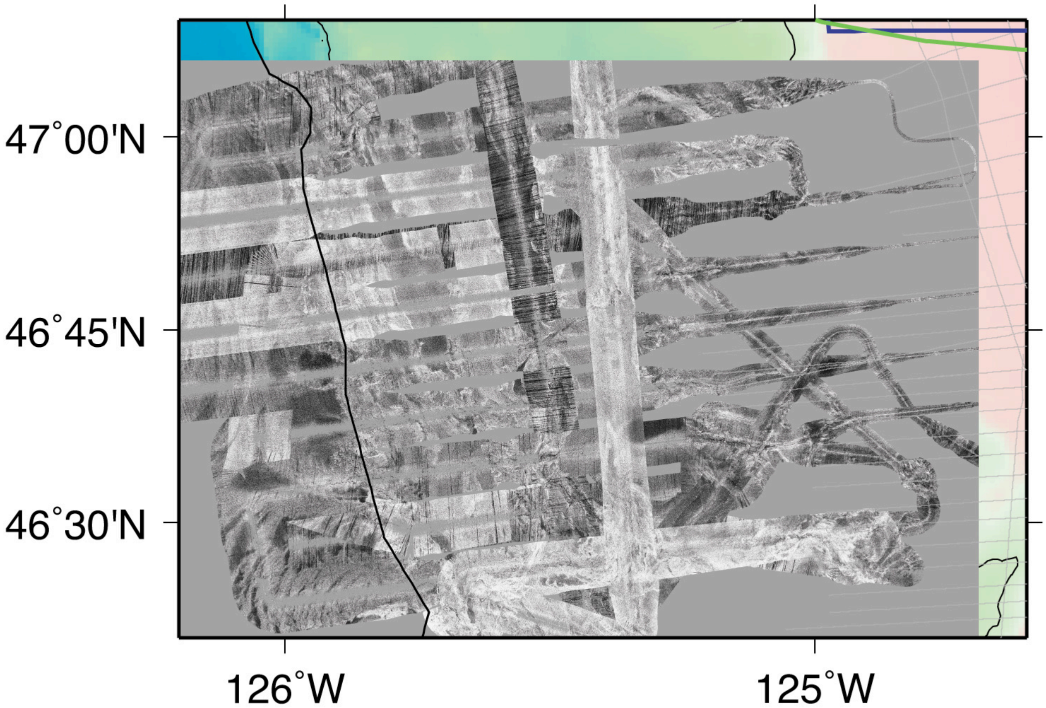
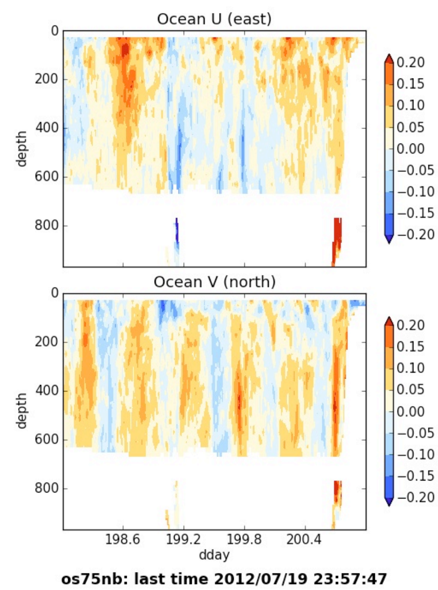


Figure 36. Image of all sidescan data collected during MGL1212.

ADCP Data

We acquired acoustic Doppler current profile (ADCP) data during MGL1212, using the *Langseth's* RDI 75KHz ADCP. Visualization of the current data on the screen showed the instrument was working normally; current velocities were typically low (~0.1-0.2 m/s). We made no attempt to process this data; the shipboard techs informed us that all *Langseth* ADCP data are post-processed and distributed by Jules Hummon of the University of Hawaii. An example of one ADCP file is shown at right.

Figure 37. Example of ADCP data acquired during cruise.



Seismic Oceanography

by Will Fortin

Seismic oceanography (SO) is the application of standard marine multichannel seismic acquisition to image the ocean interior. The seismic oceanography portion of this cruise is an add-on "piggyback" to the funded open access cruise and effectively provides a second dataset at no additional cost to the proposed work. No seismic lines were planned to collect SO datasets but they served as a good test of resolution due to acquisition geometry providing valuable information for planning SO data collection as well as useful SO data for about half of the survey. Funding for the expendable instruments came from a separate ONR grant.

The SO portion of this cruise consists of the processing of the collected seismic data and the deployment of 89 expendable instruments, mostly eXpendable BathyThermograph instruments (XBTs). This includes 71 XBT T5 instruments, 12 XBT T7 instruments, one T-4 instrument, and five XCTD instruments (eXpendable Conductivity, Temperature and Depth). The data from the expendable instruments is paired with the seismic data for processing and post-processing "ground truth" measurements. Watchstander duties included the launch of the expendable probes and logging of the launch details.

The original XBT/XCTD data collection plan was quickly scrubbed at the start of the cruise. Original cruise geometry was set to have the air guns at a depth of 15m resulting in a notch at 50Hz in the source signal. Limiting the source signal to the lower frequencies was intended to help better image deep geology structures, like the plate boundary, but initial stacks in the water column indicated that this low-frequency source did not provide good returns from (weak) impedance contrasts in the water column. Examination of the source signature at 15 m depth led the PIs to decide to move the air-gun array to a depth of 9 m for the second half of the cruise to gain a comparison of the higher-frequency source. We focused our SO efforts on the lines acquired while the source and streamer were at 9 m depth.

Few of the seismic lines shot were specifically processed for SO; instead focus was kept on the processing of the underlying geology and the training of scientists in the active-source marine seismic processing method. No data was migrated with SO in mind. The expendable instrument data set was processed on board. This included editing the data files to exclude bad data and producing postscript plots of each expendable instrument.

Deployment Table.

The table on the next two pages shows all XBT/XCTD deployments conducted during MGL1212.

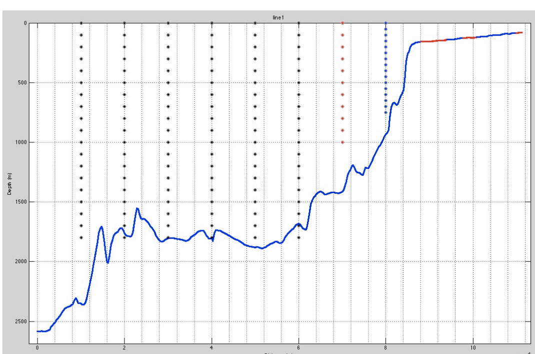
Date	Time	Seq. #	SN	Lat deg (N)	Lat min (N)	Long deg (W)	Long min	Probe	EM122 CBD at splash point	Last Good Depth m	Line Name	Launch Location:	Shot #	Comments
7/12/12	20:16:00	1	342163	46	33.96729	124	38.62305	T-4	558	485	1480.64	Stern	n/a	
7/13/12	11:22:00	2	360336					T-5	2180	2148	line11	port	1129	
7/13/12	11:54:00	3	360332	46	29.47	125	27.3	T-5	2156	1195	line11	port	1208	
7/13/12	12:24:00	4	360328	46	32.02	125	27.93	T-5	1770	1866	line11	port	1301	
7/13/12	13:50:00	5	360331	46	37.25	125	29.23	T-5	1676	1697	line11	port	1501	
7/13/12	14:08:00	6	360327	46	38.72	125	29.61	T-5	1775	660	line11	port	1556	XBT short
7/13/12	14:11:00	7	360335	46	39.1	125	29.7	T-5	1787	627	line11	port	1568	XBT short
7/13/12	14:16:57	8	360326	46	39.38	125	29.77	T-5	1763	436	line11	stbd	1580	Switched to stbd; XBT short
7/13/12	14:21:00	9	360330	46	39.63	125	29.83	T-5	1811	601	line11	port	1590	XBT short
7/13/12	15:00:00	10	360334	46	42.6	125	30.57	T-5	2040	1947	line11	port	1703	
7/13/12	16:15:00	11	11074075	46	47.81	125	31.87	XCTD-1	1917	1000	line11	port	1901	SP 1846 Shut down strings 1 and 2 ; switched to XC
07/1402012	14:15:00	12	360329	46	58.655	125	59.672	T-5	2540	2170	line1A	port	3801	
7/14/12	15:29:00	13	360333	46	59.32	125	52.046	T-5	1673	458	line1A	port	4001	XBT short
7/14/12	16:08:00	14	360325	46	59.7	125	47.9	T-5	1763	597	line1A	stbd	4102	XBT short
7/14/12	16:43:00	15	360375	47	0.04	125	44	T-5	1853	572	line1a	stbd	4201	XBT short
7/14/12	17:55:33	16	360374	47	0.7	125	36.54	T-5	1759	956	line1A	stbd	4401	XBT short
7/14/12	19:15:09	17	360373	47	1.4094	125	27.80957	T-5	1834	590	line1A	stbd	4614	XBT short
7/14/12	20:22:50	18	360378	47	2.04	125	20.92	T-5	1788	1121	line1A	port	4802	XBT short
7/14/12	21:33:51	19	11074078	47	2.73	125	12.76	XCTD-1	1392	661	line1A	port	5101	Terminated Early
7/14/12	22:50:25	20	1141239	47	3.42	125	4.49	T7	1384	895	line1A	port	5212	XBT short
714/2012	6:51:07	21	1141249	46	55.196	124	59.99	T7	497	497	line3	stbd	6630	XBT short
7/15/12	8:08:22 AM	22	1141238	46	54.485	125	7.604	T7	707	411	line3	stbd	6826	XBT short
7/15/12	10:01:00	23	360377	46	53.5166	125	19.11914	T5	1891	1928	line3	port	7120	
7/15/12	11:48:00	24	360376	46	52.287	125	30.583	T5	1702	916	line3	port	7420	XBT short
7/15/12	13:41:00	25	360379	46	51.48	125	42.657	T5	1911	763	line3	port	7720	XBT short
7/16/12	10:45:29	26	346952	46	44.55176	125	22.2627	T5	2042	1957	line5	port	?	Good/Problesm with exel
7/19/12	8:56:17	27	360381	46	37.25	125	55.62	T5	2582	319	line6	port	21100	short, reshot on stbd side
7/19/12	9:00:32	28	360382	46	37.29	125	55.16	T5	2586	707	line 6	stbd	21111	short
7/19/12	9:31:47	29	360380	46	37.6	125	51.75	T5	2352	1026	line 6	stbd	21200	short
7/19/12	10:08:10	30	360384	46	37.96	125	47.86	T5	2331	795	line 6	stbd	21300	short
7/19/12	10:46:40	31	360383	46	38.3	125	43.95	T5	2082	667	line 6	stbd	21400	short
7/19/12	11:24:46	32	346950	46	38.65	125	40.09	T5	1767	718	line 6	port	21500	short
7/19/12	12:03:023	33	360364	46	38.99	125	36.17	T5	1656	304	line 6	port	21600	short, relaunched
7/19/12	12:16:03	34	360368	46	39.11	125	34.86	T5	1703	1231	line 6	port	21635	short
7/19/12	12:41:17	35	360363	46	39.33	125	32.3	T5	2124	2111	line 6	port	21700	good!
7/19/12	13:20:50	36	360367	46	39.688	125	28.313	T5	1651	1649	line 6	port	21800	
7/19/12	13:53:00	37	360366	46	40.014	125	24.573	T5	1911	1965	line 6	port	21900	
7/19/12	14:32:00	38	360362	46	40.355	125	20.567	T5	1908	1917	line 6	port	22000	
7/19/12	15:08:19	39	360370	46	40.6821	125	16.71191	T5	1436	1484	line6	port	22100	
7/19/12	15:00:00	40	360371	46	41.0161	125	12.825	T5	1032	1162	line6	port	22200	
7/19/12	16:20:00	41	11074081	46	41.1616	125	8.7451	XCTD1	997	658.1	line6	port	22300	
7/19/12	16:55:00	42	360365	46	41.67	125	5.02	T5	837	847.3	line6	port	22400	
7/19/12	17:40:00	43	360372	46	42.02	125	0.74	T5	909	783.6	line6	port	22509	
7/19/12	18:17:00	44	1141244	46	42.32	124	57.261	T7	788	508	line6	stbd	22600	
7/19/12	18:51:00	45	1141243	46	42.635	124	53.372	T7	594	492	line6	stbd	22700	
7/20/12	3:44:08	46	1141242	46	50.958	124	57.733	T7	550	541	line4	stbd	24589	
7/20/12	4:19:22	47	1141247	46	50.6	124	2.107	T7	584	572	line 4	stbd	24703	
7/20/12	4:48:37	48	1141246	46	50.284	125	5.896	T7	657	655	line 4	stbd	24800	Problem with XBT readings, unrealistic T values aft
7/20/12	5:22:55	49	1141248	46	49.956	125	9.795	T7	800	737	line 4	stbd	24900	
7/20/12	5:55:00	50	11074080	46	49.611	125	13.88	XCTD1	1193	724	line4	stbd	25003	
7/20/12	6:29:14	51	360369	46	49.286	125	17.75	T5	1380	1385	line 4	stbd	25104	
7/20/12	6:59:58	52	360361	46	48.97	125	21.509	T5	2004	690	line 4	stbd	25200	Shorted out
7/20/12	7:33:07	53	360337	46	48.39	125	25.1	T5	1982	1994	line 4	stbd	25300	
7/20/12	8:05:41	54	360341	46	48.18	125	29.1	T5	1554	619	line 4	stbd	25403	
7/20/12	8:38:24	55	360345	46	47.95	125	33.2	T5	1933	1503	line 4	port	25500	
7/20/12	9:12:21	56	360346	46	47.37	125	37.04	T5	1836	1862	line 4	port	25600	
7/20/12	9:46:50	57	360342	46	47.16	125	40.57	T5	1911	1866	line 4	port	25700	
7/20/12	10:21:51	58	360338	46	46.55	125	44.5	T5	1921	1960	line 4	port	25800	
7/20/12	10:56:47	59	360347	46	46.57	125	48.8	T5	1892	1856	line 4	port	25902	
7/20/12	11:28:51	60	360343	46	46.23	125	46.23	T5	2290	2130	line4	port	26000	
7/20/12	12:01:51	61	360348	46	45.87	125	56.54	T5	2544	2206	line 4	port	26100	
7/20/12	12:35:58	62	360344	46	45.51	125	0.46	T5	2585	2196	line4	port	26200	
7/20/12	20:04:08	63	360339	46	54.37	125	58.946	T5	2563	2174	line2	port	28100	
7/20/12	20:37:00	64	360340	46	54.72	125	55.04	T5	2045	2083	line2	port	28200	
7/20/12	21:17:00	65	360295	46	55.069	125	51.134	T5	1811	1824	line2	port	28300	
7/20/12	21:42:00	66	360296	46	55.418	125	47.223	T5	1881	1924.7	line2	port	28400	
7/20/12	22:19:00	67	360294	46	55.762	125	43.321	T5	1846	1877	line2	port	28500	

Date	Time	Seq. #	SN	Lat deg (N)	Lat min (N)	Long deg (W)	Long min	Probe	EM122 CBD at splash point	Last Good Depth m	Line Name	Launch Location:	Shot #	Comments
7/20/12	22:57:00	68	360292	46	56.162	125	38.874	T5	1834	1873.7	line2	port	28614	
7/20/12	23:30:00	69	346949	46	56.5	125	35.053	T5	1878	2111	line2	port	28712	
7/21/12	0:00:55	70	11074077	46	56.79	125	31.59	XCTD-1	1867	1097	line2	port	28800	
7/21/12	0:37:00	71	346951	46	51.146	125	27.509	T5	1840	1847.8	line2	port	28900	
7/21/12	1:11:19	72	360291	46	57.482	125	23.587	T5	1956	2126.8	line2	port	29005	
	1:42:00	73	360290					T5	1825		line2	port	29100	bad XBT temp readingn, terminated early and redo
7/21/12	1:48:55	74	360289	46	57.834	125	19.428	T5	1819	1858.8	line2	port	29111	
7/21/12	2:17:40	75	360293	46	58.127	125	15.954	T5	1670	1700.9	line2	port	29200	
7/21/12	2:54:16	76	360298	46	58.467	125	11.931	T5	1448	1404	line2	port	29303	
7/21/12	3:27:43	77	360297	46	58.7915	125	8.0498	T5	1514	1589.7	line2	port	29402	
7/22/12	2:29:49	78	346955	46	57.227	125	24.365	T5	1953	1983.3	line 10 (cross line 2)	port	35454	
7/22/12		79	360300	46	48.66	125	23.33	T5	2050	2074	line 10 (cross line 4)	port	35772	
	5:34:24	80	360299	46	44.268	125	22.813	T5	1940	1965	line 10 (cross line 5)	port	35936	odd signals at 1562 m but kept recording
		81	356413	46	40.06	125	22.3	T5	1911	1939.5	line 10(cross line 6)	port	36092	
7/22/12	7:41:05	82	356419	46	35.79	125	21.79	T5	1887	1908	line 10(cross line 7)	port	36252	
7/22/12	8:43:00	83	356420	46	31.28	125	21.17	T5	2086	2038	line10(cross line 8)	port	36412	
7/22/12	9:49:00	84	356414	46	27.15	125	20.7	T5	2178	2111	line10(cross line 9)	port	36572	
7/22/12	18:23:00	85	356418	46	27.34	125	20.09	T5	2162	2170	line 9A	port	40950	
7/22/12	19:51:46	86	356415	46	28.119	125	11.078	T5	1995	1111	line 9A	port	41185	XBT short
7/23/12	0:50:05	87	346956	46	29.05	125	59.68	T5	1811	1803	line9B	port	42337	
7/23/12	2:46:03	88	356416	46	228.23	125	9.766	T5	1972	1979	lin9B	port	42598	
7/2/12	5:28:10	89	356417	46	26.983	125	24.26758	T5	2114	2148	line9B	port	42972	

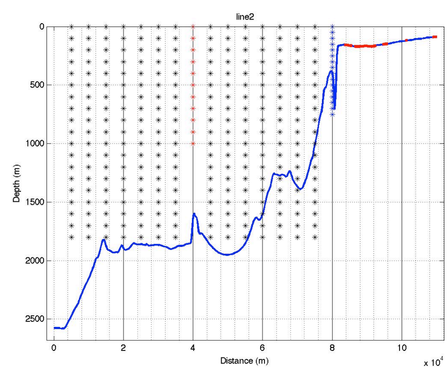
Drop Maps.

The maps below show bathymetry and XBT/XCTD positions on each line where SO operations were conducted.

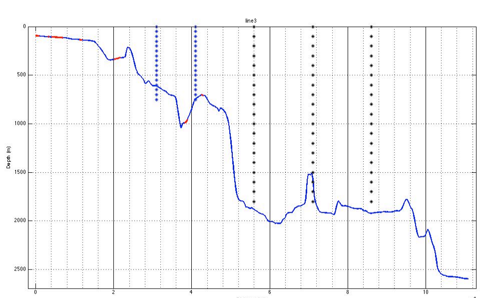
Line 1:



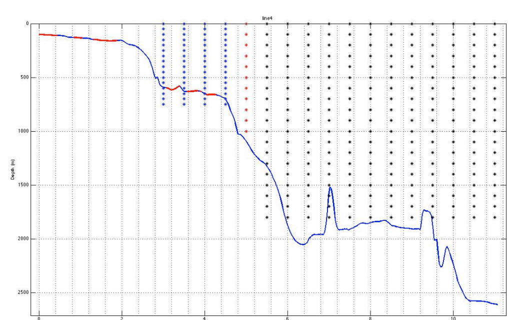
Line 2:



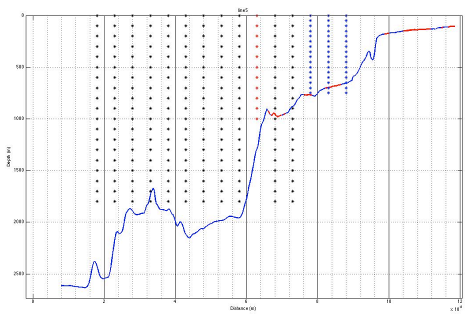
Line 3:



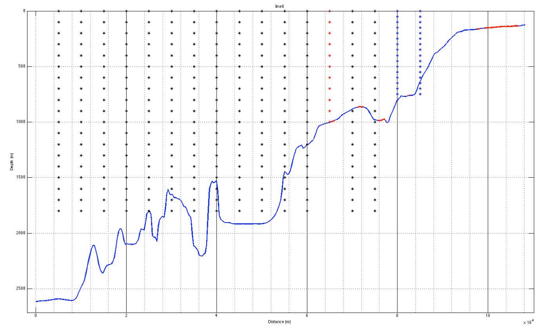
Line 4:



Line 5:



Line 6:



Line 11: