

Year-4 Cascadia Initiative OBS Recovery Cruise

Cruise OC1508B R.V. Oceanus

August 26, 2015 - September 02, 2015

Newport, Oregon to Newport, Oregon



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Background

As part of the 2009 American Recovery and Reinvestment Act (ARRA) spending, NSF's Earth Sciences (EAR) and Ocean Sciences (OCE) divisions each received \$5M in facility-related investment. The funds are targeted toward Facilities that support EarthScope and MARGINS science objectives, with an initial emphasis on onshore/offshore studies of the Cascadia margin. The ARRA funds have been used by UNAVCO, IRIS, and OBSIP to improve seismic and geodetic datasets in the Cascadia region including improvements to real-time GPS capabilities, densification of the onshore seismic networks, and the construction and deployment of an array of 60 ocean-bottom seismographs (OBS) for offshore community experiments.

The Cascadia Initiative (CI) is an onshore/offshore seismic and geodetic experiment that addresses questions ranging from the structure of the megathrust and its potential for large earthquakes to volcanic arc structure, and to the formation, deformation and hydration of the Juan de Fuca and Gorda plates. An article in the GeoPRISMS Newsletter (Spring 2011, issue No. 26) described CI scientific objectives, the outcome of an open community workshop held in October 2010 to develop deployment plans for the offshore component of the experiment, and formation of the Cascadia Initiative Expedition Team (CIET). Over its planned 4-year data acquisition period, the offshore portion of the Cascadia Initiative will involve the deployment and recovery of ~280 OBSs at ~160 different sites and a total of about 14 cruises.

Cruise Objectives and Assessment

The primary cruise objective was to recover 24 WHOI OBS deployed in July 2014 (cruise OC1407A), as part of the Year-4 Cascadia Initiative OBS array. The WHOI OBS were deployed offshore southern Oregon and northern California (Figs. 1, 2, 3). The OBS (Figs. 4, 5, 6) were provided by the NSF-funded U. S. National Ocean Bottom Seismograph Instrumentation Pool (OBSIP) and by WHOI.

Fourteen OBS carry intermediate-period seismometers (Nanometrics Trillium Compact), and were designed and built by WHOI for the Amphibious Array with funding from the American Recovery and Reinvestment Act (ARRA). Ten OBS, funded by the W.M. Keck Foundation, carry broadband seismometers (Guralp CMG-3T) and strong-motion accelerometers (Kinometrics Episensor). All OBS carry a Differential Pressure Gauge (DPG). Because they carry a strong-motion accelerometer, the Keck OBS were deployed in the region of Cape Mendocino where there is considerable regional seismicity. Moderate-sized local earthquakes might result in clipping of the seismometers but not the accelerometers.

OC1508B Ship Track

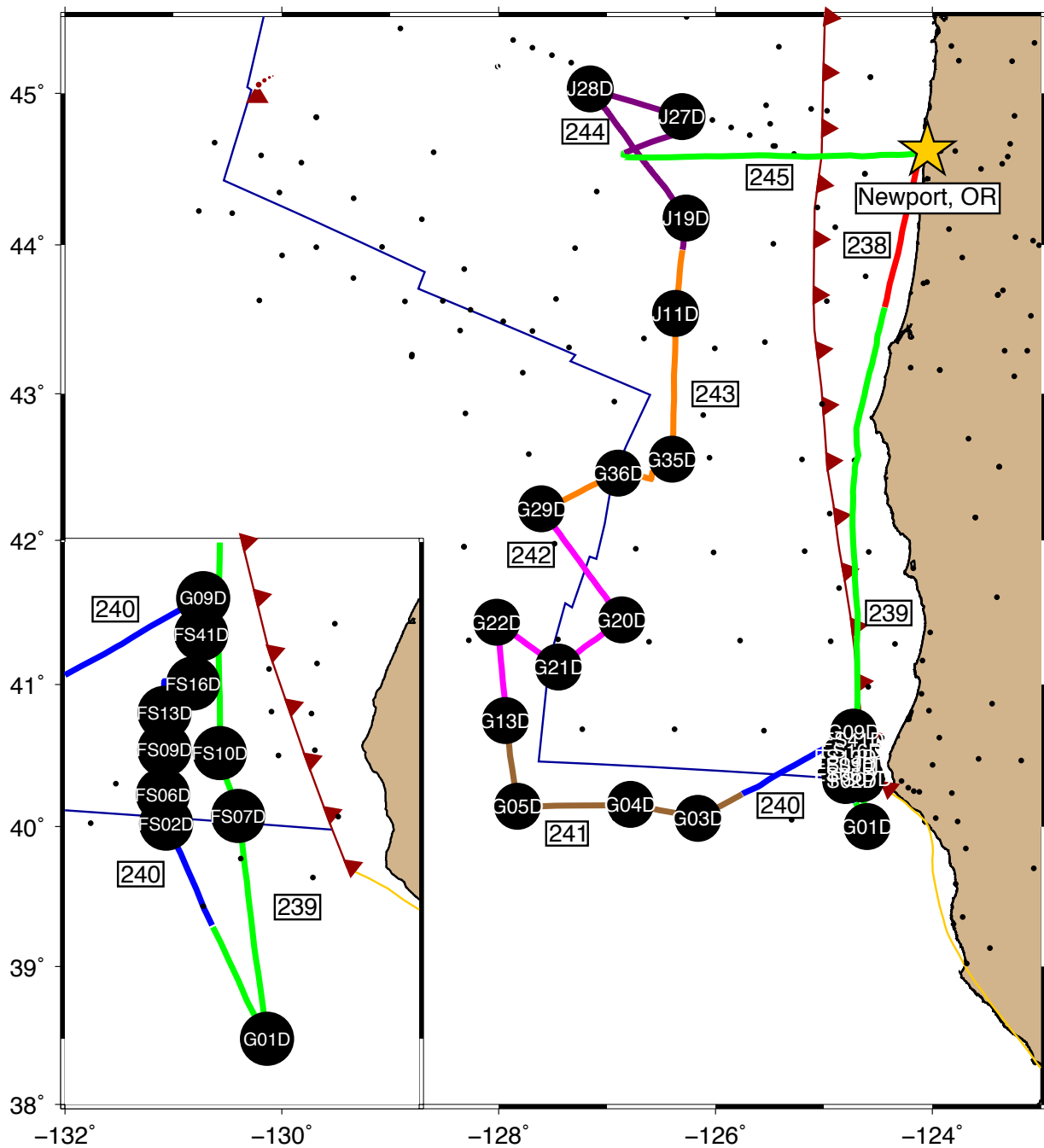


Figure 1. OC1508B cruise track. Numbers in boxes show day-of-year 2015 (UTC). Black filled-circles and associated numbers show OBS stations recovered on this cruise. Cruise commenced on day 238 (2015-08-26), and ended on day 141 (2015-09-02). Small black dots show the locations of recent OBS deployments. Inset shows the locations of the Keck OBS, which are equipped with a strong-motion accelerometer as well as a broadband seismometer.

OC-1508B Science Party

John Collins	Chief Scientist	Woods Hole Oceanographic Institution
Alan Gardner	OBS Engineer	Woods Hole Oceanographic Institution
Tim Kane	OBS Technician	Woods Hole Oceanographic Institution
Dan Kot	OBS Technician	Woods Hole Oceanographic Institution
Jared Schwartz	OBS Engineer	Woods Hole Oceanographic Institution
Kurt Caviggia	Observer	Leidos, Seattle

OC-1508B R/V Oceanus Crew

Jeff Crews	Master
Robert Cruise	Chief Engineer
Eric Balianz	Chief Mate
Don Heffern	Second Mate
John San	Engineer
Henry "Chip" Millard	Engineer
Doug Beck	Bos'n
Patrick Breshears	AB
Marc Simpson	AB
Donald Highsmith	Cook
Thomas Leong	Asst. Cook
Robert Hagg	Marine Technician

Cruise Narrative

Tuesday, August 25 (PDT). Collins, Kane, Kot, and Schwartz arrive Newport at ~10:30 PDT. Gardner arrived the previous evening. Loaded all gear in the afternoon. Discussed weather forecast with Captain Jeff Crews. Forecast for Cape Mendocino area, where all 10 Keck-OBS are deployed, is good for the next few days. As this region often has ugly weather, we opt to recover the Keck OBS first, and then the ARRA-OBS. This is a change in plan relative to the initial cruise plan filed with OSU.

Wednesday, August 26 (PDT). Underway from OSU dock at 10:47 PDT. Weather excellent. Steaming south at ~10.5 knots. Coast visible to port.

Thursday, August 27 (PDT). Weather excellent. Making ~12 knots. ETA first site ~10:30 PDT.

Station FS10D (OBS I.D. S81)

On Station:	08/27/2015 17:23 UTC (08/27/2015 10:23 PDT)
OBS Type:	Keck
Water Depth:	1154 m
Enable Command:	08/27/2015 17:23:43 UTC
Lock Guralp Command:	08/27/2015 17:27:35 UTC (No Lock)
Release Command:	08/27/2015 17:35:06 UTC
Est. Lift-Off Time (double ping)	08/27/2015 17:39:20 UTC
Surface Time:	08/27/2015 18:23 UTC
Time On Deck:	08/27/2015 18:33 UTC
Time on Station:	1 hr. 10 min.
Rise Rate:	23 m/min
Comments:	Lots of mud on frame

Station FS07D (OBS I.D. S84)

On Station:	08/27/2015 19:10 UTC (08/27/2015 12:10 PDT)
OBS Type:	Keck
Water Depth:	1274 m
Enable Command:	08/27/2015 19:10:30 UTC
Lock Guralp Command:	08/27/2015 19:12:15 UTC
Release Command:	08/27/2015 19:16:26 UTC
Est. Lift-Off Time (double ping)	08/27/2015 19:20:41 UTC
Surface Time:	08/27/2015 19:59 UTC
Time On Deck:	08/27/2015 20:07 UTC
Time on Station:	57 min.
Rise Rate:	33 m/min

Station G01D (OBS I.D. S85)

On Station:	08/27/2015 21:58 UTC (08/27/2015 14:58 PDT)
OBS Type:	Keck
Water Depth:	1007 m
Enable Command:	08/27/2015 21:58:01 UTC
Lock Guralp Command:	08/27/2015 22:00:07 UTC
Release Command:	08/27/2015 22:07:15 UTC
Est. Lift-Off Time (double ping)	08/27/2015 22:11:32 UTC

Surface Time: 08/27/2015 22:43:30 UTC
Time On Deck: 08/27/2015 22:49 UTC
Time on Station: 51 min.
Rise Rate: 31 m/min

Station FS02D (OBS I.D. S86)

On Station: 08/28/2015 00:59 UTC (08/27/2015 17:59 PDT)
OBS Type: Keck
Water Depth: 948 m
Enable Command: 08/28/2015 01:07:07 UTC
Lock Guralp Command: 08/28/2015 01:09:17 UTC
Release Command: 08/28/2015 01:13:55 UTC
Est. Lift-Off Time (double ping) 08/28/2015 01:18:12 UTC
Surface Time: 08/28/2015 01:49:50 UTC
Time On Deck: 08/28/2015 02:00 UTC
Time on Station: 61 min.
Rise Rate: 30 m/min

Station FS06D (OBS I.D. S89)

On Station: 08/28/2015 02:21 UTC (08/27/2015 19:21 PDT)
OBS Type: Keck
Water Depth: 1947 m
Enable Command: 08/28/2015 02:21:15 UTC
Lock Guralp Command: 08/28/2015 02:22:51 UTC
Release Command: 08/28/2015 02:28:18 UTC
Est. Lift-Off Time (double ping) 08/28/2015 02:32:35 UTC
Surface Time: 08/28/2015 03:48 UTC
Time On Deck: 08/28/2015 03:58 UTC
Time on Station: 1 hr. 37 min.
Rise Rate: 26 m/min
Comments: Masses of mud on frame

Station FS09D (OBS I.D. S83)

On Station: 08/28/2015 04:21 UTC (08/27/2015 21:21 PDT)
OBS Type: Keck
Water Depth: 2122 m
Enable Command: 08/28/2015 04:21:30 UTC
Lock Guralp Command: 08/28/2015 04:22:52 UTC
Release Command: 08/28/2015 04:26:20 UTC
Est. Lift-Off Time (double ping) 08/28/2015 04:30:35 UTC
Surface Time: 08/28/2015 05:47:50 UTC
Time On Deck: 08/28/2015 05:55 UTC
Time on Station: 1 hr. 34 min.
Rise Rate: 28 m/min
Comments: Masses of mud on frame

Friday, August 28 (PDT). Weather excellent for much of day. Winds picked up to ~20 knots by evening.

Station FS13D (OBS I.D. S80)

On Station: 08/28/2015 13:18 UTC (08/28/2015 06:18 PDT)
OBS Type: Keck
Water Depth: 2291 m
Enable Command: 08/28/2015 13:18:04 UTC
Lock Guralp Command: 08/28/2015 13:19:45 UTC
Release Command: 08/28/2015 13:24:20 UTC
Est. Lift-Off Time (double ping) 08/28/2015 13:28:35 UTC
Surface Time: 08/28/2015 14:42:20 UTC
Time On Deck: 08/28/2015 14:50 UTC
Time on Station: 1 hr. 32 min.
Rise Rate: 31 m/min
Comments:

Station FS16D (OBS I.D. S82)

On Station: 08/28/2015 15:15 UTC (08/28/2015 08:15 PDT)
OBS Type: Keck
Water Depth: 1080 m
Enable Command: 08/28/2015 15:15:42 UTC (Release #1)
Disable Command: 08/28/2015 15:32:20 UTC (Release #1)
Lock Guralp Command: 08/28/2015 15:34:02 UTC
Enable Command: 08/28/2015 15:41:41 UTC (Release #2)
Release Command: 08/28/2015 15:44:34 UTC
Est. Lift-Off Time (double ping) 08/28/2015 15:48:57 UTC
Surface Time: 08/28/2015 16:31:00 UTC
Time On Deck: 08/28/2015 16:38 UTC
Time on Station: 1 hr. 23 min.
Rise Rate: 26 m/min
Comments: Release #1 very noisy after enable => move to Release #2

Station FS41D (OBS I.D. S88)

On Station: 08/28/2015 17:06 UTC (08/28/2015 10:06 PDT)
OBS Type: Keck
Water Depth: 1079 m
Enable Command: 08/28/2015 17:06:06 UTC
Lock Guralp Command: 08/28/2015 17:08:20 UTC (not locked)
Release Command: 08/28/2015 17:17:10 UTC
Est. Lift-Off Time (double ping) 08/28/2015 17:21:25 UTC
Surface Time: 08/28/2015 18:02 UTC
Time On Deck: 08/28/2015 18:09 UTC
Time on Station: 1 hr. 3 min.
Rise Rate: 26 m/min
Comments:

Station G09D (OBS I.D. S87)

On Station: 08/28/2015 18:29 UTC (08/28/2015 11:29 PDT)
OBS Type: Keck
Water Depth: 716 m

Enable Command: 08/28/2015 18:29:50 UTC
Lock Guralp Command: 08/28/2015 18:31:15 UTC
Release Command: 08/28/2015 18:36:42 UTC
Est. Lift-Off Time (double ping) 08/28/2015 18:40:57 UTC
Surface Time: 08/28/2015 19:06 UTC
Time On Deck: 08/28/2015 19:13 UTC
Time on Station: 44 min.
Rise Rate: 29 m/min
Comments:

Station G03D (OBS I.D. T111)

On Station: 08/29/2015 02:02 UTC (08/28/2015 19:02 PDT)
OBS Type: ARRA
Water Depth: 4057 m
Enable Command: 08/29/2015 02:02:19 UTC
Release Command: 08/29/2015 02:03:54 UTC
Est. Lift-Off Time (double ping) 08/29/2015 02:06:22 UTC
Surface Time: 08/29/2015 03:26:21 UTC
Time On Deck: 08/29/2015 03:39 UTC
Time on Station: 1 hr. 37 min.
Rise Rate: 51 m/min
Comments:

Saturday, August 29 (PDT). Weather very good.

Station G04D (OBS I.D. T101)

On Station: 08/29/2015 13:16 UTC (08/29/2015 06:16 PDT)
OBS Type: ARRA
Water Depth: 4350 m
Enable Command: 08/29/2015 13:16:42 UTC
Release Command: 08/29/2015 13:18:27 UTC
Est. Lift-Off Time (double ping) 08/29/2015 13:22:54 UTC
Surface Time: 08/29/2015 14:54:00 UTC
Time On Deck: 08/29/2015 14:59 UTC
Time on Station: 1 hr. 43 min.
Rise Rate: 48 m/min
Comments: No Flag. (Torn off on deployment?)

Station G05D (OBS I.D. T112)

On Station: 08/29/2015 19:28 UTC (08/29/2015 12:28 PDT)
OBS Type: ARRA
Water Depth: 4464 m
Enable Command: 08/29/2015 19:28:30 UTC
Release Command: 08/29/2015 19:30:04 UTC
Est. Lift-Off Time (double ping) 08/29/2015 19:34:32 UTC
Surface Time: 08/29/2015 21:06 UTC
Time On Deck: 08/29/2015 21:15 UTC
Time on Station: 1 hr. 47 min.

Rise Rate: 48 m/min
Comments:

Station G13D (OBS I.D. T114)

On Station: 08/30/2015 01:04 UTC (08/29/2015 18:04 PDT)
OBS Type: ARRA
Water Depth: 3187 m
Enable Command: 08/30/2015 01:04:05 UTC
Release Command: 08/30/2015 01:05:30 UTC
Est. Lift-Off Time (double ping) 08/30/2015 01:09:57 UTC
Surface Time: 08/30/2015 02:23 UTC
Time On Deck: 08/30/2015 02:49 UTC
Time on Station: 1 hr. 45 min.
Rise Rate: 44 m/min
Comments: Missed first pick-up attempt

Station G22D (OBS I.D. T107)

On Station: 08/30/2015 06:57 UTC (08/29/2015 23:57 PDT)
OBS Type: ARRA
Water Depth: 3092 m
Enable Command: 08/30/2015 06:57:20 UTC
Release Command: 08/30/2015 06:58:59 UTC
Est. Lift-Off Time (double ping) 08/30/2015 07:03 UTC
Surface Time: 08/30/2015 08:09 UTC
Time On Deck: 08/30/2015 08:15 UTC
Time on Station: 1 hr. 18 min.
Rise Rate: 47 m/min
Comments:

Sunday, August 30 (PDT). Weather very good.

Station G21D (OBS I.D. T106)

On Station: 08/30/2015 13:32 UTC (08/30/2015 06:32 PDT)
OBS Type: ARRA
Water Depth: 3293 m
Enable Command: 08/30/2015 13:32:57 UTC
Release Command: 08/30/2015 13:34:40 UTC
Est. Lift-Off Time (double ping) 08/30/2015 13:39:07 UTC
Surface Time: 08/30/2015 14:46:30 UTC
Time On Deck: 08/30/2015 14:54 UTC
Time on Station: 1 hr. 22 min.
Rise Rate: 49 m/min
Comments:

Station G20D (OBS I.D. T103)

On Station: 08/30/2015 17:49 UTC (08/30/2015 10:49 PDT)

OBS Type: ARRA
Water Depth: 2931 m
Enable Command: 08/30/2015 17:49:24 UTC
Release Command: 08/30/2015 17:52:56 UTC
Est. Lift-Off Time (double ping) 08/30/2015 17:57:22 UTC
Surface Time: 08/30/2015 19:02:20 UTC
Time On Deck: 08/30/2015 19:09 UTC
Time on Station: 1 hr. 10 min.
Rise Rate: 45 m/min
Comments:

Station G29D (OBS I.D. T102)

On Station: 08/31/2015 00:48 UTC (08/30/2015 17:48 PDT)
OBS Type: ARRA
Water Depth: 2911 m
Enable Command: 08/31/2015 00:48:40 UTC
Release Command: 08/31/2015 00:49:50 UTC
Est. Lift-Off Time (double ping) 08/31/2015 00:54:16 UTC
Surface Time: 08/31/2015 01:57:30 UTC
Time On Deck: 08/31/2015 02:20 UTC
Time on Station: 1 hr. 32 min.
Rise Rate: 46 m/min
Comments: Chief Mate missed OBS twice. Second time ran over the OBS, resulting in lost flag, ship's paint on the syntactic foam floatation, transducer likely damaged, and strut on sensor deployment arm bent. Captain took over.

Station G36D (OBS I.D. T109)

On Station: 08/31/2015 05:45 UTC (08/30/2015 22:45 PDT)
OBS Type: ARRA
Water Depth: 3780
Enable Command: 08/31/2015 05:57 UTC
Release Command: 08/31/2015 06:04 UTC
Est. Lift-Off Time (double ping) 08/31/2015 06:08:11 UTC
Surface Time: 08/31/2015 07:27:45 UTC
Time On Deck: 08/31/2015 07:30 UTC
Time on Station: 1 hr. 45 min.
Rise Rate: 48 m/min
Comments: Approx. 18 attempts before successful enable. Approx. 12 attempts before release command acknowledged. Seafloor bathymetry? For enable and release, success followed just after ship got underway to move off drop site. Captain speculated that we had issues when ship was in the trough.

Monday, August 31 (PDT). Weather Excellent.

Station G35D (OBS I.D. T104)

On Station: 08/31/2015 13:35 UTC (08/31/2015 06:35 PDT)
OBS Type: ARRA
Water Depth: 2823
Enable Command: 08/31/2015 13:35:08 UTC
Release Command: 08/31/2015 13:40:18 UTC
Est. Lift-Off Time (double ping) 08/31/2015 13:44:44 UTC
Surface Time: 08/31/2015 14:47:50 UTC
Time On Deck: 08/31/2015 14:51 UTC
Time on Station: 1 hr. 16 min.
Rise Rate: 46 m/min
Comments:

Station J11D (OBS I.D. T113)

On Station: 08/31/2015 20:11 UTC (08/31/2015 13:11 PDT)
OBS Type: ARRA
Water Depth: 3001
Enable Command: 08/31/2015 20:11:45 UTC
Release Command: 08/31/2015 20:13:11 UTC
Est. Lift-Off Time (double ping) 08/31/2015 20:17:37 UTC
Surface Time: 08/31/2015 21:23 UTC
Time On Deck: 08/31/2015 21:29 UTC
Time on Station: 1 hr. 18 min.
Rise Rate: 46 m/min
Comments:

Station J19D (OBS I.D. T105)

On Station: 09/01/2015 01:20 UTC (08/31/2015 18:20 PDT)
OBS Type: ARRA
Water Depth: 2955
Enable Command: 09/01/2015 01:20:09 UTC
Release Command: 09/01/2015 01:25:05 UTC
Est. Lift-Off Time (double ping) 09/01/2015 01:29:32 UTC
Surface Time: 09/01/2015 02:36:35 UTC
Time On Deck: 09/01/2015 02:48 UTC
Time on Station: 1 hr. 28 min.
Rise Rate: 44 m/min
Comments:

Tuesday, September 01 (PDT). Weather Excellent.

Station J28D (OBS I.D. T110)

On Station: 09/01/2015 13:52 UTC (09/01/2015 06:52 PDT)
OBS Type: ARRA

Water Depth: 2856
Enable Command: 09/01/2015 13:52:13 UTC
Release Command: 09/01/2015 13:55:04 UTC
Est. Lift-Off Time (double ping) 09/01/2015 13:59:30 UTC
Surface Time: 09/01/2015 14:58:30 UTC
Time On Deck: 09/01/2015 15:05 UTC
Time on Station: 1 hr. 13 min.
Rise Rate: 48 m/min
Comments:

Station J27D (OBS I.D. T108)

On Station: 09/01/2015 18:28 UTC (09/01/2015 11:28 PDT)
OBS Type: ARRA
Water Depth: 2815
Enable Command: 09/01/2015 18:29:38 UTC
Release Command: 09/01/2015 18:32:13 UTC
Est. Lift-Off Time (double ping) 09/01/2015 18:36:39 UTC
Surface Time: 09/01/2015 19:34:10 UTC
Time On Deck: 09/01/2015 19:43 UTC
Time on Station: 1 hr. 15 min.
Rise Rate: 49 m/min
Comments:

Wednesday, September 02 (PDT). Weather Excellent. Steaming to port. First line ashore 10:26 PDT.

OBS Operations

We recovered all 24 WHOI OBS that were deployed as part of the Year-4 Cascadia Initiative OBS array. These stations were deployed offshore southern Oregon and northern California in July 2014 on cruise OC1407A. All of the OBS were recovered on the starboard side using the Morgan knuckle-boom crane, which was positioned just forward of the instrument recovery location. We did not utilize space on the O-1 deck. OBS recoveries went well. We used the starboard hull-mounted 12 kHz transducer for all acoustic communication other than on-deck testing. Acoustics were excellent. Median ascent rates for the Keck and ARRA OBS were 29 ± 3 m/minute and 48 ± 1.5 m/minute, respectively (Tables 2 and 3). The Keck rise rate is noticeably slower than from that observed on CIET-3 ($33 \text{ m} \pm 2$ m/minute). Although the seismometer pressure housing now carries a robust tripod (Fig. 5), the additional weight is compensated by a block of syntactic foam with 5 lbs of buoyancy mounted on the deployment arm (Fig. 4 top). Perhaps the explanation lies in the unusually large amounts of mud that we observed on many of the Keck frames. Fig. 4 (top) shows a stream of mud shedding from a Keck OBS during recovery. Median on-station time was 85 ± 11 minutes.

Tables 4 and 5 list the clock drifts for the Keck and ARRA OBS. The Keck OBS is equipped with a Seascan temperature-compensated crystal oscillator. The median clock drift rate for the Keck OBS was 0.83 ± 0.59 ms/day. The ARRA OBS are equipped with a Symmetricom chip-scale atomic clock (CSAC) that has much better performance than the Seascan clock, at the cost of increased power (120 mW versus 5 mW). The median clock drift for the ARRA OBS was 0.02 ± 0.01 ms/day.

Data Screening

The ~60 OBS deployed as part of the Year-4 array are located in areas of U.S. Navy operations, and consequently there is the potential that the OBS might record information that should not be made public for reasons of national security. In accordance with an MOU between the U.S. Navy and the National Science Foundation (NSF), the U.S. Navy have the right to redact portions of high-sample-rate (>6 Hz sampling frequency) ground-motion and pressure data that it considers of national security interest. In order to minimize the impact on science, the U.S. Navy agreed to provide low-pass filtered versions of the high-sample-rate data as soon as possible after OBS retrieval. The redacted data will be provided to the OBS group within 90 days of the end of the OBS recovery cruise.

For OC1508B, Kurt Caviggia from Leidos (Seattle office) participated in the cruise in order to protect the Navy's interests and to provide low-pass filtered data. All stations recovered on cruise OC1508B are of Navy interest. All data (high- and low-sample rate) from all stations were downloaded over a private I.P. network to WHOI-owned external hard-drives attached to a Windows laptop or an Apple laptop. The WHOI network was firewalled from the ship's network, and access to the private network was restricted to 3 individuals only (Caviggia, Gardner, and Collins). The Keck OBS data were downloaded via the Windows laptop using the Quanterra program *BalerAdmin*, while the data from the ARRA OBS were downloaded via the Apple laptop using the GNU program *wget*. These data were then copied by Caviggia onto one or more of his own computers and/or storage

devices where all the high-sample-rate data were then low-pass filtered. The Navy representative then made a data volume containing: (i) low-pass filtered versions of all high sample-rate data from all stations; and (ii) unfiltered versions of the low sample-rate data from all stations. This “clean” data volume was then copied by Caviggia to a WHOI external drive. This procedure worked well with the exception of one station, T110, which generated a *write* error. The issue was traced to the fact that an intermediate file exceeded 2 GB, which caused the relevant C-language program *sdrssplit* (written and supported by Doug Neuhauser, Univ. California Berkeley) to die. Further investigation showed that the version of *sdrssplit* on the Leidos Linux laptop was compiled for a 32-bit rather than a 64-bit architecture. Recompiling the program using 64-bit code fixed this issue.

As a safeguard against loss of the original data, a single WHOI-owned disk drive containing all of the original data from all stations was retained by WHOI. This disk drive was labeled appropriately, hand-carried back to WHOI, and handed to the WHOI Security Officer for safekeeping. This drive will eventually be returned to an authorized U.S. Navy representative upon receipt of the screened data set. As a precaution against data offloading mistakes (e.g. networking outages, operator errors, blunders) the original data were retained on the OBS. These data will be erased from the OBS recording media within 15 days of the return of the OBS to the WHOI OBS Lab.

Missing OBS

Over the course of the 4 Cascadia Initiative deployments, 4 WHOI ARRA OBS did not respond to acoustic commands and were unable to be recovered in the normal manner. OBS T112 and T115 were deployed at stations J11B and G36B, respectively (CIET-2), and T105 and T109 were deployed at stations J45C and J29C, respectively (CIET-3).

Fortunately, J11B/T112 was recovered on cruise TN-229 in August 2013 by John Delaney and Giora Proskurowski using the Canadian ROPOS ROV. On the same cruise, an attempt was made to dive on station G36B/T115 but the weather precluded launching the ROV. The cause of the acoustics problem on station J11B was a malfunctioning Edgetech navigation transducer. The transducer’s ceramic ring is supposed to be held above the baseplate via 6 rubber tabs. For the transducer on the OBS deployed at station J11B, 4 of these tabs were dislocated, which allowed the ceramic ring to fall close enough to the base plate to cause arcing between the base plate and the ceramic. Examination of the transducers on the normally recovered ARRA OBS showed that the ceramic was readily dislodged, sometimes by just a gentle squeeze on the transducer. This is clearly a manufacturing flaw. Stations J29C and J45C were recovered on cruise TN-312 in June/July 2014 by Richard Allen and Maya Tolstoy using the WHOI ROV Jason. The cause of the acoustic problem for both instruments, as for station J11B, was a poorly assembled Edgetech navigation transducer. All three OBS recovered via ROV had full data loads and running clocks.

Weather and time permitting, an attempt will be made to recover station G36B on the CIET-4 cruise (R/V Thompson, Oct. 01-15) tasked with recovering the LDEO TRM OBS with the Jason ROV.

Table 1. WHOI OBS Year-4 Station Locations and Deployment Time-Line

Station Name	WHOI OBS I.D.	OBS Type	Drop Date (UTC)	Launch Time (UTC)	Station Lat. (deg)	Station Lat. (min)	Station Lat. (hemi)	Station Long. (deg)	Station Long. (min)	Station Long. (hemi)	Station Lat. (decimal degrees)	Station Long. (decimal degrees)	Station Depth (m)	Recovery Date (UTC)	Recovery Time (UTC)	Deploy. Duration (days)
FS13D	S80	Keck	07/16/2014	14:48:46	40	29.6226	N	124	48.2052	W	40.49371	-124.80342	2291	08/28/2015	14:50	408.0
FS10D	S81	Keck	07/17/2014	8:28:19	40	25.9703	N	124	41.6410	W	40.43284	-124.69402	1154	08/27/2015	18:33	406.4
FS16D	S82	Keck	07/16/2014	12:57:05	40	32.2701	N	124	44.8051	W	40.53784	-124.74675	1080	08/28/2015	16:38	408.2
FS09D	S83	Keck	07/16/2014	17:17:39	40	26.2599	N	124	48.2201	W	40.43767	-124.80367	2122	08/28/2015	05:55	407.5
FS07D	S84	Keck	07/17/2014	5:56:53	40	20.2739	N	124	39.4641	W	40.33790	-124.65774	1274	08/27/2015	20:07	406.6
G01D	S85	Keck	07/17/2014	2:24:30	39	59.9956	N	124	36.0489	W	39.99993	-124.60082	1007	08/27/2015	22:49	406.9
FS02D	S86	Keck	07/16/2014	22:22:49	40	19.5615	N	124	48.0122	W	40.32603	-124.80020	948	08/28/2015	02:00	407.2
G09D	S87	Keck	07/16/2014	9:14:40	40	39.9910	N	124	43.6153	W	40.66652	-124.72692	716	08/28/2015	19:13	408.4
FS41D	S88	Keck	07/16/2014	11:12:16	40	36.7434	N	124	43.8612	W	40.61239	-124.73102	1079	08/28/2015	18:09	408.3
FS06D	S89	Keck	07/16/2014	19:57:39	40	22.1999	N	124	48.4049	W	40.37000	-124.80675	1947	08/28/2015	03:58	407.3
G04D	T101	ARRA	07/14/2014	15:34:19	40	9.4639	N	126	47.0804	W	40.15773	-126.78467	4350	08/29/2015	14:59	411.0
G29D	T102	ARRA	07/12/2014	22:34	42	13.0449	N	127	36.3136	W	42.21742	-127.60523	2911	08/31/2015	02:20	414.2
G20D	T103	ARRA	07/13/2014	6:16:04	41	27.0950	N	126	51.8250	W	41.45158	-126.86375	2931	08/30/2015	19:09	413.5
G35D	T104	ARRA	07/12/2014	12:22:43	42	33.3403	N	126	23.9410	W	42.55567	-126.39902	2823	08/31/2015	14:51	415.1
J19D	T105	ARRA	07/11/2014	18:59:23	44	10.7419	N	126	16.2713	W	44.17903	-126.27119	2955	09/01/2015	02:48	416.3
G21D	T106	ARRA	07/13/2014	14:35:04	41	7.3601	N	127	26.8812	W	41.12267	-127.44802	3293	08/30/2015	14:54	413.0
G22D	T107	ARRA	07/13/2014	20:33	41	26.0152	N	128	0.9966	W	41.43359	-128.01661	3092	08/30/2015	08:15	412.5
J27D	T108	ARRA	07/11/2014	4:35	44	50.9335	N	126	18.4980	W	44.84889	-126.30830	2815	09/01/2015	19:43	417.6
G36D	T109	ARRA	07/12/2014	16:35:08	42	27.7054	N	126	53.7883	W	42.46176	-126.89647	3780	08/31/2015	07:30	414.6
J28D	T110	ARRA	07/11/2014	10:56:06	45	1.8089	N	127	9.3623	W	45.03015	-127.15604	2856	09/01/2015	15:05	417.2
G03D	T111	ARRA	07/14/2014	21:26:26	40	3.5247	N	126	9.6707	W	40.05875	-126.16118	4057	08/29/2015	03:39	410.3
G05D	T112	ARRA	07/14/2014	7:34:40	40	8.5824	N	127	49.5435	W	40.14304	-127.82573	4464	08/29/2015	21:15	411.6
J11D	T113	ARRA	07/12/2014	0:34:46	43	32.4971	N	126	22.1132	W	43.54162	-126.36855	3001	08/31/2015	21:49	415.9
G13D	T114	ARRA	07/14/2014	2:13:03	40	44.8941	N	127	56.2250	W	40.74824	-127.93708	3187	08/30/2015	02:49	412.0

Table 2. CIET Year 4 WHOI Keck OBS Rise Rates

Station Name	WHOI OBS I.D.	OBS Type	Station Depth (m)	Rise Rate (m/min)
FS10D	S81	Keck	1154	23
FS07D	S84	Keck	1274	33
G01D	S85	Keck	1007	31
FS02D	S86	Keck	948	30
FS06D	S89	Keck	1947	26
FS09D	S83	Keck	2122	28
FS13D	S80	Keck	2291	31
FS16D	S82	Keck	1080	26
FS41D	S88	Keck	1079	26
G09D	S87	Keck	716	29
			Median	29
			MAD	3

Table 3. CIET Year 4 WHOI ARRA OBS Rise Rates

Station Name	WHOI OBS I.D.	OBS Type	Station Depth (m)	Rise Rate (m/min)
G03D	T111	ARRA	4057	51
G04D	T101	ARRA	4350	48
G05D	T112	ARRA	4464	48
G13D	T114	ARRA	3187	44
G22D	T107	ARRA	3092	47
G21D	T106	ARRA	3293	49
G20D	T103	ARRA	2931	45
G29D	T102	ARRA	2911	46
G36D	T109	ARRA	3780	48
G35D	T104	ARRA	2823	46
J11D	T113	ARRA	3001	46
J19D	T105	ARRA	2955	44
J28D	T110	ARRA	2856	48
J27D	T108	ARRA	2815	49
			Median	48
			MAD	1.5

Table 4. CIET Year 4 Keck OBS Clock Performance (Seascan)

Station Name	WHOI OBS I.D.	Total Seascan Drift (s)	Deployment Duration (days)	Seascan Drift Rate	Drift Rate (ms/day)	Absolute Drift Rate (ms/day)
FS13D	S80	0.6617	408.03	1.877051E-08	1.62	1.622
FS10D	S81	0.5956	406.45	1.696045E-08	1.47	1.465
FS16D	S82	0.6766	408.20	1.918378E-08	1.66	1.657
FS09D	S83	0.7518	407.55	2.134998E-08	1.85	1.845
FS07D	S84	0.0492	406.62	1.399689E-09	0.12	0.121
G01D	S85	0.1778	406.88	5.057740E-09	0.44	0.437
FS02D	S86	0.2708	407.18	7.697909E-09	0.67	0.665
G09D	S87	-0.2267	408.46	-6.424700E-09	-0.56	0.555
FS41D	S88	-0.1170	408.32	-3.315589E-09	-0.29	0.286
FS06D	S89	0.4021	407.38	1.142405E-08	0.99	0.987
Median Absolute Drift Rate (ms/day)						0.83
MAD						0.59

Table 5. CIET Year 4 ARRA OBS Clock Performance (CSAC)

Station Name	WHOI OBS I.D.	Total CSAC Drift (s)	Deployment Duration (days)	CSAC Drift Rate	Drift Rate (ms/day)	Absolute Drift Rate (ms/day)
G04D	T101	0.0071	411.02	1.999096E-10	0.0170	0.0170
G29D	T102	0.0025	414.19	7.124627E-11	0.0060	0.0060
G20D	T103	0.0159	413.57	4.446976E-10	0.0380	0.0380
G35D	T104	-0.0165	415.14	-4.601835E-10	-0.0400	0.0400
J19D	T105	0.0021	416.36	5.722767E-11	0.0050	0.0050
G21D	T106	-0.0124	413.04	-3.474027E-10	-0.0300	0.0300
G22D	T107	0.0180	412.56	5.036166E-10	0.0440	0.0440
J27D	T108	-0.0045	417.66	-1.247291E-10	-0.0110	0.0110
G36D	T109	0.0081	415.65	2.266163E-10	0.0200	0.0200
J28D	T110	0.0002	417.21	4.915849E-12	0.0000	0.0000
G03D	T111	0.0077	410.29	2.169467E-10	0.0190	0.0190
G05D	T112	-0.0097	411.60	-2.718110E-10	-0.0230	0.0230
J11D	T113	0.0170	415.91	4.733454E-10	0.0410	0.0410
G13D	T114	-0.0023	412.05	-6.520283E-11	-0.0060	0.0060
Median Absolute Drift Rate (ms/day)						0.0195
MAD						0.0135

CIET4 WHOI OBS Sites

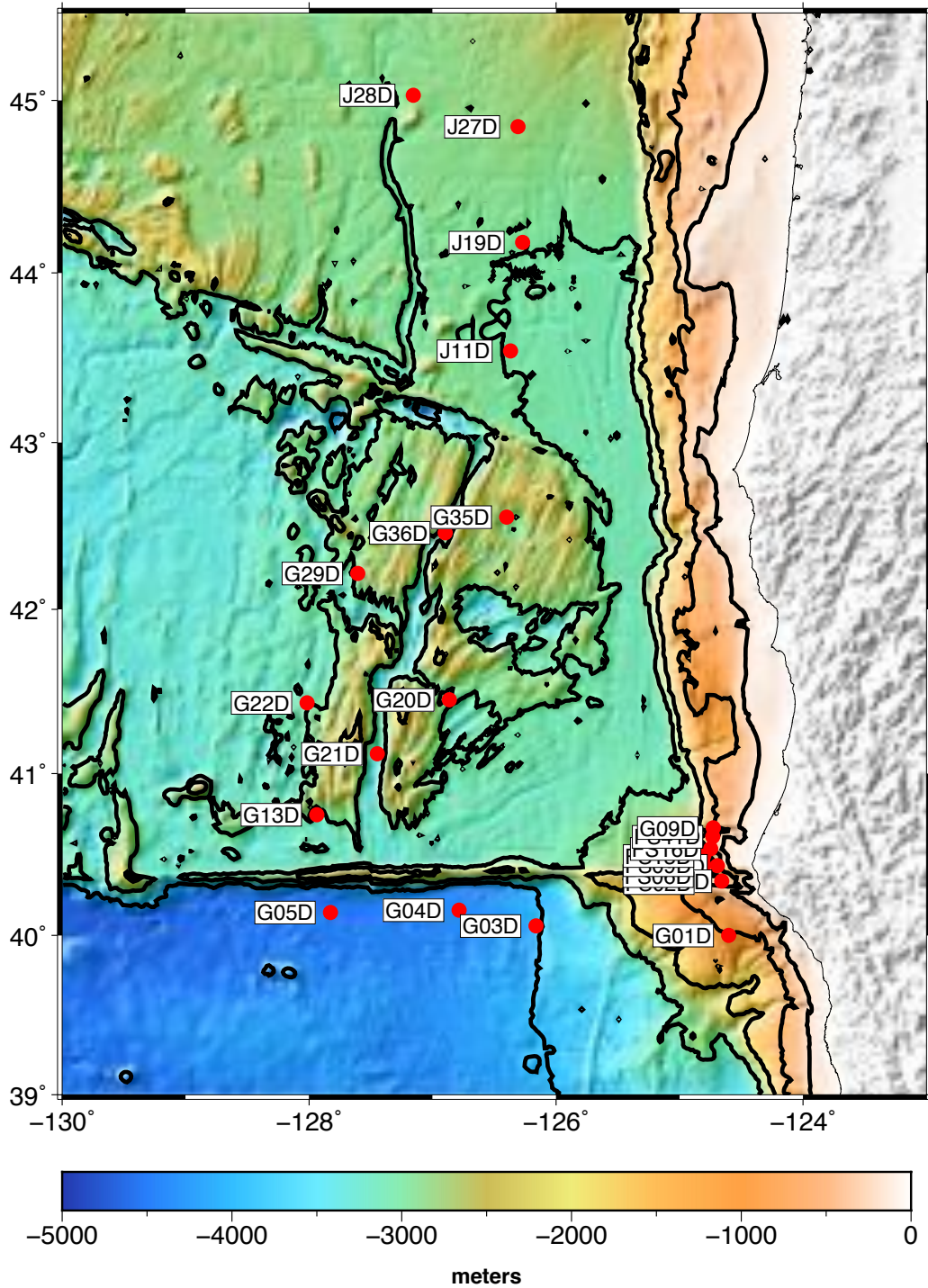


Figure 2. Locations of the stations visited and recovered on cruise OC1508B of the R.V. Oceanus are shown as labeled red circles superimposed on satellite-derived bathymetry. Figure 3 shows a higher resolution map of the cluster of stations in the southeast corner of the map (i.e. offshore Cape Mendocino).

CIET4 WHOI Keck OBS Sites

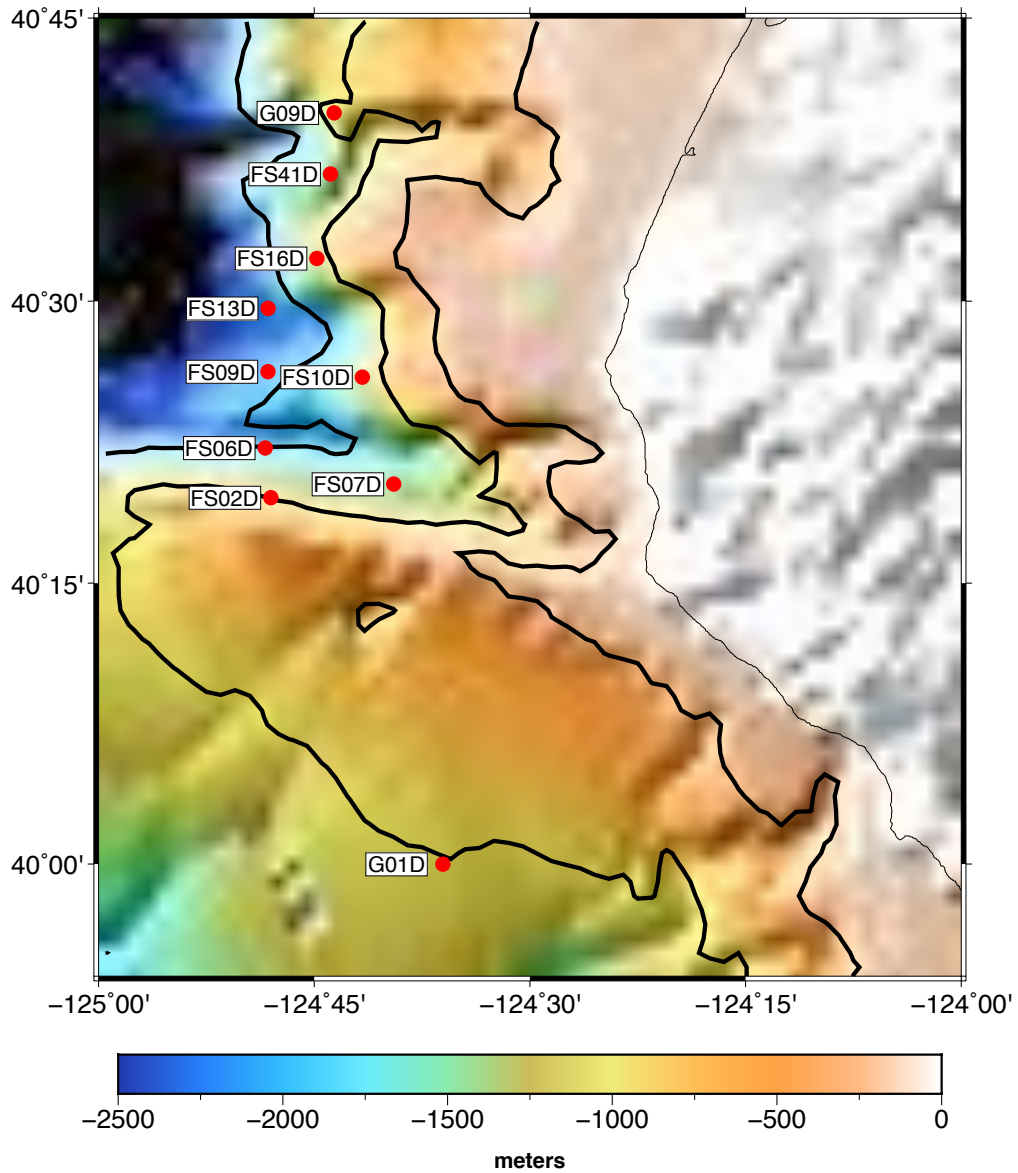


Figure 3. Locations of the stations instrumented with the WHOI Keck OBS are shown as labeled red circles superimposed on satellite-derived bathymetry. These OBS carry a strong-motion accelerometer in addition to a broadband seismometer.

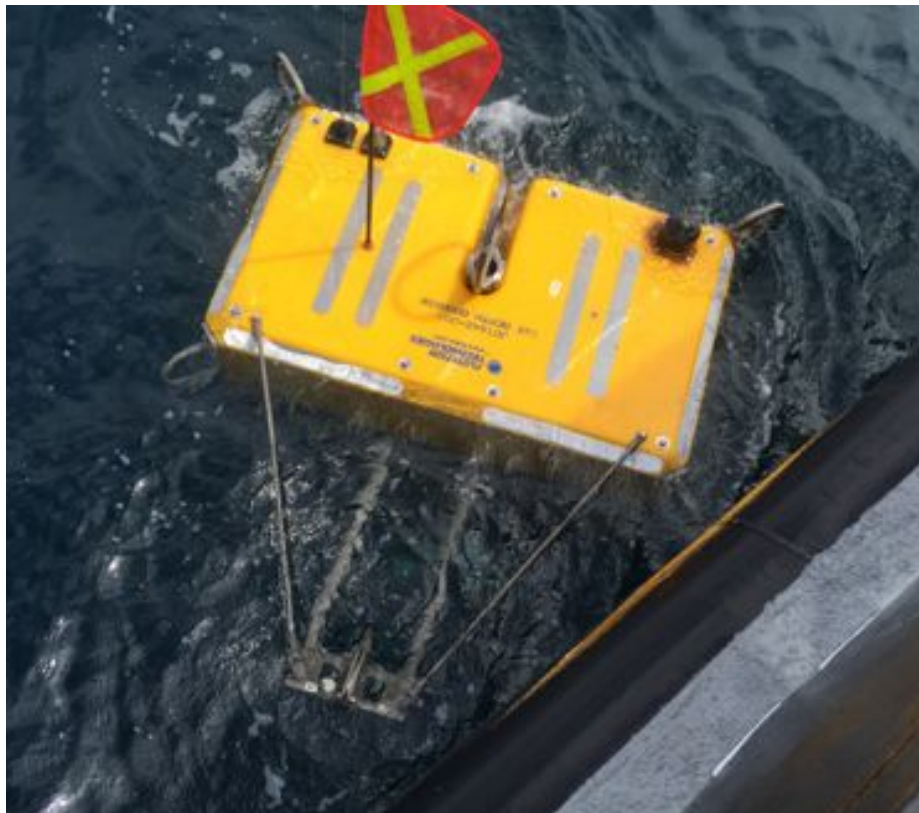


Figure 4. Recovery of a WHOI Keck OBS (top) and a WHOI ARRA OBS (bottom).



Figure 5. View of the “feet” added to the pressure housing holding the Guralp CMG-3T seismometer. The goal was to improve coupling to ground.

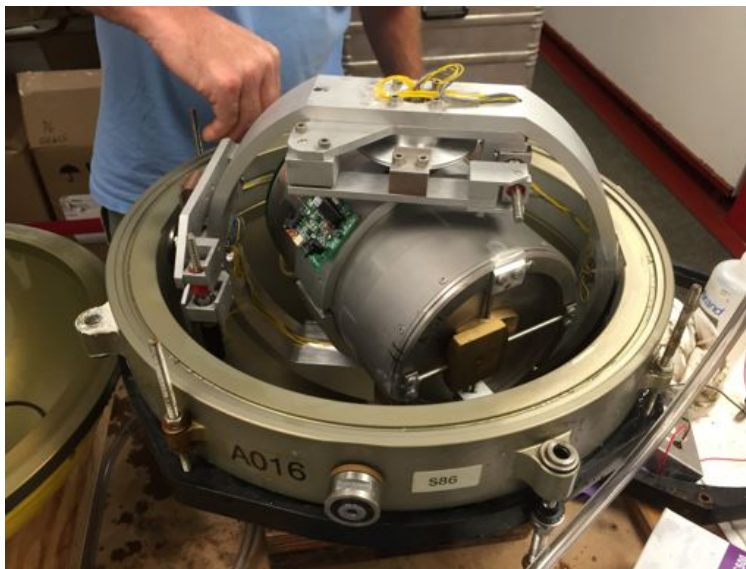


Figure 6. A view of the Guralp seismometer that was deployed at station FS02D. Note the vertical axis of the seismometer is now lying in the equatorial plane of the pressure housing. This shows that the seismometer pressure housing was lying on its side on the seafloor. The leveling system rotated the seismometer to the correct orientation.

Acknowledgements

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