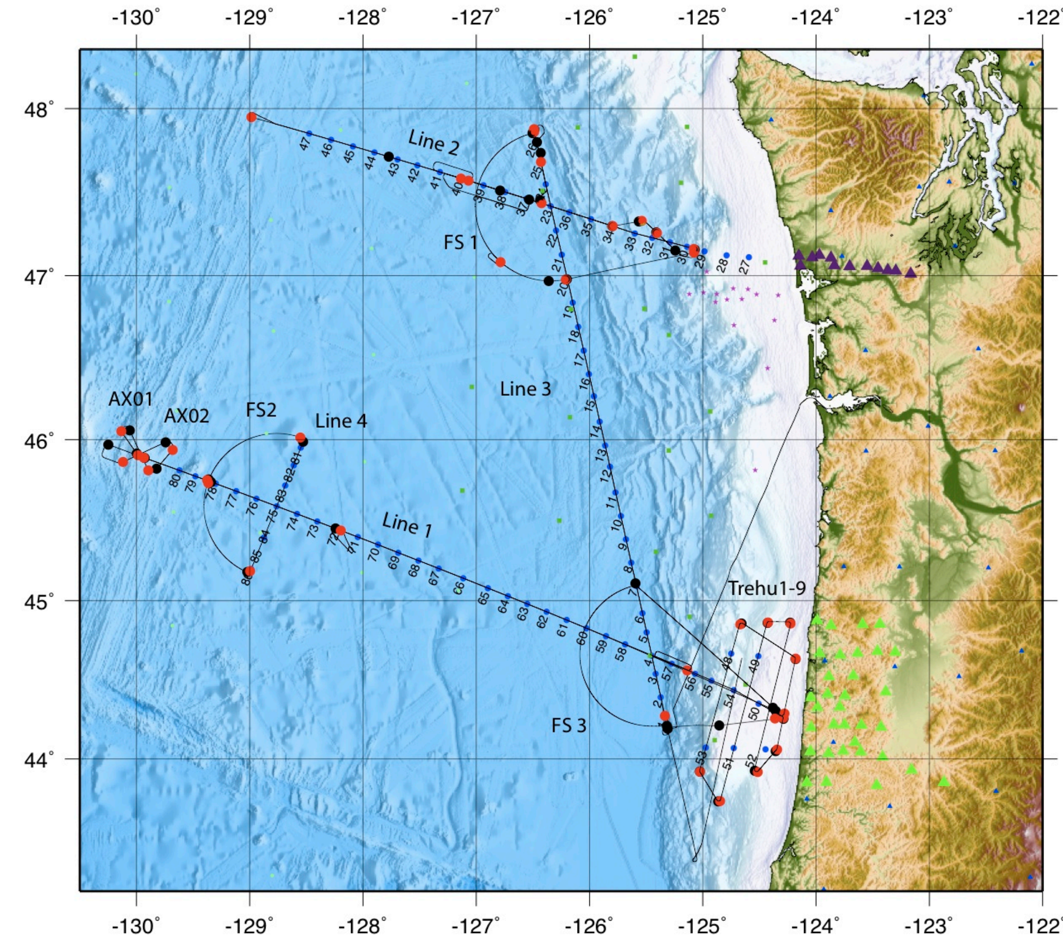
Final Cruise Report

Juan de Fuca Plate: Ridge to Trench

R/V *Langseth* MGL1211



June 13 to July 8 2012, Astoria – Astoria
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1. Scientific Objectives

Subduction zones, where two tectonic plates collide, are the sites of the world's most devastating earthquakes and tsunamis, of explosive arc volcanism, and high landslide hazard. As one tectonic plate descends beneath the other, water stored within the descending plate is released deep in the earth and is believed to play an important role in these subduction-related phenomena, contributing to the generation of arc magmas, of intraslab earthquakes at intermediate depths, and in the mechanical characteristics of the megathrust interface. Despite the importance of water bound in oceanic plates for many subduction processes, little is known about how the plate becomes hydrated, the extent and distribution of hydration, and how the state of hydration of the descending slab contributes to earthquake hazard at different subduction zones.

At the Cascadia subduction zone, where volcanic eruptions and megathrust and intraslab earthquakes pose significant hazards in the heavily populated northwestern US, the state of the down-going Juan de Fuca (JdF) plate is of particular interest. With the young age and therefore presumed warm state of the JdF plate, hydration of the oceanic lithosphere may be confined to the crust, limiting the potential volume of water stored in the plate to less than in other subduction systems. However, numerous observations support the presence of abundant water within the Cascadia subduction zone. Some of the water entering the subduction zone is transported within the sediment section and the highly porous upper crust, but seismicity located below the oceanic crust suggests the presence of water reaching into at least the shallowest mantle of the down-going plate. Regional variations in subduction zone properties and seismicity are observed along the Cascadia margin and variations in incoming plate hydration could be important.

Our study is designed to test the hypothesis that the JdF plate is significantly hydrated prior to subduction, transporting water into the subduction zone, and contributing to along-strike variations in structure and seismicity along the Cascadia margin. Progressive alteration of crustal and mantle rocks due to water circulation within the oceanic lithosphere can give rise to detectable changes in seismic velocities, and seismic techniques are well suited for remote detection of plate hydration. In our study coincident long-streamer (8 km) multi-channel seismic (MCS) and wide-angle ocean bottom seismometer (OBS) profiles will be used to characterize crustal and shallow mantle velocities and distribution of faulting across complete transects of the JdF plate, from formation at the mid-ocean ridge, through alteration and hydration within the plate interior, to subduction at the Cascadia trench. Seismic data will also be collected along a 400 km long line parallel to the Cascadia subduction zone to characterize variations in the architecture and velocity structure of the down-going plate from Oregon to Washington.

The plate transects are chosen to provide reference sections of JdF plate structure and evolution offshore two contrasting regions of the Cascadia subduction zone, and spanning the maximum age range of the plate (8-9 Ma). Reflection images derived from the long-streamer data will be used to characterize sediments, igneous basement, and Moho and sub-Moho structure with an emphasis on faulting in the plate interior and variations in crustal structure along the trench. Tomography methods will be used to resolve velocities within the upper 1-2 km of the crust at lateral resolutions of ~2km using the streamer data, and lower crust and mantle velocities at lateral resolutions of 10-20 km using OBS data. Characterization of the structure of the young JdF plate prior to subduction will facilitate comparative studies with other subduction zones where the age of the down-going plate is typically older and plate hydration may be more extensive. The plate transects will also provide the first continuous ridge-to-trench images ever acquired at any oceanic plate, feasible at the JdF due to the small size of the plate.

2. Survey Plan

Our planned survey is shown in Figure 1 and included 1. two ridge-perpendicular transects to characterize plate evolution and faulting across the full width of the JdF plate (Line 1 and 2), 2. a long trench-parallel line outboard of the Cascadia accretionary wedge to characterize along-trench variations in the downgoing plate (Line 3), 3. a short reference line over young ridge flank crust beyond the region of near ridge-axis faulting (Line 4), and 4. three fan lines for study of mantle anisotropy. The main considerations in the positioning of each line are described further below. In addition to the primary motivations of plate evolution and structure of the downgoing plate, survey lines were located to optimize leverage of existing seismic and hydrologic data, and to complement planned studies with the OOI and Cascadia Amphibious Facility.

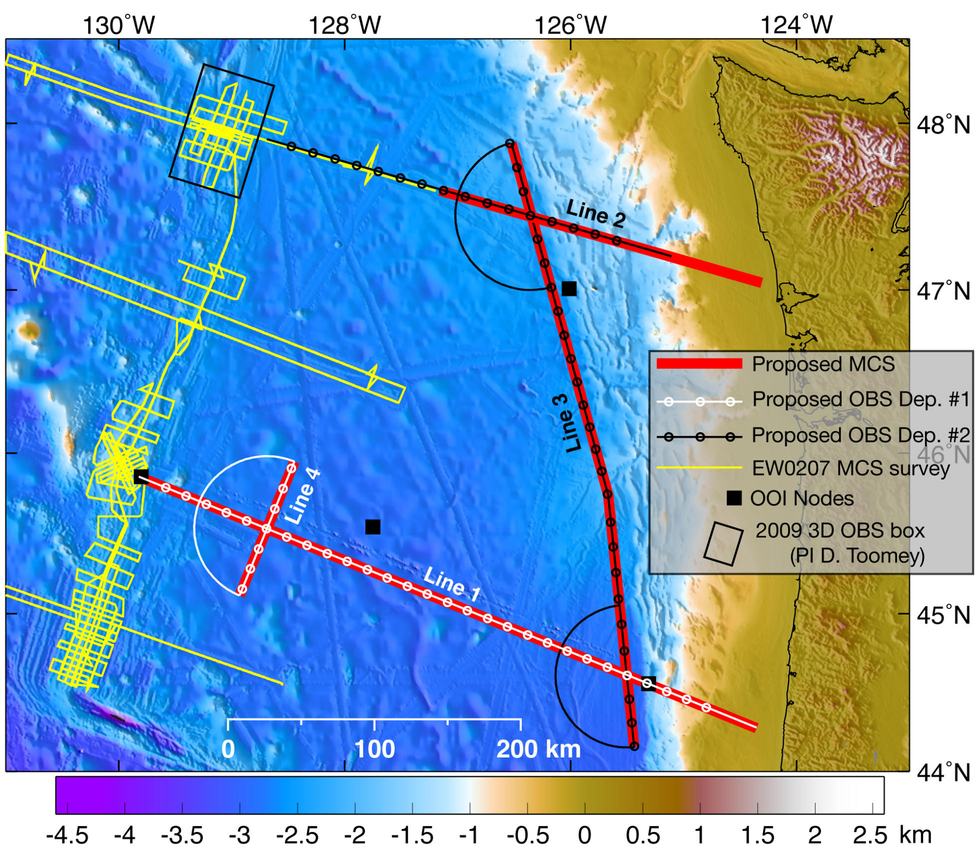

Fig. 1. Proposed survey plan. Locations of the existing EW0207 MCS and Endeavour 3D OBS experiments are indicated, as well as location of OOI nodes (see legend).

Line 1 crosses the central JdF plate extending from the ridge axis at Axial Volcano to offshore Oregon at Hydrate Ridge at the latitude of a major structural boundary in the Cascadia forearc. This region coincides with a prominent gravity high bounding two deep structural basins in the forearc and may be an important asperity in the Cascadia subduction megathrust [*Wells et al*., 2003*; Song and Simons*, 2003]. Intermediate-depth intraslab seismicity is minimal in this region of the subduction zone, in contrast to further north. Line 1 crosses two pseudofault zones, providing the opportunity to characterize structure associated with these important discontinuities, and forms a partial flow line crossing more than one spreading segment. Existing seismic data is available for both Axial Seamount and Hydrate Ridge (two nodes of the Regional Cable Observatory of the OOI), providing detailed characterization of crustal structure at the Line 1 transect end points [e.g. *West et al*., 2000; *Tréhu et al*. 1994]. Line 1 was also located to intersect Cascadia at the location of the onshore/offshore ORWELL wide-angle transect [*Parsons et al.,* 1999; *Gerdom et al.,* 2000] (Fig. 1), and the Oregon 1993/94 broadband teleseismic profile [*Li and Nabelek,* 1999; *Bostock et al.,* 2002] which together provided the best characterization of subduction zone structure along the Oregon margin available prior to our study.

Line 2 transects the northern Juan de Fuca plate offshore Grays Harbor, along a flow line within a single spreading segment, uninterrupted by the numerous propagator wakes that transect the JdF plate elsewhere. In contrast to the southern profile, significant intraplate seismicity, including that originating within the uppermost mantle, is observed within this region of the subduction zone with abundant intermediate depth earthquakes beneath the eastern Olympic Peninsula. Line 2 coincides with and extends landward of a ridge flank MCS transect acquired in 2002 (part of cruise EW0207) which provides evidence of crustal faulting as well as upper crustal velocity variations for 150 km into the JdF plate interior [Nedimovic et al., 2008; 2009]. Line 2 also coincides with the ODP FlankFlux transect where a wealth of existing heat flow, hydrologic, and drilling data are available [e.g. *Davis et al*., 1997]. Ridge-axis crustal and mantle structure is well constrained at Endeavour segment from two prior seismics studies: the 2002 MCS study EW0207 [Van Ark et al., 2007], and the 2009 OBS study of Toomey et al. [MGL0910]. As with Line 1, Line 2 was also designed to optimize integration with existing onshore seismic data and intersects the margin at approximately the latitude of the prior CAFE broadband seismic transect [*Abers et al*., 2009].

Line 3 is located ~10 km west of the Cascadia deformation front parallel to the trench on the abyssal plain. This line was designed to continuously sample similar age and oldest JdF plate (8-9 My) just prior to subduction for over 400 km along the trench to facilitate study of along-strike variations associated with JdF plate segmentation, including any crustal thickness variations or anomalous basement relief presently entering the trench. Line 3 was also expected to resolve the deep structure of several of the WNW-trending active strike-slip faults [*Applegate et al.,* 1992; *Goldfinger et al.,* 1992, 1996; *MacKay,* 1995] that deform the Cascadia forearc where they extend farthest onto the incoming plate.

Line 4 is an ~ 100 km long isochron line located on young crust east of Axial seamount and oriented perpendicular to Line 1. The primary goal for this line was to characterize crustal and upper mantle structure beyond the ridge axis regime for comparison with older near trench crust. An additional goal for this line was to characterize crustal and mantle anisotropy in the young plate for a study of changes in anisotropy (or lack thereof) as the plate reaches the trench. Wide-angle data collected in orthogonal directions at the intersections of Line 1 and 4 as well as Line 3 with 1 and 2 will provide the needed constraints on magnitude of crustal and mantle anisotropy in young crust and near the trench. In addition to these primary lines, we also planned to acquire wide-angle data along three semi-circle fan lines to provide further constraints on the orientation of mantle anisotropy in the young crust and near trench setting.

Additional Programs

In addition to our primary survey goals, two add-on programs were conducted on our cruise, taking advantage of the opportunities provided by the plate-scale imaging. One was a seismic oceanographic study of the water column within Cascadia Basin led by Berta Biescas at Dalhousie and involved the acquisition of closely spaced XBT and XSV data during the MCS phase of our study. A report summarizing the Seismic Oceanography component is provided in Appendix 10.

The other program was a landward extension of our subduction zone imaging using an additional 6 OBS deployed at the shallow water end of Lines 1 and 2 with complementary deployment of arrays of land stations in Oregon and Washington. This study was led by Anne Trehu at OSU, and Geoff Abers and Helene Carton at Lamont.

3. Cruise Description

Our experiment was conducted as a two-ship survey using the *Oceanus* to deploy and recover 47 OBS in two phases and the R/V *Langseth* for MCS acquisition and airgun-only operations during OBS deployments. *Langseth* survey operations were coordinated with the *Oceanus* and conducted in three phases:

Phase 1. OBS shooting for Lines 2 and 3 and Fan Line 1;

Phase 2. MCS acquisition along Lines 2, 3, 1, AX01, AX02;

Phase 3. OBS shooting for Line 1, OBS/MCS acquisition for Fan 2 and Line 4, OBS only acquisition for the Trehu program add-on lines, Fan 3 and a final Line 3 southern extension.

The *Oceanus* departed Newport OR on June 7 (cruise OC1206A) and began operations with the first deployment of 47 OBS along Line 2 and 3. The *Langseth* was scheduled to depart Astoria on June 11 once the first OBS deployment phase was near completion, but was delayed for ~2.5 days due to complications with obtaining our IHA permit from NMFS. The Friday before departure, concerns were raised to NMFS about the possible presence of Southern Resident Orca whales off the central Washington coast (see below) and our permit was delayed as options for additional mammal mitigation procedures were discussed. In the final permit negotiated, the easternmost portion of our Washington line

(Line 2) was removed from our survey for later acquisition as part of the Holbrook cruise to follow ours which was focused in this same area and for which additional mitigation procedures would be needed.

Following these negotiations, our IHA permit was obtained on the afternoon of June 13 and we departed Astoria at 19:00 local, transiting to begin OBS acquisition at the southern end of Line 3, followed by Fan line 1 and Line 2. While OBS shooting from the *Langseth* was underway, the *Oceanus* conducted CTD stations and acoustic surveys at each OBS. The 8-km long MCS streamer was deployed at the end of Line 2 near Endeavour Ridge and then all MCS lines were shot (in order of Lines 2, 3, 1, AX01, AX02) while the *Oceanus* retrieved and then redeployed 46 OBS along Line 1 and 4 (one OBS from deployment 1 was not recovered). During MCS operations 267 XBT and 120 XSVs were deployed along the primary lines for the seismic oceanography objectives (see Appendix 10). The final phase of our program included OBS/MCS acquisition of Fan line 2, Line 4 and a portion of Line 1, after which the streamer was recovered. OBS-only acquisition then resumed along Line 1, the Trehu/Abers Oregon add-on lines 1-9, Fan line 3. The remaining cruise time was used to extend OBS Line 3 ~ 100 km to the south before transiting back to Astoria for arrival early afternoon on July 8. While seismic acquisition was underway in this last phase, the *Oceanus* conducted CTD to-yo's at Axial Seamount, and CTD stations at each OBS (no acoustic surveys were conducted for the second OBS deployment). Once *Langseth* airgun operations were complete, the *Oceanus* recoverd all OBS from Lines 1 and 4, returning back to Newport on July 13. Details on *Langseth* operations for each of these three phases are described below. *Oceanus* operations were led by Pablo Canales and Helene Carton and are described in the OC1206A cruise report. Seismic acquisition parameters are included in Appendix 5 Table A5.2 and the summary seismic line log is provided in Appendix 5 Table A5.1. Each of the primary lines were acquired in multiple segments due to extended power-down and shut down periods for marine mammals. Track maps for each of the three phases of seismic acquisition are included below along with a more detailed description of each phase.

Phase 1: We departed Astoria on Wednesday June 13 at 1900L and transited 13 hours to the southern end of Line 3 where we deployed the gun array for a 12 m gun tow depth and maneuvered to begin the OBS shoot of this line (OBS03, Fig. 2). While coming on-line, the airgun array was shutdown due to a whale sighting followed by a 30 minute array ramp-up period; an early indication of the primary challenges experienced during the cruise. Acquisition of OBS03 began at 13:23L at the primary shot interval used for the OBS program of 500 m, shot on distance, ~216 sec target interval at survey speeds of 4.5 knots. There were a total of four power downs along this line (2 - whales, 1 - sea lion, 1 - seals) and a long powerdown/shutdown due to seals playing in the gun strings that prevented acquisition of the northernmost ~20 km of Line 3. Following OBS03, we acquired the northern fan line in two parts (OBSFS01, OBSFS01A) with a loss of 44 km along the southern half of the fan, also due to presence of seals within the gun strings.

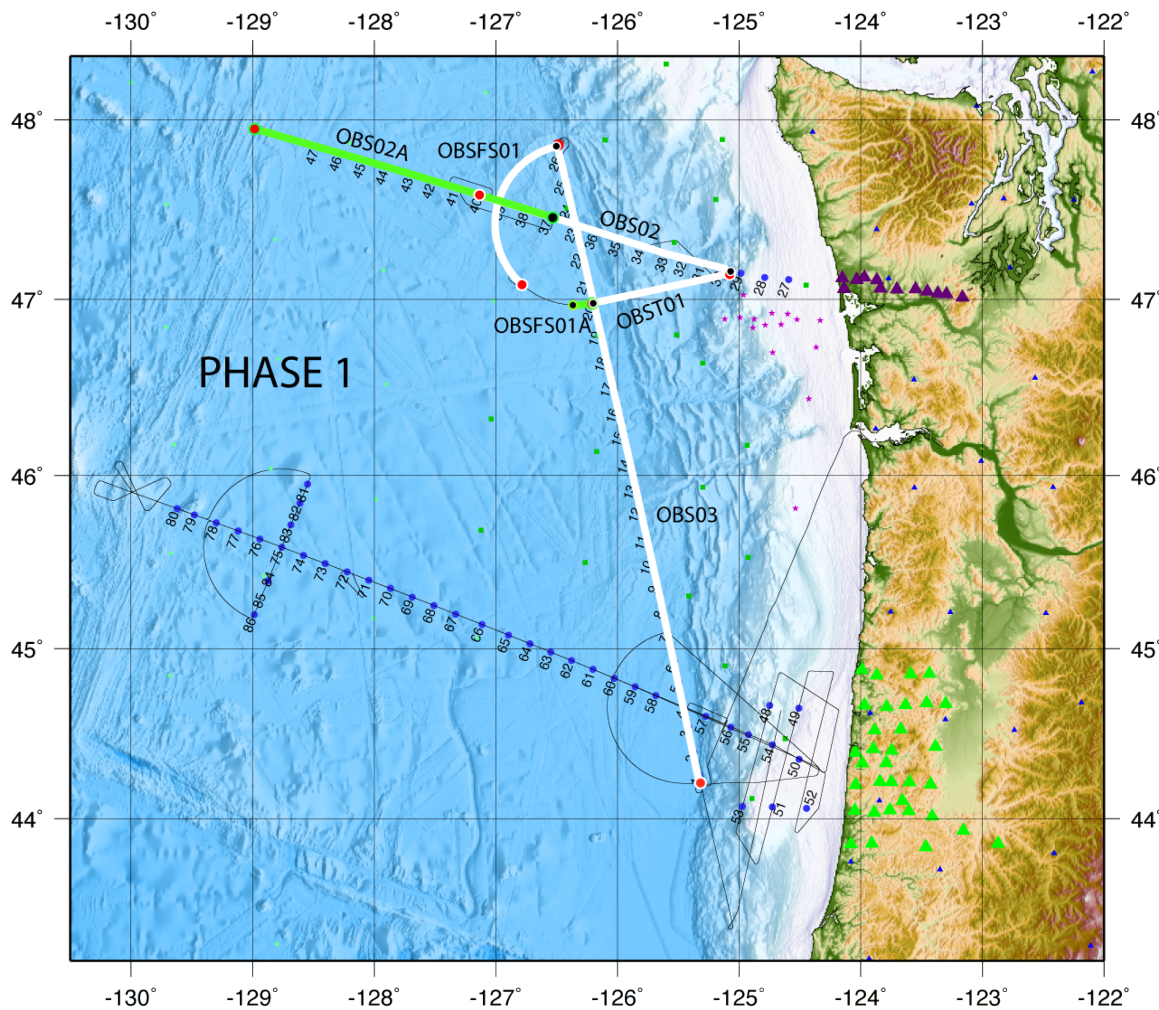

Figure 2. Track map for Phase 1 of the survey with seismic line names indicated (note-prefix for all line names is MGL1211). Primary lines shot in multiple segments are shown with different colored line for each segment (white-green-red-blue). Black/red dots show line start/end locations respectively. Numbered blue dots indicate OBS locations.

After completing OBSFS01A, we transited east to begin OBS acquisition along Line 2. As we were constrained by our IHA to remain seaward of the 1000m contour on the slope, we began Line 2 just west of OBS#30 (Fig. 2). Line 2 was acquired in 2 parts due to an extended shut down that continued to dusk on June 18 (JD171), preventing further acquisition for the night. During this time we transited back to reshoot from OBS#23 to 37, although only part of this section was successfully acquired the following day. We had a total of 6 power downs and 2 shut downs along OBS02. Both shut downs were due to seals entering and remaining within the safety radius of the seismic source. Acquisition of the second part of Line 2 continued at dawn on June 19 starting just east of OBS#37 and ending east of the Endeavour Marine Protected Area (MPA). We had 1 power down and 4 shutdowns (all to seals in the gun strings) during acquisition of OBS02A

At this point in our survey we had used all budgeted contingency time plus an additional 12 hours requiring us to eliminate some portion of our planned survey. We decided to drop the planned MCS-only acquisition of Line 4 and instead shoot this line only once at a compromise 150 m shot interval which would provide low fold (~26) MCS as well as useful OBS data. This change from two passes of Line 4 to one freed up 24 hours in the planned survey, 12 of which covered the already used contingency leaving 12 hours of new contingency for the remaining program. An additional 10 hours were gained during streamer deployment and 16 hours at the end of the MCS phase due to rapid streamer recovery.

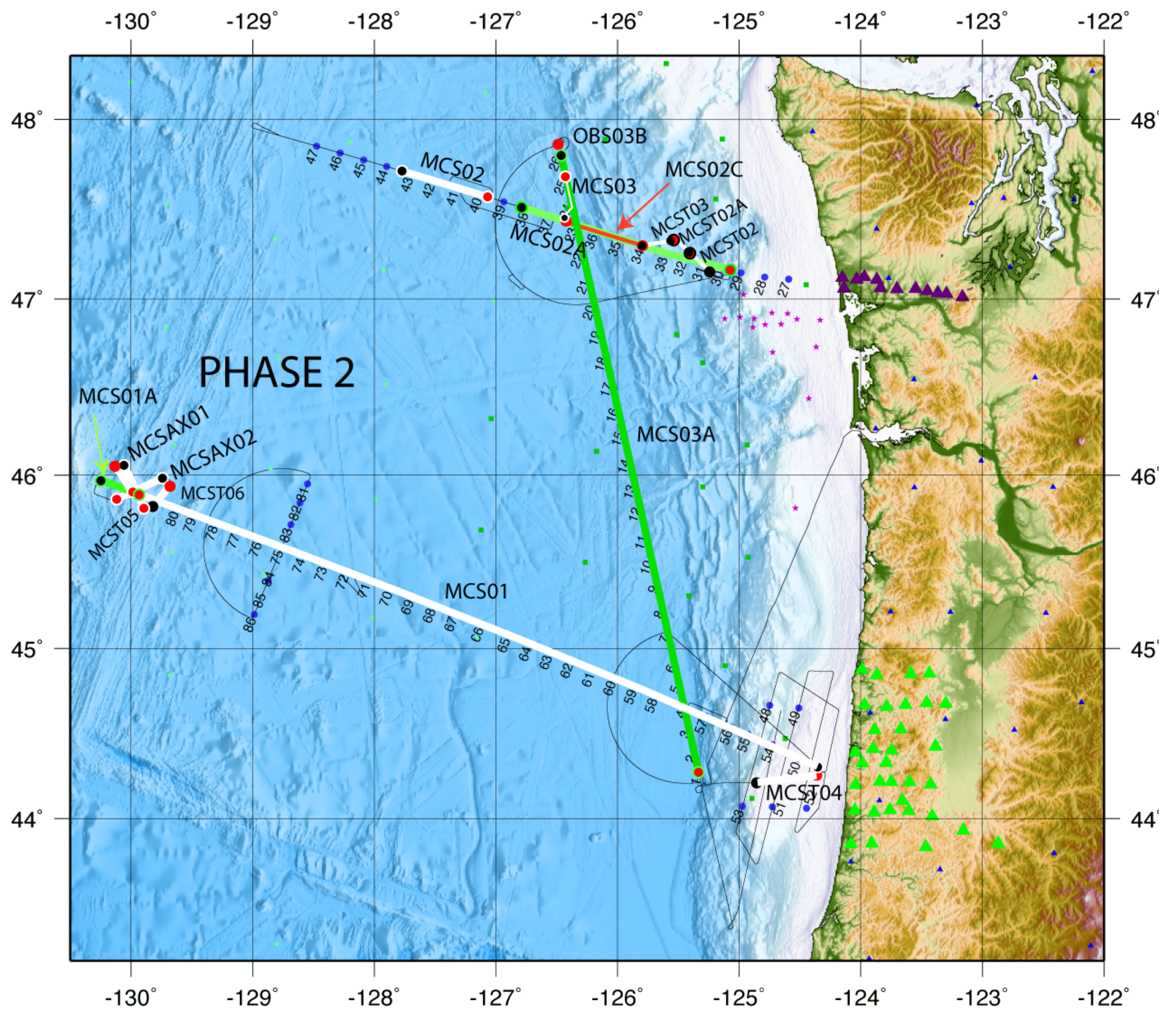

Figure 3. Track map for Phase 2 of the survey with seismic line names indicated (note-prefix for all line names is MGL1211). Primary lines shot in multiple segments are shown with different colored line for each segment (white-green-red-blue). Black/red dots show line start/end locations respectively. Numbered blue dots indicate OBS locations.

Phase 2: The MCS acquisition phase (Figure 3) started with deployment of the streamer beginning at 07:08l/14:08z on June 20/JD172. Our 8 km streamer was built adding 2 km of streamer 1 to the tail section of streamer 3. Deployment went smoothly and was complete in 14 hours with only minor trim work required on streamer 3. The 4 string gun array was redeployed with the source at 9 m tow depth. MCS acquisition began along Line 2 (MCS02) at ~OBS 43, shooting on distance at a 37.5 m shot interval (~15 sec at 4.5 knots). Due to the extended shutdowns experienced during OBS acquisition along Line 2, we planned to reshoot from OBS 41 to 40 at a 500 m shot interval after acquiring this portion for MCS. However, when we came on line for the OBS reshoot near daybreak June 21, seals were present and we were shut down for the next 9 hours while we transited as slowly as streamer towing would allow (3.5 knots). MCS acquisition along Line 2 resumed (MCS02A, Figure 3) at 21:45z on June 21/JD173 just west of OBS 38 but was interrupted frequently with 6 power downs and 4 extended shut downs before the end of line near OBS 30. To recover some of the missing portion of this line we turned back onto Line 2 and reshot from E to W crossing OBS 36, 35, and 23 (MCS02B, Figure 3). We then turned north to come on Line 3 and began MCS03 shooting south to north. As we had not been able to acquire data from OBS 25 to 26 during line OBS03, this segment was shot at a compromise shot interval of 150 m so that useful OBS and (low fold) MCS data could be acquired (OBS03A, Fig. 3). We then turned south on Line 3, resuming MCS acquisition (MCS03A).

During MCS03A we experienced 7 power downs (5 for seals, 2 for dolphins), 1 power down/shut down for dolphins and 2 power down/shut downs for porpoises. The second porpoise shut down resulted in early termination of Line 3. Gun maintenance work was conducted on the transit to begin Line 1 and 100 m was added to the streamer lead-in to improve recurring problems encountered on turns when it had been difficult to keep the lead-in from moving into the gun array. We began MCS01 on June 26/JD178 at 01:29z and ended on June 28/ JD180 at 12:43z after 60 hours. We had a total of 3 power downs along this line for whales, 2 of which resulted in loss of ~1 hour of acquisition.

With MCS acquisition of Lines 1, 2, and 3 complete and most of the contingency time gained by dropping the MCS-only shoot of Line 4 remaining, we decided to acquire several short contingency lines at Axial seamount. These lines were designed to support a study of change in the magma body imaged beneath Axial Seamount before (in 2002) and after the volcanic eruption in 2011. The selected lines -AX01 and AX02 -were located to coincide with lines 60 and 63 acquired during cruise EW0207. Line AX01 was shot with the 6600 cu in source and AX02 with the 3300 cu in source. Due to time spent on extended gun maintenance work after both AX01 and AX02, we decided not to acquire a third planned contingency line through the hydrothermal vent site discovered on the flank of Axial seamount last summer. Phase 2 ended on JD181 with a short portion (8km) of Line 1 not acquired during MCS01 due to a premature turn off line the prior day (MCS01A).

Phase 3: For phase 3 of our survey (Fig. 4) we resumed OBS acquisition, beginning with the first of 4 segments of Line 1 (OBS01) shot at a 500 m interval (streamer still deployed). Between OBS 77 and 76, we turned north to acquire the first half of fan line 2 (OBSFS02A), followed by Line 4 (OBS04), and the second half of fan line 2 (OBSFS02B). These 3 lines were acquired at a 150 m shot interval. We had intended to recover the streamer at the end of the fan shoot, but with nightfall approaching we decided to continue on Line 1 with the streamer until dawn (OBS01A). Streamer recovery went very smoothly, the guns were reconfigured for 12 m tow depth, and we were back online after 7 hours 20 minutes.

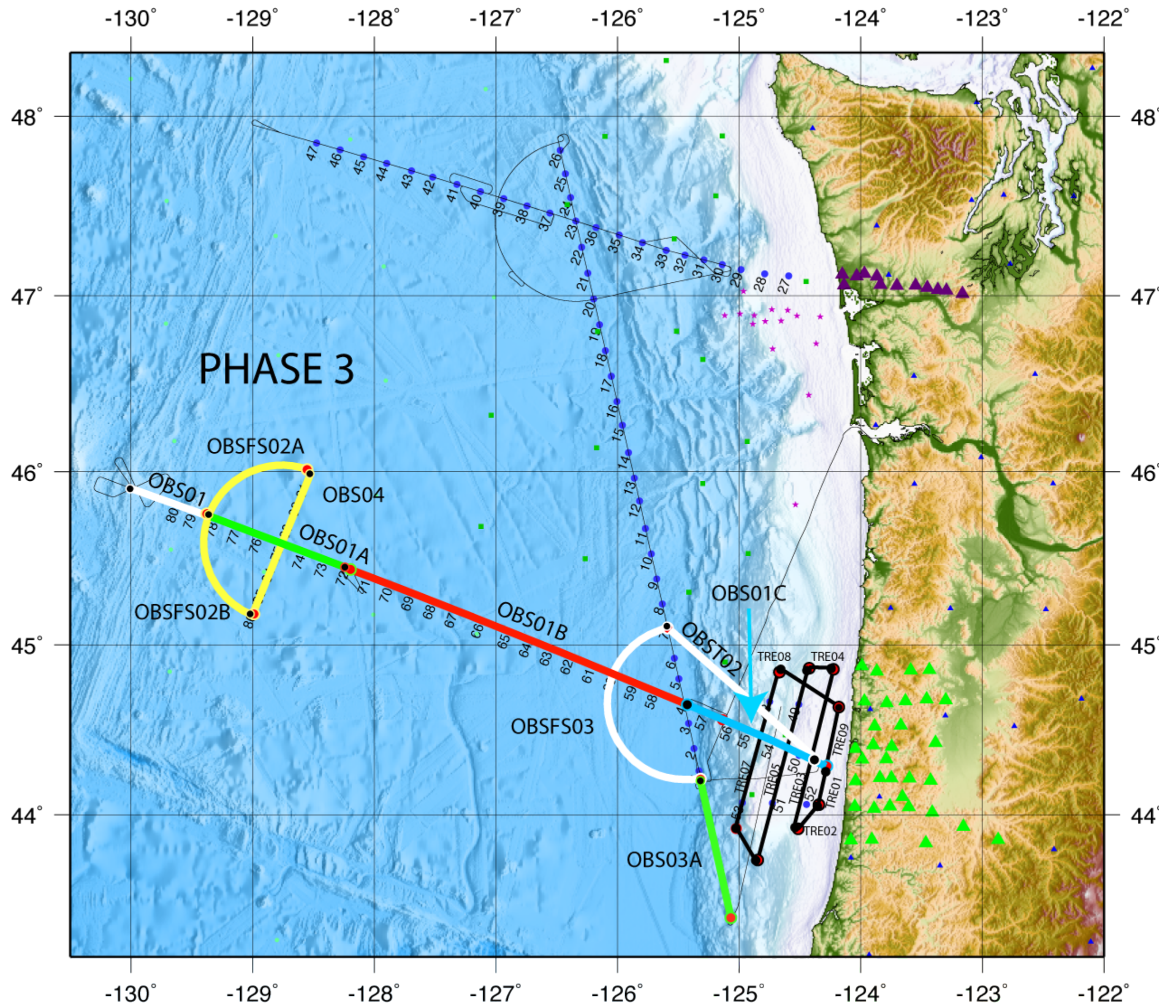

Figure 4. Track map for Phase 3 of the survey with seismic line names indicated (note-prefix for all line names is MGL1211). Primary lines shot in multiple segments are shown with different colored line for each segment (white-green-red-blue). Black/red dots show line start/end locations respectively. Numbered blue dots indicate OBS locations.

OBS acquisition along the 3rd segment of Line 1 (OBS01B) was uninterrupted for the next 1.5 days until we reached the deformation front just passed OBS4 when we had an extended shut down for dolphins (3 hours). Fortunately, we were able to resume operations by nightfall and the decision was made to reshoot this important section. The final leg of Line 1 was shot without interruption ending on JD185 at 14:01L (OBS01C, Fig. 4).

Upon completion of Line 1 at ~6 nm from the Oregon coast, we began the 2 day Trehu survey with all lines acquired using a 170 m shot interval, ~60 sec at speeds of 5.5 knots. This survey was composed of 9 lines (TRE01-09) shot on an ~ NE-SW oriented grid to the deployed OBS and an array of land stations. This survey was completed in 2.25 days time on JD187 at 19:35L. We then transited northwest to the northern end of fan line 3 (OBSFS03, also shot at 170 m at 5.5 knots). We used the time remaining to extend OBS Line 3 further south by ~100 km (OBS03A – also labeled OBS03C in some cruise documentation, 500 m shot interval) with the survey ending at ~1950z/1250L on JD188.

IHA Issues

Our IHA was not issued as expected prior to departure and we were delayed in Astoria by 2.5 days. This delay occurred when new information concerning the local Southern Resident Orca (SRO) whale population of Pudget Sound was brought to NMFS attention on the Friday before our departure. A group of SRO were reported to have left Pudget Sound the prior week and watch groups for this population were concerned that they may have gone to feed in the area of our planned Washington line near Grays Harbor. After discussions with NSF, NMFS, LDEO-OMO, all PIs for our project, and Steve Holbrook, the decision was made to remove the easternmost end of Line 2 and add a day to the Holbrook cruise which would be used to complete our line. The reschedule of this line to Holbrook's cruise made up for part of our lost contingency time (budgeted at 3 days) due to our 2.5 day delayed departure. As a result, we left Astoria with 1.5 days of contingency budgeted.

Leap Second

A leap second was added to UTC time at 11:59:59 pm GMT on June 30 to synchronize atomic clocks with the speed of the rotation of the earth. Spectra provides the time stamp for the shot logs, P190 files etc, and was not adjusted for the leap second. Hence the times in all shotlogs and P190s files for shots after midnight UTC July 1 were off by 1 second from the GPS time stamp used for the rest of the ship's instrumentation. Dave and Jay put all shotlogs from July 1 00:00z onward in a separate folder for later processing as needed. This leap second correction occurring midway through our survey, will need to be dealt with in the analysis of all deployed OBS and land stations.

Coordination of OBS and MCS Operations

Close coordination of *Langseth* and *Oceanus* operations was required throughout our survey and was accomplished via regular email and skype chat between the PIs as well as use of an R2R eLog netbook which was set up on both ships and accessible to both via the web (http://elog.rvdata.us:8115/MGL1211-SE/). Using this elog, as well as tracking our ship's positions on the www.sailwx.info site, each group was able to track the position of the other and plan accordingly. Due to delays and missed acquisition during phase 1 of our survey associated with frequent marine mammal encounters, especially close coordination was required to ensure that OBS reshoot lines during phase 2 were completed with adequate time left to recover and redeploy all OBS prior to phase 3 seismic operations.

http://www.sailwx.info/shiptrack/shipposition.phtml?call=WDC6698

This sailwx site is updated automatically every hour, about half an hour after the position is transmitted in.

Problems were initially encountered in connecting the R2R eLog to the Langseth internal network as the UDP reader for the GPS navigation string did not work as expected. After communication with Laura Stolpe of the eLog support group at WHOI, Jay Johnstone was able to fix the elog conf to read the navigation string via a serial port connection, like the set-up of the elog deployed on the Oceanus.

Summary

Our cruise was highly successful. We achieved all of our primary science objectives with the exception of the postponed acquisition of the near-shore portion of our northern transect Line 2, and MCS acquisition along Line 4. Streamer feathering was negligible throughout the cruise (average=2.98° equivalent to 400 m offset at tail end of streamer) and from our initial analysis, the MCS data quality is good. Guns and streamer components functioned well throughout the cruise with all gun maintenance accomplished on transit lines. Weather was favorable throughout. The primary limitation experienced during acquisition were the frequent power downs and shut downs required due to marine mammal sightings. We spent a total of 72 hrs 14 minutes on mammal mitigation, 8 hrs 39 minutes on gun maintenance, 20 hrs 37 minutes on deployment and recovery of gear, and 31 hours on transits from/to port. We acquired a total of 2343 line km of OBS data and 1581 line km of MCS data with over 45,000 shots fired and a cumulative MCS data volume of 557 GB. (Table 1 provides a day-by-day summary of production time and kilometers acquired). The success of the cruise was, in large part, due to the high level of expertise and commitment of the science technical support party, the ships captain, officers and crew as well as the LDEO-OMO, who provided key onshore support to overcome last minute problems with our IHA permit and ensure our survey could proceed. We are deeply appreciative of the dedication and professionalism of all of these groups. The Langseth is a very impressive operation due to their efforts.

Table 1. Summary of Acquisition Achieved, Equipment Maintenance, and Mammal Mitigation times.

Day	Gun/Streamer Maintenance hours	Mammal Mitigation hours	OBS Km acquired	MCS km acquired	OBS hours acquired	MCS hours acquired	Number of PD/SD* on line
13-Jun							
14-Jun	0	2:30	30		3:38		1
15-Jun	0	0:21	197		23:39		2
16-Jun	0	4:27	155		19:33		4
17-Jun		10:06	111.5		13:48		3
18-Jun		1:14	189		22:29		3
19-Jun		14:53	74.5		9:07		7 (night)
20-Jun		0:12	113.5		13:54		1
21-Jun	1	11:19		69.6		8:15	2 (9 cont hrs)
22-Jun	0:56	3:56		148.39		19:10	6
23-Jun		11:56		148.39		12:04	6
24-Jun		0:57		197.21		23:03	5
25-Jun	4:43	1:39		142.275		17:37	3
26-Jun		1:09		178.84		22:51	3
27-Jun		0:55		189.19		23:05	1
28-Jun				168.6		24:00:00	0
29-Jun	1:00			149.78		23:00	0
30-Jun		0:34	188.25	188.25	23:20		2
1-Jul	1:00	0:36	137.95		17:20		0
2-Jul		0:56	194		23:04		1
3-Jul		8:29	132.55		15:28		5
4-Jul		2:03	209.95		21:38		3
5-Jul		3:10	210.63		20:45		4
6-Jul	0:13	0:24	220.02		23:23		2
7-Jul			179.62		19:45		0
8-Jul							
Total	8:39	72:14	2343.47	1580.525	277:48	172:45	64

* PD/SD – Power Down/Shut Down

Power Down and Shut Down procedures are as follows:

Power downs

A power down involves a reduction in the source volume to a single 40 cu in gun, ("mitigation gun). A power down is conducted when a mammal enters the safety radius for the full array for a given water depth, but outside the safety radius for the mitigation gun. The gun ramp-up procedure involves firing the guns every 17 s and adding one gun each shot, requiring 30 minutes to reach full volume. Following a power down the following procedures are followed:

--If the mammal is observed to have left the radius within 8 minutes - immediately return

to full volume.
--If the mammal is observed to leave the safety radius after 8 minutes - begin ramp -up.
--If the mammal is not observed to leave the safety radius- visually observe safety radius for 30 minutes. If it is not observed in that time –initiate ramp up.
--In low visibility times (or at night), if a mitigation gun is firing, ramp up to full volume can occur (e.g. if gun maintenance work is underway at night, ramp-up can occur as long as mit gun is remains firing throughout).

Shut downs
A "shut down" means no airguns can be fired and is initiated if a mammal enters the safety radius for the mitigation gun. Following a shut-down, the above procedures apply for ramping up. In low visibility times or at night, ramp up from a shut down is initiated when the full safety radius zone can be observed again.

4. Cruise Narrative

(Note: Midnight UTC=17:00 Local time)

Monday/Tuesday June 11/12: Standing by in Astoria waiting for our IHA permit to be issued.

Wednesday June 13/JD165: We received notice at 16:00 local time (L) that the signed IHA had been received at Lamont and we obtained the OK to prepare for departure. We left Astoria at 19:00 L with calm seas (5 ft), slightly overcast skies, and winds 10-15 knts. The EM122 was turned on and logging begun as we left the Columbia River and headed off the shelf to our survey start waypoint at the southern end of Line 3. The magnetometer was deployed and a science meeting was held at 20:00L.

Thursday June 14/JD166: Gun deployment began at 08:00L after a transit of 13 hrs. Our Protected Species Observers (PSO) noted two pods of dolphins and a whale during gun deployment. At 09:25L gun deployment was complete and ramp-up began. However, a whale was observed just as we were coming online requiring a mammal mitigation power down with the 30 minute observation period followed by a full ramp up. At 13:23L we began our first line (OBS03) shooting to the deployed OBS along Line 3 from south to north. We spent a total of 2.5 hours today due to mammal mitigation.

Friday June 15/JD167. We continued today on trench parallel line OBS03. Weather was excellent and acquisition went well with 2 short power downs (~ 20 minutes each). The *Oceanus* passed us last night as they headed south to complete a suite of CTD casts at each OBS. After completing all CTDs today, they will travel north to survey in each OBS. Jay succeeded in getting the R2R elog to correctly pull in the ship nav via serial port and we began logging OBS crossings using the R2R elog. As the elog is available over the external network, the *Oceanus* can now track our progress remotely, as we can theirs. The ability to monitor operations of both ships using the R2R elog proved very useful during the cruise.

Saturday June 16/JD168. Acquisition on Line OBS03 continued for most of the day until we reached ~ OBS 25 when we had a power down due to seals near the ship (later identified by the PSO as Northern Fur Seals). After initial sighting, the seals migrated aft to play in the guns requiring us to shut down completely. Robert advised against turning around to reshoot based on his prior experience that seals don't go far once they have found an offshore site to feed. As we continued on line, the seals left the region briefly, we ramped back up (30 minutes), fired one full power shot and then they were back playing in the guns again, requiring another full shut down. We decided to abandon the rest of Line 3 and planned to reshoot from OBS 25 to 26 at shorter interval shots when we return during the MCS phase. We turned west and began acquisition along fan line OBSFS01.

Sunday June17/JD169. A pair of northern fur seals were observed immediately at dawn and we shut down the array as they moved aft into the gun strings. The seals stayed within the array for 4 hours until we decided to bring the guns on deck as these seemed to be their primary interest. The gunners did the maintenance check Robert was intending to do on the transit line planned for after the fan line and the guns were redeployed. The seals immediately returned and we were shut down until 16:22L when we were able to start the mitigation gun and begin ramp up. 24 shots in total were acquired along OBSF01A completing fan line 1 at 16:35L. We experienced a loss of 44 km along this line in 9.25 hours of down time.

Monday June 18/JD170. We began line OBS02 at 02:34L heading toward Endeavour segment of the Juan de Fuca Ridge. The bridge had trouble maintaining speed given the 3 m seas. The weather eased by mid morning and acquisition proceeded smoothly until 15:08L when a group of seals returned. For the next 4 hours we had numerous power downs/shut downs until 19:37L when the seals stayed within the gun strings continuously and we were shut down for the entire night. We spent the next 7 nighttime hours heading back to mid way between OBS#23 and 37, along a course parallel to our prime line but 7 km south, for multibeam acquisition. We speculated that the seals were from the same group that we picked up on the previous 2 days as we were crossing through the same region just west of the deformation front.

Tuesday June 19/JD171. Seals were gone at daybreak and we resumed production with a 30 minute observation period followed by full ramp up. We began line OBS02A at 7:54L. Seas calm and winds at 20 knts. Acquisition proceeded smoothly until 13:25L when we had to power down and then shut down for seals until 15:36L. Between OBS 40 and 41 we acquired only 6 shots. One other power down before end of Line 2.

Wednesday June 20/JD172. Gun recovery began at 07:08L in preparation for deploying the streamer to begin the MCS phase of our survey. Deployment went very smoothly: 2 km of streamer 1 was added to the tail end of streamer 3 to build the full 8 km and a few weights were removed from the tail end of streamer 3. We began MCS02 at 21:20L after a total deployment time of 14 hours. Given the loss of OBS line 2 between OBS 40 and 41, we decided to reshoot this stretch after MCS acquisition of this portion.

Thursday June 21/JD173. As we came online to reshoot OBS Line 2 from OBS41-40, seals were immediately in the gun strings and acquisition was prevented. The seals remained with us until 14:14L when we finally began ramp up for MCS02A after no acquisition since daybreak. Extended power down and shut downs for seals and porpoises occurred later along the line near and along the western portion of the deformation front, but we continued online to end near OBS#30 just west of the 1000 m contour on the slope, as per our IHA.

Friday June 22/JD174. At the end of line 2, we ran 3 transit lines (MCST02, T02A, and T03) back toward line 2 and then reshot the important section over the deformation front where we had been shut down the prior day (MCS02B). This reshoot went well with 1 short power down. We turned off line to head north after crossing OBS#23. We shot MCS03 up to OBS#25 and then switched to a longer 150 m shot interval for combined MCS/OBS acquisition (OBS03B) along this stretch where we were shut down during OBS03A.

Saturday June 23/JD175. We began MCS03A at 7:20L and continued along line for rest of day with 4 short power downs.

Sunday June 24/JD176. Continued on MCS03A with a few power downs for mammal sightings but no shut downs.

Monday June 25/JD177. We ended MCS03A early due to shut down for porpoises that would prevent us from shooting again before the end of line. While turning, we encountered problems again with the streamer lead-in crossing over and getting caught in the gun lines. Robert decided we needed to add 100m to the lead-in to improve the tow configuration and ensure the lead-in stays out of guns. Considerable high amplitude 60 Hz noise is evident in outer part of streamer that will need to be filtered. We began MCS01 at 18:30L in shallow water depths (< 100m).

Tuesday June 26/JD178. During the day, we experienced one extended shut down period due to a whale following us (17:40-18:38L and 18:53-19:55L) during which we slowed to 3.5 knots, as well as a short power down for dolphins. Had to kill gun G1 from string 3 due to misfiring. Otherwise continued on line without incident.

Wednesday June 27/JD179. Robert reported a leak in gun string 3 but as it was not diminishing the source volume significantly, the decision was made to postpone gun work until our transit to MCSAX01. We continued today on MCS01 with few interruptions. Weather continued to be very good (4-7 ft seas).

Thursday June 28/JD180. Ended MCS01 at 12:43z/05:43L. Gun repair work was done on transit to AX01 (EW0207 line 60) during which time gun string 2 was brought on board revealing 2 guns hanging by the air hose with high likelihood of loss had gun string recovery been postponed. We continued to have problems with guns failing throughout the shoot of the Axial lines. Additional gun repair work was needed after AX02 (EW0207 line 63) and we decided there would not be sufficient time to shoot AX03 over the hydrothermal vent discovered on the ridge flank in summer 2011. AX01 was shot using the full gun array and AX02 was shot using 3300 cu. in. source. Seas were 7-9 ft. At the end of these Axial Seamount lines an estimated 16 hours of contingency remained for the second OBS acquisition phase of our program.

Friday June 29/JD181. Due to miscommunication between Robert and the bridge on Thursday, line MCS01A was ended without the requested 4 km of runout, leaving us with a truncated line just short of the summit of Axial. We decided to reshoot the missed portion of this line prior to beginning OBS acquisition along Line 1. This reshoot ended 4 km east of WP7, after which we switched to line OBS01, shooting at 500 m shot interval. This resumption of OBS acquisition marked the beginning of Phase 3 of our program. At WP8 we turned to port to begin OBSFS02A shooting from south to north, at the 150 m shot interval MCS/OBS compromise.

Saturday June 30/JD182. Uneventful day of acquisition along Line 4 (OBS04) and the second half of the fan line 2 (OBSF02B), all shot at the 150 m shot interval for both MCS and OBS. We had planned to recover the streamer after this fan line was complete. However, with slow data acquisition along both fan line segments (~4.0 knots, using ~4 hours contingency) due to strong currents from the north, our estimated end-of-line shifted to after nightfall. Recovering the streamer at this point would have prevented us from resuming OBS acquisition along Line 1 until daybreak. We decided to continue acquisition along Line 1 with the streamer deployed until dawn Sunday (OBS01A).

Sunday July 1/JD183. Streamer recovery began at 13:00z/06:00L and was complete in 7.5 hours with resumed OBS acquisition along Line 1 at 20:26z/13:30L (OBS01B). As we had budgeted 24 hours for streamer recovery, we gained 16 hours of additional contingency time for the remaining OBS program. We continued for the rest of the afternoon on OBS01B without any power downs. At midnight July 1 a leap second was added to UTC time (see section 3 above).

Monday July 2/JD184. We continued along OBS01B with one extended power down/ ramp up in the morning and another in the evening of ~2 hours during which time we lost 15 km of line. This loss was over a critical stretch at the deformation front and we decided to go back to reshoot this section using 9 hours of our remaining contingency.

Tuesday July 3/JD185. Completed OBS01C at 14:01L and began the 2-day Trehu survey with TREHUOBS01, OBS02 and OBS03. Anne requested we acquire these lines using a 170 m shot interval, 60 sec at 5.5 knots.

Wednesday July 4/JD186. We experienced one extended power down in the morning along TREHUOBS04 for 2 whale and 1 porpoise sighting. Few shots were acquired along this line. July 4th festivities included 4 rounds of shooting toilet paper rolls from the sonobuoy launcher in the afternoon. At 10 pm, the captain generously agreed to fire several white and green flares to the delight of those gathered.

Thursday July 5/JD187. Acquisition on the Oregon shelf lines continued with TREHUOBS07, 08, and 09. The Trehu survey was completed at 19:35L and we turned to transit northwest to the northern end of fan line 3.

Friday July 6/JD188. Continued on transit line to begin fan line 3 at 07:39L (OBSFS03). Both the transit and the fan line were shot using the same acquisition parameters as the Trehu survey (170 m shot interval at 5.5 knots) to provide a consistent dataset within this Oregon margin region. The starboard compressor, which had worked without problems throughout the cruise, failed in the morning with a snapped piston which will need repair in Astoria. We lost only 10 shots in moving to the port compressor. The port compressor currently vibrates excessively due to some as yet undiagnosed internal balancing problem. In the evening, the Knudsen desk unit failed and the system was turned off - repairs will be needed in Astoria.

Saturday July 7/JD189. We completed OBSFS03 at 01:18L. With our remaining survey time we shot an additional 100 km along a southward extension of Line 3 (OBS03C, shot at 500 m interval). We ended OBS03C at 12:50L and slowed to retrieve the gun array. Recovery was complete by 13:45L and we began transit to Astoria.

Sunday July 8/JD190. Arrived in Astoria at ~13:00 L. Cruise MGL1211 complete.

5. Summary of onboard data processing

Onboard data processing conducted during MGL1211 is summarized below with further details provided in the appendices.

MCS data (***Appendix 6 and 7***): During our prior cruises on the *Langseth* and *Ewing* (MGL0812 and EW0207), SIOSEIS had been used to generate continuously updating near-real time stacks plotted using the Atlantek plotter. This was not possible during MGL1211 as a working SUN to drive this plotter no longer exists. Instead brute stacks were generated using SIOSEIS after acquisition (scripts used included in Appendix 7). The SIOSEIS brute stack uses a velocity function hung from the seafloor depth for each shot grabbed from the SEGD headers. The velocity function used for stacking was modified from the one used for the ALEUT study for the thicker sediment section at Cascadia. A function based on ESP 5 from Vera et al. 1990 was used for the two Axial seamount lines. Brute stacks were then migrated at water velocity (see Appendix 7.2) to collapse seafloor diffractions and improve the image of the sediment portion of the sections for identification of faulting.

With completion of each MCS line, Dave Martinson generated P190 navigation files which we checked and merged with the raw SEG-D files using Paradigm's Echos (procedures described in Appendix 6). The merged files were written out as Echos dsk files for use in post-cruise processing. One of the P190 files was found to have been generated with incorrect geometry and it was passed back to Dave for correction (MCS03A). Another of the P190 files was missing the first shot (MCST04) and this SEG-D file was excluded in building the dsk file. Note that the P190 files for 2 lines (MCS03A and MCS01) needed to be split into 2 parts for making the dsk files as these lines contained more than 9999 shots (the maximum number of shots that can be processed with Echos/Focus in the PROTAPE module, see Appendix).

Multibeam bathymetry data (*Appendix 8 and 9*): MB-system was used to clean the multibeam bathymetry data after each days acquisition. All multibeam files were first converted from the raw *.all files to format *.mb59, then cleaned, manually ping edited, and gridded at 50 m on a daily basis. Day plots of the cleaned multibeam and side-scan were generated. At the end of the cruise final grids (50m) of the swath data were generated (maps included in Appendix 9). A roll bias was identified from differencing data acquired in opposite directions along the flat sedimented plate interior. The last patch test done on the *Langseth* was prior to the Costa Rica cruise in 2011. Another is clearly needed and should be done as soon as possible.

Serial data (*Appendix 12***).** Time and data values were extracted from the daily files from the raw serial strings for centerbeam bathymetry, gravity, magnetics, along with temperature, salinity and conductivity from the TSG and daily plots were generated (included in Appendix 12). Spikes were excluded in the day plots, but the data files were not edited.

6. Initial Results

Initial results derived from the brute stacks of the MCS data generated at sea are described below.

The Line 1 transect from Axial seamount to the Oregon coast is spectacular. Beginning at Axial seamount, we image the eastern edge of the magma body beneath Axial as well as a weak event – likely magma lens diffration tail - beneath the flank of the small seamount immediately east of Axial, indicating this seamount is also likely to be volcanically active. A low frequency Moho event is visible beneath the flank of the seamount, but little other crustal reflectivity. Continuing east along the profile, a cluster of sub-Moho reflections are observed ~ 75 km from the seamount (at ~-129.185, 45.699) and then a change in Moho character to a sharp high frequency event. At the western edge of the wide pseudofault zone crossed along Line 1, a bright cluster of sub-Moho reflectivity is observed that forms a horizontal v-shaped zone opening toward older crust. At the eastern boundary of the pseudofault zone, another similar, although weaker, sub-moho cluster is observed. These clusters of sub-Moho events appear analogous to those observed along Line 1-3 from EW0207, interpreted there as frozen magma lenses at the tip of the propagating Northern Symmetric segment.

Approximately 90 km east of the pseudfault (at JD179 05:12:05), a series of bright ridgeward facing lower crustal reflectors (LCR) – spaced ~5-10 km apart - are observed. These LCR are highly reminiscent of those observed in the Western Pacific (Reston et al., 1998) and in older Cocos plate crust near IODP hole 1256D (Hallenborg et al., 2003). These events appear confined to the lower crust, as is observed in these other regions. Note there is a sub-horizontal event that the LCR appear to stop just below that appears to be a pegleg multiple within the sediments (not a sub horizontal UCR as observed in the Western Pacific study). Top of oceanic crust is remarkably smooth in this region and faulting within the sediments appears to begin in this region although further processing will be needed to confirm this. It appears that along Line 1 we have imaged the transition from non-reflective young crust, to reflective older crust characterized by bright dipping LCRs.

As we approached the trench, oceanic crust deepens and Moho changes from ~ horizontal to more undulating and disrupted event, possibly due to crustal-scale faulting (Fig. 5). Small fault offsets are evident disrupting the sediment section. Although they can not be traced to the seafloor in the MCS data, 2 possible faults are evident in the side-scan data immediately west of the deformation front indicating they do offset the seafloor surface. Top of oceanic crust can be traced for 20 km to possibly 50 km beneath the sedimentary accretionary wedge.

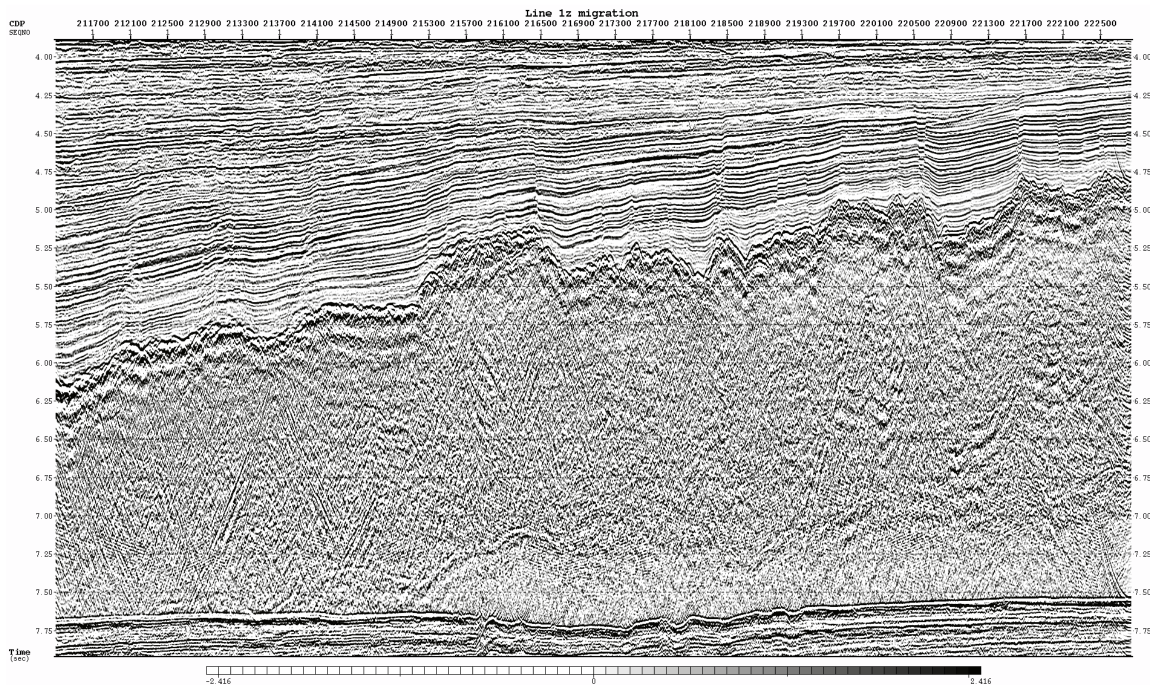

Figure 5. Brute stack of portion of Line 1 near the deformation front showing faults transecting the sediment section and arcuate Moho reflection, possibly disrupted by faults.

Line 2 overlaps the eastern end of EW0207 Line 1_3 and shows well imaged Moho and small offset faults within the sediments. An ~ 30 km stretch of Line 2 was not acquired due to the 9 hour period on June 21 when we were shut down with seals playing in the gun strings. East of this gap, Moho is evident for a few km prior to becoming obscured by the seafloor and sediment multiples. There is no clear indication of LCR along this line in our brute stack. Moving into the accretionary wedge, over 2 seconds of folded and faulted sediments are imaged and we expect that the internal structure of this landward vergent section of the wedge will be well resolved with further processing.

Our along-trench Line 3 transect of the downgoing plate, reveals several strike-slip faults offsetting the sediment section including 2 of those previously mapped by MacKay et al., 1995. An ~6 km wide small seamount is imaged, that may be part of the series of seamounts inferred by Trehu and colleagues to be entering the subduction zone (eg. Trehu et al 2012). Different styles of reflectivity in the crust are observed along the margin including sections of antithetic events that transition into clusters of bright synthetic events, that dip either to the south or north (Fig. 6). These clusters of northward and southward dipping reflectivity bound the two pseudofault zones crossed along this transect. Further analysis will be needed to determine whether this reflectivity is due to true intracrustal horizons or side-scattered energy from basement scarps that change dip direction across the pseudofaults.

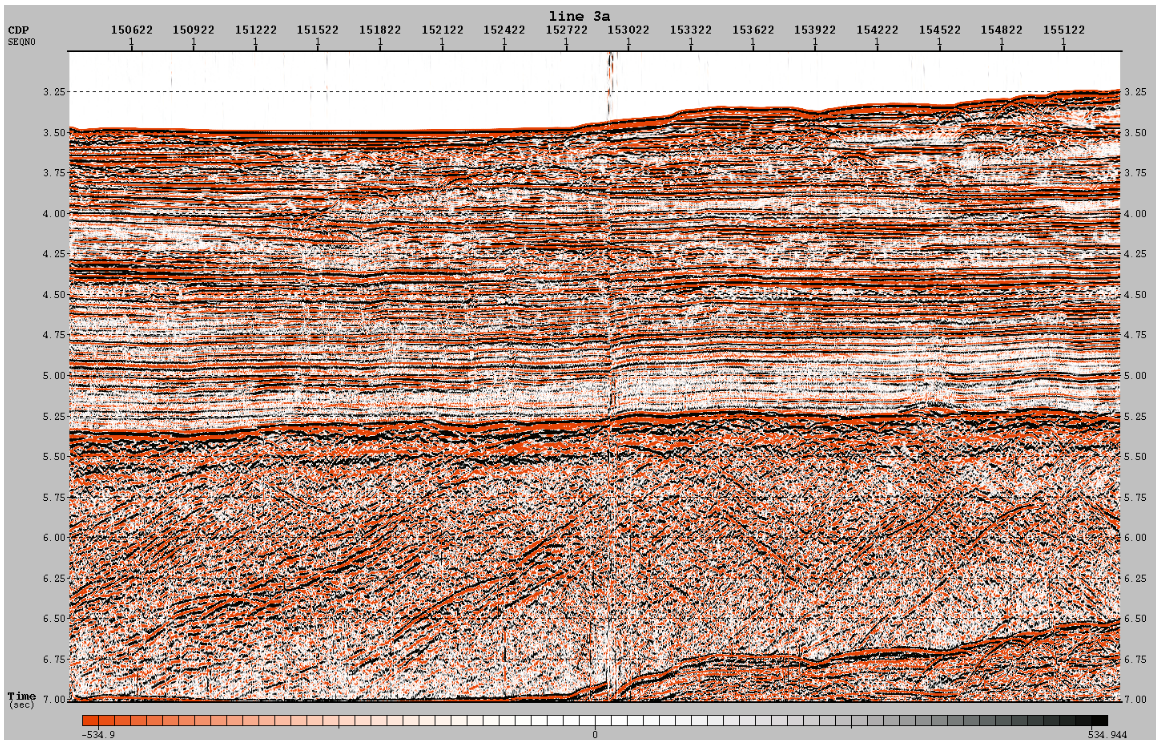

Figure 6. Portion of Line 3 showing bright dipping reflectivity below top of oceanic crust that changes from antithetic in the south (right hand side) to synthetic north dipping events (left hand side).

7. Summary and Recommendations

The Langseth facility and personnel

The *Langseth* facility is in excellent shape. The physical spaces are well maintained and quite clean, the perennial problems with too much AC in the main lab that we experienced 4 years prior were solved and the engine room and all departments appeared to be in good order. We found morale among the ships crew to be good, much better than in 2008. Some of the seismic gear was also in better condition. A brand new lead-in for Streamer 3 was used for our program and we experienced no downtime due to streamer problems. There were no issues with the acquisition system crashing with data loss like we experienced during MGL0812. The starboard compressor failed due to a snapped piston ~30 hours prior to the end of the cruise, but this failure did not impact operations.

We can not overemphasize the excellence of the scientific technical staff onboard the *Langseth*. Robert, Dave, Jay and Mike and the gunners Carlos, Mike and West are the heart of the seismic operation and their expertise, dedication and resourcefulness are essential to the smooth operations we experienced. These experts must be retained! Their level of experience and dedication are outstanding. But this group (especially Robert and David) are working at unsustainable levels and an adequate rotation for them is needed. Another IT person who can relieve Dave needs to be hired. We had only 3 gunners on our cruise due to the inability to find a last minute replacement when the chief gunner had emergency medical problems right before our cruise. This was very hard for Robert who needed to participate in all gun recoveries and deployments and plans to sustain the gunner staff are also a high priority (Carlos is nearing retirement!).

Onshore support

We received excellent support from the LDEO marine office that enabled our cruise to go forward in the face of several daunting last minute challenges. A few weeks prior to our cruise, Pablo Canales, Chief Scientist for the *Oceanus* cruise, learned from the OSU marine office that they do not handle foreign permitting requests for upcoming cruises and they had assumed (without ever informing him) that Pablo had filed the Canadian Clearance application needed for *Oceanus* to deploy OBS along Line 2. The Canadian Clearance application needed to have been filed 6 months prior and there was no time left to initiate the process. Jeff Rupert of the LDEO-OMO provide vital assistance in negotiating with his US State Department contact to add the *Oceanus* leg to the *Langseth* application. Canadian authorization for both ships was successfully obtained just prior to sailing. Another last minute hurdle was the discovery less than 10 days before sailing that the gravimeter aboard the *Langseth* is on an ITAR list of export-controlled equipment and we were without required authorization to travel with it into foreign waters. Sean Higgins and others at CU were able to negotiate a waiver permitting us to sail with the gravimeter. Finally when our cruise was delayed in Astoria and our departure uncertain due issues with our IHA permit. Sean Higgins and Meagan Cummings of the LDEO-OMO were key to the successful negotiations with NMFS that allowed us to sail on July 13. We are deeply grateful to Meagan and Sean for their assistance in achieving a workable solution that allowed the cruise to proceed.

Communications

The current procedures for conveying course plans with the bridge and the lead time required for changes (and dependencies with who is on watch) led to some difficulties with the inevitable adjustments needed to optimize the survey for science goals. In *Langseth* operations, the Chief Scientist conveys shooting plan requests to the Chief Science Officer (CSO) who then handles all communication with the bridge, but there is no routine communication with all three. While this chain of communication worked adequately for much of the survey, inadequate communication adversely impacted the survey achieved for a couple lines. Routine daily meetings between the Captain, Chief Science Officer, and Chief Scientist would have been very helpful and we recommend this as standard practice for future programs.

The Science Support Plan generated prior to our program is a very useful document outlining expected acquisition parameters, ship capability, data handling etc and the generation of this document is a terrific addition to the OMO cruise preparation process. However, this document is a useful reminder for all and should be reviewed once the cruise is underway. We recommend that every cruise begin with a scheduled meeting of the Chief Scientist with the CSO and rest of technical science support staff, where the SSP is reviewed in detail, similar to the phone meeting we had once underway with Meagan Cummings, to go over the IHA. Another part of this standard meeting should be to review the set of logs that the technical staff generates to support the cruise. Since I had sailed on the Langseth I was aware of what documentation was being produced but this would not be true for many scientists arriving onboard. A list and description of the suite of logs generated would also be very useful to include in the SSP.

Computing Resources

We were unable to generate continuously updating brute stacks using SIOSEIS due to lack of a working SUN to drive the Atlantek plotter. Although we generated stacks after acquisition, the near real-time capability was greatly missed and solutions should be sought to restore this.

The one license for Echos currently available is not enough and we reccommend negotiating additional licenses from Paradigm with next years license renewal. Also, it would be useful to have VoxelGeo and GeoDepth included in the next year request. OpenOffice is needed for proc1 and the single stand-alone disk version of GeoMapApp, while very useful, is not enough. Additional copies should be obtained for the ship (or even better- a networked version of GeoMapApp needs to be developed).

The HighSeasNet service worked quite well during our cruise with one unfortunate delay of 5 hours (issue identified at UCSD) when we were trying to reach Anne Trehu to make a final decision on her shooting plan. As a result of not being able to reach her, we needed to revise the shooting plan given to the bridge on short notice. Robert estimates that it costs the science techs approximately 2 days a trip to deal with problems associated with HighSeasNet. NSF should evaluate the cost/benefits of continuing with this service given the availability of commercial services, which could provide higher bandwidth at comparable and possibly lower cost.

Multibeam Sonar

BIST tests were run on a daily basis to evaluate functioning of the EM122. As BIST tests result in data loss for 5-10 minutes and it would be worth evaluating whether one per day is really needed.

A roll bias was detected in the multibeam data from inspection of our coincident tracks run in opposite directions over flat seafloor. A patch test must be done to improve the multibeam data quality and really should be done routinely several times a year. Dave noted that a patch test could be done as part of the upcoming JMS Inspection.

Quality of Life

There are ongoing issues with the lack of adequate single person berthing for the ships' crew and science support staff that need to be addressed with future modifications of the staterooms. For the science party, the living quarters are adequate. Some of the chairs in the main lab are broken and need to be replaced. The black plastic chairs are preferable over the more expensive purple (Steelcase Think?) chairs and we recommend buying more of these. They are easier to move around in the lab and a better overall seat design for a moving ship.

The food was excellent on this trip with less fried food than during MGL0812, a regular salad bar, and fruit throughout, which was highly appreciated. One minor comment- we all used too many paper cups and we recommend returning to primarily plastic cups and ceramic mugs for hot drinks.

Marine Mammal Issues

Improved procedures for negotiating with permit agencies to facilitate timely accommodation of requested modifications to survey plans prior to a cruise are needed. With IHA permits typically not issued until the day before sailing, there is considerable risk of delayed departures in the future that could be averted if there were adequate time to make changes to a cruise plan in response to issues that arise in the permit process.

The loss of acquisition time due to seals entering the source strings and remaining there for long periods was considerable (over 2 days). The PSOs suggested that the northern fur seals which we encountered repeated near the Line 3/2 intersection were feeding in this offshore location after their rooking season. Given this, the early summer season should probably be avoided in the scheduling of future surveys in the area.

We note that our IHA for working in Canadian waters had a 4490 m exclusion zone for all mammals and an extensive seismic program (eg a 3D study at Endeavour) would be extremely difficult to conduct with a similar IHA.

New Capability

During the final OBS acquisition phase of our program it would have been very useful to have the capability to tow a short streamer. There is broader need with the academic community for high-resolution short streamer portable seismic systems. The *Langseth* has many of the components needed for such a system including a GI gun array and sufficient streamer section but an acquisition system would need to be purchased. We recommend that this OMO evaluate options for such a system and that the issue be raised with the MLSOC. This system could be onboard for use during OBS ops as desired, for coring ops like the program before ours, or for deploying on other ships as a portable system.

R2R elog

We found the R2R elog very useful for coordinating with *Oceanus* operations while we were underway and it would be good to adopt this as an ongoing log on the *Langseth*. While the R2R elog is a redundant capability in many ways to the elog already run on the

Langseth, it is specially configured for logging science party events and was used exclusively by the science party. We have a couple recommendations that have been passed to the R2R elog developers at WHOI: the capability to enter a time/position manually after the fact, to add missed events, would be very useful (perhaps a dedicated event type for this). Also, it would be very useful to be able to edit the elog config while at sea (e.g to add people and types of actions. Also, the *Langseth* elog should be added to the logs archived at MGDS/NGDC.

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