Natural Resources Canada | Ressources naturelles Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7558

Report of Cruise 2010005PGC
C.C.G. Vessel John P. Tully
22 September – 2 October 2010

SeaJade-I Seafloor Earthquake Array Japan-Canada Cascadia Experiment
Ocean bottom seismometer deployment and active-source airgun refraction and reflection program

G.D. Spence, M. Riedel

2014

Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7558

Report of Cruise 2010005PGC
C.C.G. Vessel John P. Tully, 22 September – 2 October 2010
SeaJade-I Seafloor Earthquake Array Japan-Canada Cascadia Experiment
Ocean bottom seismometer deployment and active-source airgun refraction and reflection program

G.D. Spence[1], M. Riedel[2]

[1] University of Victoria, School of Earth and Ocean Sciences, 3800 Finnerty Road, Victoria, British Columbia
[2] Natural Resources Canada, Geological Survey of Canada, 9860 West Saanich Road, Sidney, British Columbia

2014

doi:10.4095/295546

This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/).

Recommended citation
Spence, G.D. and Riedel, M., 2014. Report of Cruise 2010005PGC, C.C.G. Vessel John P. Tully, 22 September – 2 October 2010, SeaJade-I Seafloor Earthquake Array Japan-Canada Cascadia Experiment, Ocean bottom seismometer deployment and active-source airgun refraction and reflection program; Geological Survey of Canada, Open File 7758, 50p. doi:10.4095/295546

Publications in this series have not been edited; they are released as submitted by the author.

TABLE OF CONTENTS

List of Tables

List of Figures

1. Summary

1.1 Objectives

The main objective of this cruise is to acquire passive seismic data for earthquake studies. The expedition is a major international collaboration of NRCan ("Public Safety Geoscience" (PSG) Program) with Japan (JAMSTEC) and the Woods Hole Oceanographic Institution (WHOI). JAMSTEC provided 35 Ocean Bottom Seismometers (OBS), which will be deployed for about 3 months to monitor earthquake activity offshore Vancouver Island. The OBS monitoring will for the first time provide direct information on seismic activity beneath the continental slope and further offshore which cannot be provided by land-based seismic networks and therefore will fill a critical knowledge gap. The filling of this knowledge gap is essential to the assessment of earthquake hazard due to the Cascadia subduction fault, an important output of the "Targeted Hazard Assessment in Western Canada" project under the PSG program.

A secondary objective involves an active seismic program (2 days) to acquire seismic data (airgun operation) across a frontal ridge for submarine slump/slide studies and linkages to gas hydrate occurrences , for the purpose of facilitating station corrections to allow improved earthquake location determination.

As a third objective, short surveys across known cold vents off Vancouver Island were conducted to acquire 12/18 kHz acoustic data of gas bubble plumes using the ship-mounted echosounder systems.

1.2 Accomplishments and Results

During the period of July 1-7, 2010, a total of 33 short-period OBSs provided by JAMSTEC were successfully deployed from the Canadian Coast Guard vessel John P. Tully off Vancouver Island in the mid- to lower-continental slope region. These deployments were coordinated with the deployment of 10 broadband OBSs by Jeff McGuire of Woods Hole, during the period of July 13-15, 2010 from the University of Oregon research vessel *Wecoma*. The short-period instruments will be deployed for a 3-month period, while the broadband instruments will be deployed for one year. The grid of OBSs was composed of four lines of instruments parallel to the margin, with a nominal instrument spacing of 20 km along each line and 16 km between lines. The continuously-recording broadband seismometers at NEPTUNE sites 889 and Barkley Canyon were incorporated into the grid, and one short-period instrument was also deployed at Site 889 (Bullseye vent) so that the short-period and broadband recordings could be compared. Three instruments, which were temporarily part of an active-source grid, were recovered after a deployment of about 26 hours; during this period, one local earthquake (< 10 km distance) and one regional earthquake (~100 km distance) were recorded, and both events were also recorded on the two NEPTUNE sites.

A short active-source program was completed on a frontal ridge where a prominent landslide, the Slipstream slide, was located. A 120-cu-in airgun was fired every 7 s, and recorded on a small grid of 5 OBSs on the crest of the frontal ridge, at a nominal spacing of 500 m, plus 2 additional OBSs in the ocean basin at a spacing of about 5 km. One refraction line, about 22 km in length, was located along the crest of the ridge parallel to the deformation front, and another set of refraction lines, nearly 20 km in length, was nominally perpendicular to the ridge and deformation front. A series of single-channel reflection lines was also recorded: 1) 2 lines were coincident with the refraction lines; 2) 3 lines, each about 8 km long, were perpendicular to the frontal ridge, with 1 outside the slide area and 2 through different segments of the slide scar; 3) 3 lines, each about 5 km long, were recorded across an intriguing north-south bathymetric feature, and showed that deformation associated with this feature extended throughout the sediment section that was imaged down to about 1 s (TWT) below the seafloor. In total, only about 33 hours of airgun data, or 17,000 shots, were collected, mostly during two nights. Unfortunately, airgun firing proved nearly impossible during the daytime, due to the restrictions imposed by DFO related to observations of marine mammals (particularly Dall's porpoise) which consistently approached the vessel after airgun firing had commenced.

Unfortunately, only a few echosounder lines to image water-column plumes could be obtained, due to time limitations, high wind conditions, equipment problems and initial difficulties in setting up the echosounder recording. The 12 kHz echosounder was not useable except in ideal wind conditions. The problem was traced to the transponder ram not being fully extended; it was initially thought that the plate covering the ram had not been removed, and although the engineers subsequently discovered from their records that the plate was removed, it was too late.

Only a few hours of water-column plume observations were possible, due to time limitations, high winds, and some equipment problems. Water-column plumes were recorded in three locations: a) on the southeast side of Barkley Canyon (Plume 1), b) near the location of the seafloor sector-scanning sonar deployed by NEPTUNE in May 2010 about 500 m northeast of the Site 889 (Bullseye vent) junction box (plumes 2 and 4, likely the same plume), and c) near the Site 889 junction box.

1.3 Operational recommendations for future cruises

1) Engineers should be asked to disable the Cathodic Protection System. This removes noise at a frequency of 60 Hz and particularly at 120 Hz, and this gives a significant improvement to data quality of a hydrophone array. However, for projects where there are extended periods of seismic recording, the engineers indicated that they would be reluctant to turn off the protection system for such extended periods of time. A solution to this problem should be investigated.
2) Engineers should be asked to extend the 12 kHz echosounder transponder ram. In the Cruise Plan submitted to Coast Guard, a request should be made to ensure that a plate possibly covering the ram exit is removed.
3) An alternative to the current Teledyne single-channel seismic array should be found. After failing to operate after a cruise in 2008, it was subsequently re-jacketed. During the 2010 cruise, the array appeared to be operational in an on-deck tap test, but when deployed and under stress no airgun signal could be seen in the array output.
4) An alternative should be found for the current EPC recorders for real-time plotting of seismic sections. On one EPC, the writing head only plotted for about half the paper width. On the other EPC, significant difficulties were encountered in getting it operational.

2. Narrative

Note that all times are Pacific Daylight Time (UT – 7 hours)

Wednesday 30 June Day 181

1000 Loading begins
1930 Leave PGC dick
1300 Ship arrives at Bullseye vent. Wind 10 kts, seas 1-2 m.

Thursday 1 July 2010 Day 182 (George, Nastasja, Subbarao in lab; Kodaira/Terada OBS)

1153 Water column plume observed on 12 and 18 kHz; east side of Barkley Canyon in ~900 m water depth

1239 **OBS 16** released. Winds 20-25 kts (105°). Ship drifts 1.7 km in 30 min; too far for pinger to receive signal?
Need to de-clutch propeller to get pinger signal.

1407 Gave bridge 3 station locations for triangulation, each 500 m from target deployment site in directions North, N120 (called East), and N240 (called West).

Calculated drift from 3 stations is ~30 m; but error is probably 100-150 m.

1539 Arrive at **OBS 17**. Wind 20-22 kts (102°)
1553 OBS 17 released. Speed Over Ground (SOG) is 1.4 kts (294°)

16:08:25 OBS at seafloor. Pinger range obtained at 500 West
16:19:05 Pinger range at 500 m North.
16:35:10 Pinger range at 500 m East.

18:57:50 **OBS 1** released.
19:28:45 Pinger range at 500 m North, ~600 m NW of deployment.
19:46:33 Pinger range at 500 m East.
20:04:45 Pinger range at 500 m West.

Michael, Martin, Peter, Tess in lab

21:17:35 **OBS 2** released. Winds ~15 kts N
21:48:45 Pinger range at 500 m West, ~750 m SW of deployment.
22:05:10 Pinger range at 500 m North, ~450 m N of deployment.
22:21:21 Pinger range at 500 m East, ~50 m S of E site.

23:53 **OBS 3** released. 2560 m water depth

Friday July 2 2010 Day 183

0000 Obana/Terada OBS

00:25 no communication with OBS; drifted too far south (800 m); go to East.

00:44	Still no communication with OBS; head to North site.
0053	At North; deploy transducer
0121	Successful measurement at South
0133	Successful measurement at West
0147	**OBS 3**. Pinger North successful!
	All positions obtained. OBS drift only 20 m from deployment!
0320	**OBS 4** released. Wind 24 kts. 2599 water depth.
0353	OBS 4 on bottom
0357	OBS 4 position South (2 km). 2581 m water.
0408	OBS 4 West. 2578 m water.
0425	OBS 4 North. 2576 m water. Wind 24 kts.
0453	**OBS 35a** deployed. 2560 m water. Wind 17 kts
0524	OBS 35a on bottom
0525	OBS 35a position fixed South (2.5 km)
0540	OBS 35a position fixed West. Water 2563. Wind 20 kts.
0556	OBS 35a position fixed North. Water 2558. Wind 25 kts.
0600	George, Nastasja in lab
0623	**OBS 32** deployed. Wind 25-30 kts N
0650	Point 1: OBS 32 pinger range determined, ~1.2 km SSE of deployment site
07:12:40	**OBS 33a** deployed. Water 2105 m.
07:23:30	Point 2: OBS 32 pinger range determined, ~600 m NW of deployment site
07:40	Point 3: OBS 33a pinger range determined, ~1.2 km SSE of deployment site
08:40	**OBS 34a** deloyed. Water 2120 m.
08:05:32	Point 4: OBS 33a pinger range determined, ~600 m SSE of deployment site
08:27:45	Point 5: OBS 34a pinger range determined, ~1.2 km SSE of deployment site
08:48:30	**OBS 31** deployed. Water 2143 m.
08:53	Point 6: OBS 32 pinger range determined, ~350 m NE of deployment site
09:16	OBS 31 at seafloor
09:19	Point 7: OBS 31 pinger range determined, ~1.3 km SSE of deployment site
09:32	**OBS 30B** deployed. Water 2143 m.
09:58	OBS 30 at seafloor.
09:59	Point 8: OBS 31 pinger range determined, ~1.3 km SSE of deployment site
10:19	Point 9: OBS 30 pinger range determined at 30N, ~500km N of OBS 30.
10:20:15	Point 10: pinger range for OBS31E, ~100 m south of OBS30N
10:24	Point 11: pinger range for OBS34aSE,, ~1 km SE of OBS 34
10:47:20	Point 12: OBS 33a pinger range at 33aN, ~500 m N of 33a
	Point 13: OBS 34a pinger range at 33aN, ~750 m NW of 34a
10:50:30	Point 14: OBS 31 pinger range at 33aN, ~1.2 km NW of 31
10:51:20	Point 15: OBS 30 pinger range at 33aN, ~1.2 km NW of 30

12 noon Kodaira/Maekawa OBS

13:01 **OBS 18** deployed. Water 1371 m
NOTE – did not extend A-frame before lowering, so instrument could on rail; it was pulled up and re-lowered.
13:18:15 pinger range for OBS 18 at 18E, ~900 m SE of deployment
13:36:50 pinger range for OBS 18 at 18W
14:01:30 pinger range for OBS 18 at 18N

15:50:10 **OBS 19** deployed. Water 1336 m (12 kHz)
16:07 on seafloor
16:08:30 pinger range for OBS 19 at 19E, ~700 m SE of deployment
16:35:05 pinger range for OBS 19 at 19W, ~700 m SSW of deployment
16:58:20 pinger range for OBS 19 at 19N

18:00 Michael, Martin, Tess, Peter in lab.

18:19:00 **OBS 20** deployed. Water 1379 m.
18:37:45 pinger range for OBS 20, ~500 m further east than 20E Water 1385 m.
19:06:13 pinger range for OBS 20 at 20W. Water 1376 m. Wind 24 kts.
19:21:30 pinger range for OBS 20 at 20N. Water 1380 m. Wind 20 kts.

20:51:50 **OBS 26** deployed. Water 922 m.
21:03:40 pinger range for OBS 26 at 26E. Water 919 m.
21:15:16 pinger range for OBS 26 at 26W. Water 957 m.
21:27:07 pinger range for OBS 26 at 26N. Water 907 m.

22:36:58 **OBS 27** deployed. Water 938.
22:48:47 pinger range for OBS 27 at 27E. Water 959 m.
23:04:05 pinger range for OBS 27 at 27W. Water 989 m. Winds 19 kts.
23:20:22 pinger range for OBS 27 at 27N. Water 910 m. Winds 17.5 kts.

Saturday July 3 2010 Day 184

12 midnight Obana/Terada OBS

01:06:20 **OBS 28** deployed. Water 1275 m. Winds 12 kts.
01:23:17 pinger range for OBS 28 at 28E. Water 1280 m. Wind 15 kts.
01:35:16 pinger range for OBS 28 at 28W. Water 1280 m. Wind 20 kts.
01:50:05 pinger range for OBS 28 at 28N. Water 1253 m. Wind 17 kts.

02:45:45 **OBS 29** deployed. Water 1268 m. Wind 15 kts.
03:02:22 pinger range for OBS 29 at 29E. Water 1268 m. 15 kts.
03:14:35 pinger range for OBS 29 at 29W. Water 1252 m. 14 kts.
03:26:55 pinger range for OBS 29 at 29N. Water 1271 m. 15 kts.

05:17:21 **OBS 25** deployed. Water 1931 m. 11 kts.
05:42:35 pinger range for OBS 25 at 25E. Water 1932 m. 10 kts.
05:55:50 pinger range for OBS 25 at 25N. Water 1941 m. 10 kts.
06:01:08 pinger range for OBS 25, ~100 m N of 25W. Water 1868 m. 9 kts.

0600 George, Nastasja, Subbarao in lab

07:13:37 **OBS 15** deployed. Water 2436 m. 9 kts.
07:44 pinger range for OBS 15 at 15E, ~900 m E of site.
07:59:30 pinger range for OBS 15 at 15N.
08:12:10 pinger range for OBS 15 at 15W.

09:12:35 **OBS 10** deployed. Water 2426 m. 7 kts.
09:43:40 pinger range for OBS 10 at 10E, ~1 km NE of site.
09:56:10 pinger range for OBS 10 at 10N.
10:10:20 pinger range for OBS 10 at 10W.

11:22:40 **OBS 9** deployed. Water 2479 m (18kHz; note 12 kHz 100-200 m shallower, due to some sort of apparent bottom disturbance, or sensitivity too high). Wind 7 kts @300°
11:54:30 pinger range for OBS 9 at 9E, ~900 m SE of site.
12:10:30 pinger range for OBS 9 at 9W.
12:27:03 pinger range for OBS 9 at 9N.

12 noon Kodaira/Maekawa OBS

13:49:00 **OBS 14** deployed. Water 2474 m (18 kHz). 10 kts @314°.
14:19:30 pinger range for OBS 14 at 14E.
14:35:50 pinger range for OBS 14 at 14W.
14:49:15 pinger range for OBS 14 at 14N.

15:48:45 **OBS 24** deployed. Water 1791 m (12 kHz). 10 kts @300°.
16:11 pinger range for OBS 24 at 24E.
16:25:45 pinger range for OBS 24 at 24W.
16:42:26 pinger range for OBS 24 at 24N.

17:53:37 **OBS 23** deployed. Water m 1673 (18 kHz). 17.5kts @290°.

18:00 Michael, Martin, Tess, Peter in lab.

18:14:47 pinger range for OBS 23 at 23E, 1688 m, 12.4 kts@290°.
18:28:16 pinger range for OBS 23 at 23N, 1676 m, 17.3 kts @303°.
18:38:53 pinger range for OBS 23 at 23W, 1652 m, 14.2 kts@300°.

19:35:48 **OBS 13** deployed. Water 1956 m (18 kHz), 10.9 kts@300°.
20:01:15 pinger range for OBS 13 at 13E, 1976 m, 12.6 kts@307°.
20:15:35 pinger range for OBS 13 at 13N, 1948.4 m, 12.4 kts @300°.
20:25:35 pinger range for OBS 13 at 13W, 1949.8 m, 11.6 kts@305°.

21:32:37 **OBS 08** deployed. Water 2503.7 m (18 kHz), 11.6 kts @276°.
22:04:00 pinger range for OBS 08 at 08E, 2503.9 m, 9.8 kts @272°. (~600 m drifted further east than proposed site)
22:21:52 pinger range for OBS 08 at 08N, 2503.1 m, 11.6 kts @267°.
22:34:32 pinger range for OBS 08 at 08W, 2503.0 m, 12.5 kts @270°.

23:50:30 **OBS 07** deployed. Water 2343 m, (18 kHz), 15 kts @ 267°.

Sunday July 4 2010 Day 185

12 midnight Obana/Terada OBS

00:20:16 pinger range for OBS 07 at 07E, 2170.3 m, 13.3 kts@277°.
(~600 m drifted further east than proposed site)
00:35:40 pinger range for OBS 07 at 07W, 2405 m, 14 kts@270°.
00:45:42 pinger range for OBS 07 at 07N, 2158.1 m, 18 kts@270°.
00:50:00 Noted apparently thick, possibly soft seafloor around OBS 07 in echo sounder signal.

OBS designated for Site 22 showed technical problems with transponders, taken out of business temporarily, will be repaired later

01:46:50 **OBS 12** deployed. Water 2058.6 m, 16.4 kts@275°
02:13:08 pinger range for OBS 12 at 12E, 2052.3 m, 16.0 kts@270°
~1.125 km due east of deployment site
02:34:36 pinger range for OBS 12 at 12W, 2061.2 m, 17.7 kts@280°.
02:44:36 pinger range for OBS 12 at 12N, 2052.5 m, 18 kts@280°.

03:42:40 **OBS 22** deployed. Water 1560.8 m, 16.4 kts@313°
04:03:25 pinger range for OBS 22 at 22E, 1729.4 m, 19.8 kts@323°
Position was ~500 east of targeted site
04:17:36 pinger range for OBS 22 at 22W, 1590.0 m, 17.2 kts@320°.
04:29:21 pinger range for OBS 22 at 22N, 1575.3 m, 18.6 kts @317°

05:42:40 **OBS 21** deployed. Water 1713.5 m, 19.8 kts @ 312°
06:04:45 pinger range for OBS 21 at 21E, ~1 km SE of site
06:19:50 pinger range for OBS 21 at 21N
06:28:40 pinger range for OBS 21 at 21W

06:00 George, Subbarao, Nastasja in lab

07:22:20 **OBS 11** deployed. Water 2036 m, 19 kts @ 315°
07:47:55 pinger range for OBS 11 at 11E, ~1 km SE of site
08:02:20 pinger range for OBS 11 at 11N
08:12:55 pinger range for OBS 11 at 11W

10:12:15 **OBS 5** deployed. Water 2558 m, 18-24 kts @ 307°
pinger range for OBS 5 at 5E, ~1 km SE of site
pinger range for OBS 5 at 5N
pinger range for OBS 5 at 5W

No response from OBS at all at any pinger station. Go to deployment site again and try there, but still no response.
11:35 sent signal to release OBS from anchor
12:29 OBS re-surfaces very close to deployment site.
Analyses show fault transponder unit.

13:00 Start of pre-seismic mammal watch.
Continued sightings and resetting of clock.
16:00 one full hour gone since last mammal sighting, guns can be deployed
16:28 firing the airgun
16:33 Sperm-whale sighting just outside exclusion zone
16:47 additional sighting of porpoises; shut-down of airgun system
17:50 go ahead for airguns; firing every 7 seconds
18:00 Michael, Martin, Tess, Peter in lab.
18:07 streamer deployed; winds at 24 kts @ 315
18:51 start of refraction line 01 at waypoint S1
19:14 sighting of porpoises; airgun stopped firing
19:25 sperm whale at 1500m; re-setting of 60-minute clock
20:28 go-ahead from mammal observers for seismic action
20:29 first shot #7746 (from blast-phone record)
20:33 12 & 18 kHz echosounders turned back on
20:44 porpoises sighted; airgun shutdown
21:00 porpoises still at bow of ship
22:04 go-ahead from mammal observers, firing airgun at limit of sun-light
22:23 start line 01 again at waypoint S1
23:06 end of line 01
23:38 Start of line (SOL) 2

Monday July 5 2010 Day 186

00:29 End of line (EOL) 2
01:01 SOL line 3
01:43 EOL line 3
03:27 SOL line 4 (long transit between lines)
05:55 EOL line 4
06:00 George, Nastasja, Subbarao in lab.
05:59 again sightings of marine mammals (fur seal); airgun shutdown
06:33 fur-seal again
06:53 fur-seal again
08:30 MMO unable to verify exclusion zone to be clear (too high winds);
Bring in airgun and shut-off of compressor
Head to Bullseye Vent area for some "Plume-hunting"
10:00 slow speed at some heading to allow for Tully email-patch
11:00 at Bullseye Vent area
2.7 kts speed of ship at 58 degrees; at start of lie (WP 13-14)
11:02 18 kHz; plume seen at ~200 m from WP 14
11:20 2.5 kts at 219 degrees
Very poor quality of echosounder-records at this heading
Quality improves after a few minutes, but no plumes
11:36 WP 5 2.0 kts @ 65 deg, no echosounders
11:49 WP 8; no echosounders
13:40 issues with echosounder operations
15:42 at WP 10 at 224 deg, 2.3 kts
15:44 18 kHz; at 244 deg; plume-2 (eastern edge); 1249 m water depth
15:48 plume-3 west; 1.7 kts@59 deg
16:07 plume 4 west; 1.7 kts at 36 deg (same as plume-2)
1255 m on 18 kHz;

Decided to bring up OBS

18:00 Michael, Martin, Tess, Peter in lab.

18:53 OBS 35a on surface
18:59 OBS 35a on deck
19:32 OBS 34a release command sent
OBS 34a released from anchor, coming up
20:21 OBS 34a on surface
20:27 OBS 34a on deck
20:34 OBS 33a release command sent
20:48 OBS 33a released from anchor, coming up
21:23 OBS 33a surfaced
OBS 33a on deck

Going to Ucluelet for refurbishing of OBS and receiving parts for backup streamer.

Tuesday July 6 2010 Day 187

07:30 in port of Ucluelet
17:30 received parcel with spare-part for backup-streamer
Heading back out again at 18:00
Slowing down at exit of harbor for whales

Wednesday July 7 2010 Day 188
00:30 on site for OBS 33b; comparison with the NEPTUNE 889-seismometer
00:33 **OBS 33b** deployed. Water 1261m, 15 kts @ 350°
00:51:55 Monster-plume south of Bullseye Vent
00:49:55 pinger range for OBS 33b at 33bE, ~1 km south of deployment site; 1261.4m, 10 kts@0°
01:04:35 pinger range for OBS 33b at 33bN, 1244 m, 14 kts@356°
01:13:45 pinger range for OBS 33b at 33bW, 1263 m, 14.5 kts @ 355°

03:56 **OBS 06** deployed. Water 2530 m, 17 kts @ 350°
04:28:45 pinger range for OBS 6 at 6E, ~1 km south of deployment site, 2530m, 18 kts @ 355°
04:45:06 pinger range for OBS 6 at 6N, 2530 m, 18.5 kts@358°
04:58:53 pinger range for OBS 6 at 6W, 2530 m, 17 kts @ 0°

03:56 **OBS 05** deployed. Water 2546 m, 13 kts @ 4°
04:28:45 pinger range for OBS 5 at 5E, ~1 km SSE of deployment site, 13 kts @ 2°
04:45:06 pinger range for OBS 5 at 6N
04:58:53 pinger range for OBS 5 at 6W

07:30 deploy short Benthos streamer (50 hydrophones at 6 inch spacing)
08:00 porpoises
08:03 echosounders turned off; porpoises
08:37 airgun in water, charged and ready to g

09:04:45 first shot line 1a (repeat of line 1-2-3).
09:55:40 just past OBS35a

10:30 Called in on Search and Rescue (downed US Coast Guard helicopter in Washington). Bring in equipment. Last shot a few hundred metres past OBS31
14:45 SAR call cancelled. Head back to OBS31

18:00 start 60-min clock for mammal watch
18:45 started clock for third time (abundant Dalls porpoises)

Rhonda confirmed with Paul Cottrell of DFO that exclusion zone for porpoises is reduced from 1500 m to 500 m. Rhonda asked for no exclusion zone but Paul Cottrell denied request.

18:55 start to warm up compressor (25 min required)
19:15 deploy airgun in aniticipation of shooting; deploy streamer as well

19:38 gun is firing
19:40 gun turned off (solenoid issue, in which gun fires repeatedly at 1 s interval)

19:41 gun back on! SOL 1a (near OBS 31)
20:08 delay to EPC changed to 2 sec
20:17 Porpoises within 150 m; shut down airgun

21:17 start airgun; ship in turn between lines
21:50 Cathodic Protection System removed; much better data quality from streamer

22:07 SOL 5a (refraction line); did not start at beginning.

Thursday July 8 2010 Day 189

00:24 EOL 5a. Transit to next line.

01:18 SOL 16. EPC changed!
01:49 EOL 16

01:58 SOL 18
02:25 EOL 18

02:49 SOL 20
03:15 EOL 20

05:24 SOL 11
06:20 EOL 11

06:32 SOL 9
07:15 porpoises near end of line; stop shooting
07:46 porpoises
07:15 porpoises
07:55 porpoises

08:57 first shot line 7.
09:05 porpoises; stop shooting.
09:40 porpoises
10:43 porpoises
11:25 whale
11:54 porpoises. SHUT DOWN and head home.
(Program stopped 1 day early so repairs could be made to one of ship's anchors; estimated repair time of 2 days means that 1 day is taken from following program)

Friday July 9 2010 Day 190

0800 at IOS dock
1030 unloading of heavy equipment finished; science equipment unloading can begin.

3. JAMSTEC Ocean bottom seismometer (OBS) *Shiuchi Kodaira*

JAMSTEC'S OBSs (4.5-Hz three-component gimbal-mounted geophones and hydrophones, continuous 16-bit digital recording with 100 Hz) were used for passive and active seismic studies of this cruise. An OBS is able to continuously record ground motions in three months. 8 or 32 G byte hard disk is used. All parts including sensors with gimbal-leveling mechanism, batteries and a recorder are installed in 17-inch glass sphere. A radio beacon (43.5880 M Hz) and flash light were attached for assisting to find an OBS at the sea surface when it is recovered. An OBS is equipped with an acoustic transponder system which controls the release mechanism and also is used for measuring a range between an OBS and a ship. An OBS is released from its anchor by electric corrosion of stainless plates when a release command was send from the vessel.

Figure 1. Photo of JAMSTEC OBS used for 2010005PGC cruise

Figure 2. OBSs on deck of John P. Tully.

Figure 3. Launch of OBS from A-frame.

3.1 OBS deployment procedure

OBS deployment procedure in this cruise is as follows:

- 30 min. before deployment
  in Lab: final check of acoustic transponder, release mechanism, flash light, radio beacon; difference between GPS clock and OBS internal-clock is measured
- Deploy OBS
  on deck: deploy OBS when ship reach the position
  in Lab: write the deployment position
- Tracking OBS
  on deck: deploy transducer over starboard railing when ship stops
  in Lab: tracking OBS. Measuring slant range, write ship position when OBS reaches at seafloor
- Positioning OBS
  For making triangulation, ranges from the ship to an OBS are measured at three positions (N, SE, SW) ~ 500 m away from a deployment position. If the ship drifts away from a deployment position during tracking OBS, the last measurement of tracking can be used as data for positioning. In this case, two positions among three (N, SE, SW) are chosen depending on direction of drifting.

3.2 Results of positioning

In order to locate an OBS at sea floor, a simple triangulation is used. An example of triangulation is shown below, and results of relocations of all JAMSTEC OBSs are listed in **Table 1**. For completeness, **Table 2** gives final locations for both short-period JAMSTEC OBSs and broadband Woods Hole instruments, deployed from July13-15, 2010 by Jeff McGuire during a Wecoma cruise. The OBS deployment log, recorded by watchkeepers, is given in **Table 3**. The final positions of all OBSs are shown in the map of **Figure 5**. The ship's track, showing the order of deployment of OBSs, is given in the map of **Figure 6**.

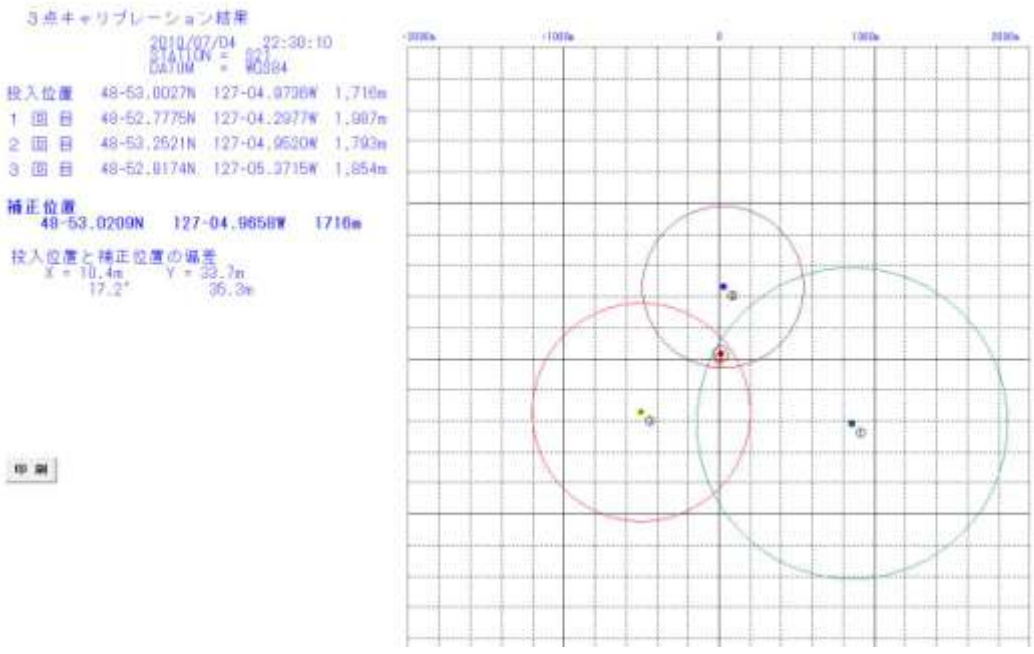

Figure 4. Example of triangulation

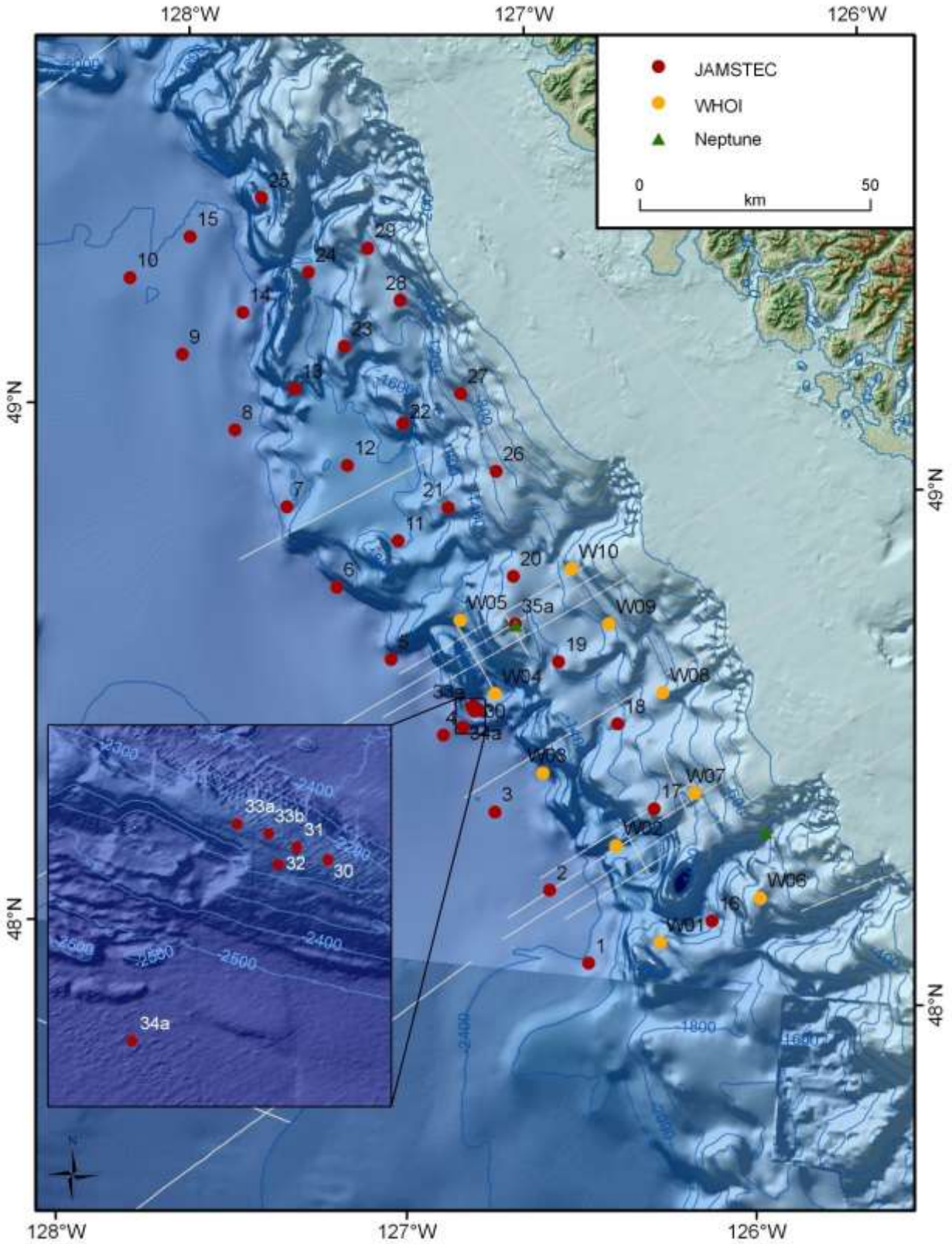

Figure 5. Map showing location of all OBSs deployed during cruise PGC2010005. OBSs 33a, 34a and 35a were only deployed for about 26 hours as part of a small grid to record refraction data on the frontal ridge adjacent to a large landslide (see **Figure 11**). The remaining OBSs are to be deployed for about 3 months. The bathymetry data are side-lit and colour-coded, with contours at an interval of 200 m.

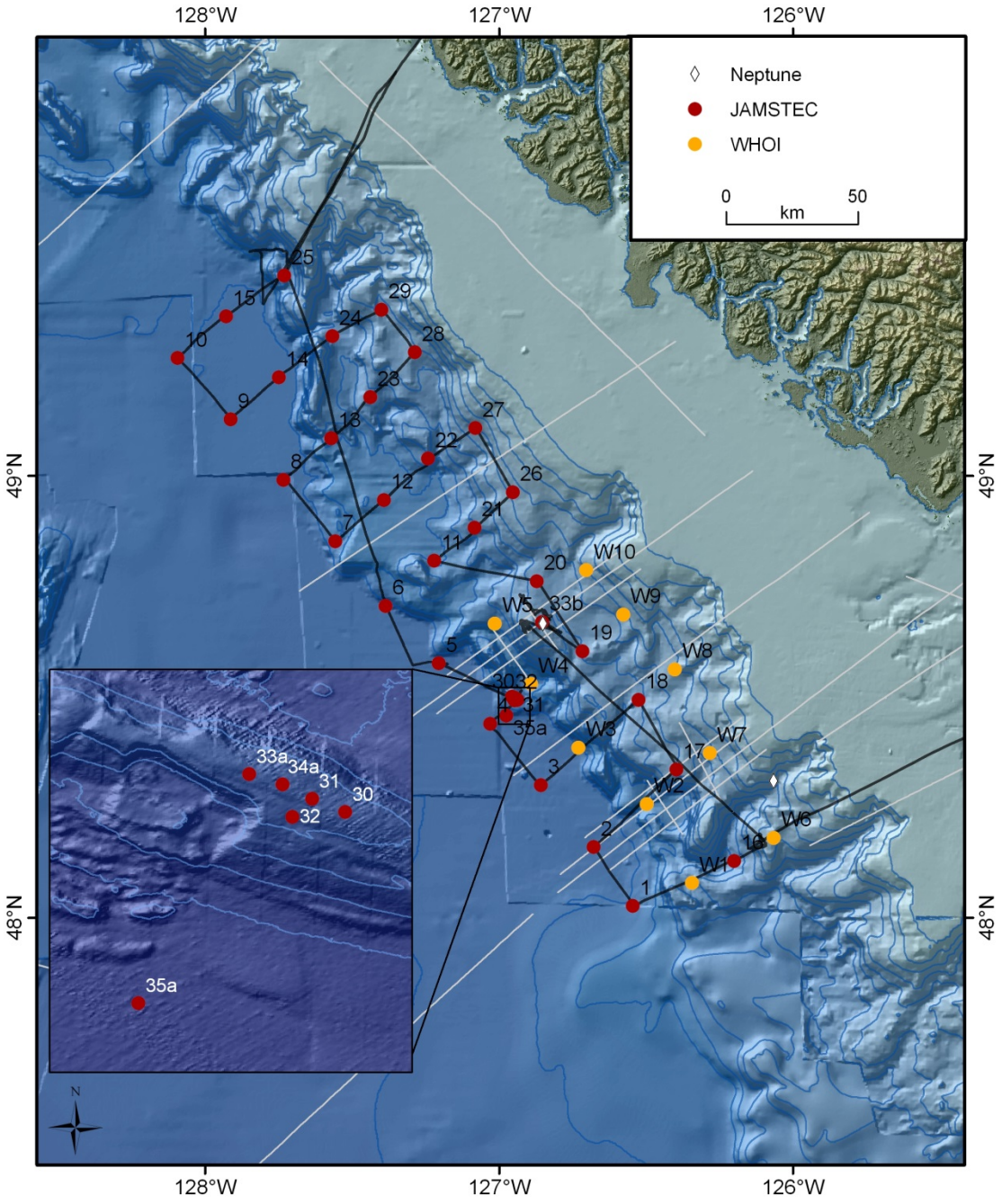

Figure 6. Map showing location of all OBSs deployed during cruise PGC2010005, and the ship's track during the deployment of the OBSs. Bathymetry is side-lit to show more structural details, particularly over the more southern half of the OBS grid where higher resolution swath bathymetry data (collected in 2004 from University of Washington cruise TN175) are available.

3.3 Example of data

We reproduced data from an OBS which was recovered soon after air gun shooting. This OBS continuously recorded ground motions from 17:00, 4th/July to 20:30, 5th/July. As shown in **Figure 7**, signals from air gun are clearly observed. Earthquakes are also observed during the approximately 26 hours of recording - a local earthquake (<10 km distance) in **Figure 8** and a more distant earthquake (~100 km distance) in **Figure 9**; Garry Rogers of PGC also verified that both earthquakes were recorded on the NEPTUNE broadband seismometer at Site 889.

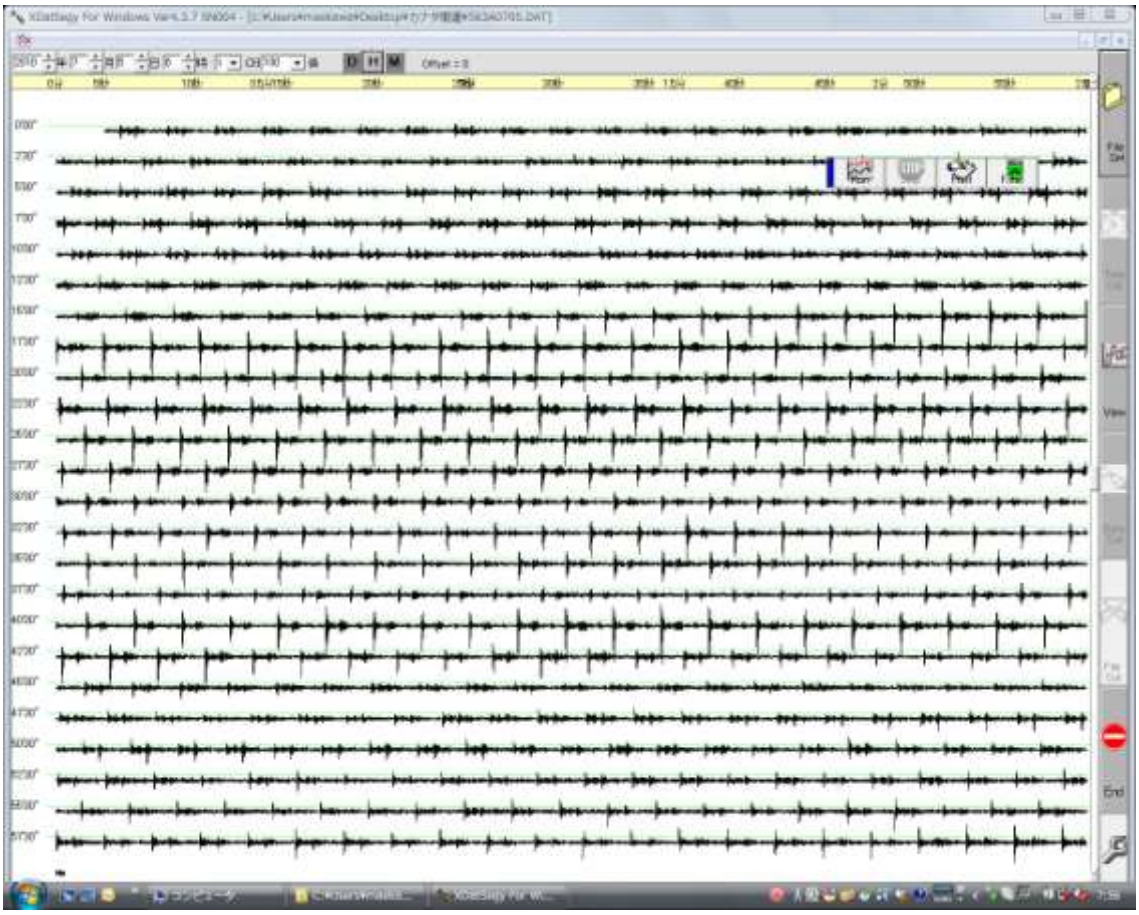

Figure 7. One hour continuous record of the vertical component (OBS34a) from 6:00 to 7:00, 5th/July.

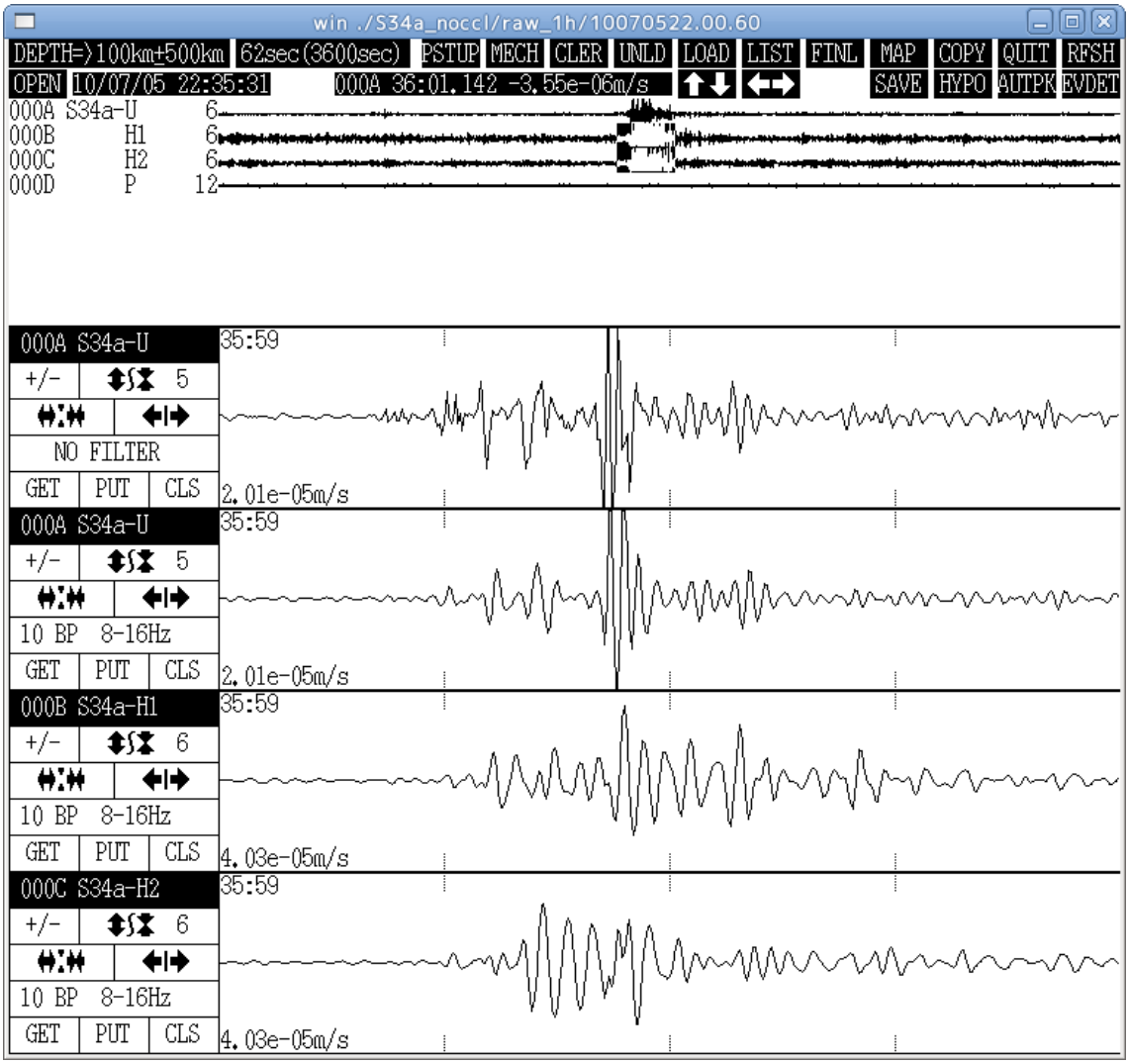

Figure 8. Example of a local earthquake observed by OBS34a.

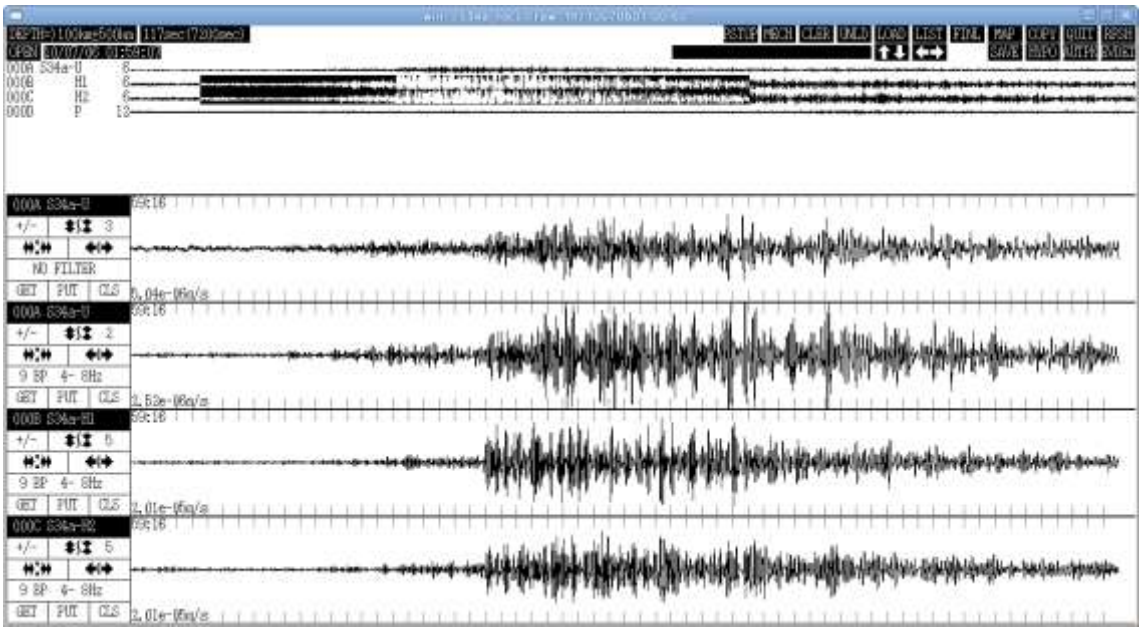

Figure 9. Example of a distant earthquake (~100 km) observed by OBS34b.

	deployment						
	time	ship position			OBS position at seafloor		
SITE	Local (UTC-7h)	Lat(N)	Lon(W)	Depth	Lat(N)	Lon(W)	Depth
1	2010/07/01 18:58:00	48_01.5915	126_32.6628	2395.0	48_01.6212	126_32,6642	2395.0
2	2010/07/01 21:17:00	48_09.6837	126_40.5903	2506.0	48_09.6883	126_40.6668	2506.0
3	2010/07/01 23:53:00	48_18.1596	126_51.4219	2554.0	48_18.1579	126_51.4297	2554.0
4	2010/07/02 03:20:00	48_26.4655	127_01.7650	2564.0	48_26.4844	127_01.7908	2564.0
5	2010/07/07 06:11:00	48_34.6745	127_12.3081	2559.0	48_34.6729	127_12.2772	2559.0
6	2010/07/07 03:56:00	48_42.4674	127_23.0663	2547.0	48_42.4468	127_23.0795	2547.0
7	2010/07/03 23:50:00	48_51.1897	127_33.4307	2343.0	48_51.1752	127_33.3948	2343.0
8	2010/07/03 21:32:00	48_59.4258	127_44.0313	2503.0	48_59.4292	127_44.0112	2503.0
9	2010/07/03 11:22:00	49_07.5693	127_54.7429	2479.0	49_07.5460	127_54.7742	2479.0
10	2010/07/03 09:12:40	49_15.7740	128_05.5376	2426.0	49_15.7665	128_05.5957	2426.0
11	2010/07/04 07:22:00	48_48.5453	127_13.1578	2036.0	48_48.5447	127_13.1735	2036.0
12	2010/07/04 01:47:00	48_56.7321	127_23.4652	2058.0	48_56.7359	127_23.4796	2058.0
13	2010/07/03 19:35:00	49_04.9632	127_34.1160	1962.0	49_04.9960	127_34.2215	1962.0
14	2010/07/03 13:49:00	49_13.1570	127_44.8692	2474.0	49_13.1710	127_44.9066	2474.0
15	2010/07/03 07:13:40	49_21.3018	127_55.6664	2435.0	49_21.3245	127_55.7144	2435.0
16	2010/07/01 12:39:00	48_07.8028	126_11.8950	1670.0	48_07.8127	126_11.9174	1670.0
17	2010/07/01 15:53:00	48_20.2915	126_23.7679	1135.0	48_20.2597	126_23.7680	1135.0
18	2010/07/02 13:01:00	48_29.7808	126_31.5621	1373.0	48_29.7482	126_31.4896	1373.0
19	2010/07/02 15:50:00	48_36.3031	126_42.8505	1335.0	48_36.3350	126_42.8723	1335.0
20	2010/07/02 18:20:00	48_45.7876	126_52.2894	1379.0	48_45.7949	126_52.2675	1382.0
21	2010/07/04 05:42:40	48_53.0027	127_04.9736	1716.0	48_53.0209	127_04.9658	1716.0
22	2010/07/04 03:42:40	49_02.2915	127_14.4333	1563.0	49_02.2968	127_14.4342	1563.0
23	2010/07/03 17:53:00	49_10.4736	127_26.1766	1670.0	49_10.5135	127_26.2189	1685.0
24	2010/07/03 15:48:00	49_18.6505	127_33.9336	1787.0	49_18.6763	127_34.0118	1787.0
25	2010/07/03 05:17:20	49_26.7160	127_43.7895	1937.0	49_26.7616	127_43.7897	1937.0
26	2010/07/02 20:51:00	48_57.7909	126_57.0811	922.0	48_57.7901	126_57.0886	922.0
27	2010/07/02 22:37:00	49_06.3825	127_04.7734	939.0	49_06.3938	127_04.7662	939.0
28	2010/07/03 01:06:00	49_16.5116	127_17.1579	1275.0	49_16.5289	127_17.1707	1275.0
29	2010/07/03 02:45:40	49_22.1940	127_23.9324	1255.0	49_22.2173	127_23.9209	1255.0
30	2010/07/02 09:32:00	48_29.7596	126_56.2025	2143.0	48_29.7359	126_56.2125	2143.0
31	2010/07/02 08:48:30	48_29.9115	126_56.5654	2141.0	48_29.8808	126_56.5814	2141.0
32	2010/07/02 06:23:20	48_29.6765	126_56.7938	2170.0	48_29.6800	126_56.7975	2170.0
33a	2010/07/02 07:12:40	48_30.1664	126_57.3211	2112.0	48_30.1563	126_57.2809	2112.0
33b	2010/07/02 08:00:00	48_30.0193	126_56.9178	2120.0	48_30.0419	126_56.9092	2120.0
34a	2010/07/02 04:53:30	48_27.5984	126_58.5381	2559.0	48_27.6141	126_58.5086	2559.0
35a	2010/07/07 00:33:00	48_40.2996	126_51.1311	1256.0	48_40.2791	126_51.1349	1256.0

Table 1. Deployment and re-located positions for short-period JAMSTEC OBSs

Number	(deg)	(min)	(deg)	(min)	Depth (m)		(dec deg)	(dec deg)
1	48	1.6212	126	32.6642	2395		48.027020	-126.544403
2	48	9.6883	126	40.6668	2506		48.161472	-126.677780
3	48	18.1579	126	51.4297	2554		48.302632	-126.857162
4	48	26.4844	127	1.7908	2564		48.441407	-127.029847
5	48	34.6729	127	12.2772	2559		48.577882	-127.204620
6	48	42.4468	127	23.0795	2547		48.707447	-127.384658
7	48	51.1752	127	33.3948	2343		48.852920	-127.556580
8	48	59.4292	127	44.0112	2503		48.990487	-127.733520
9	49	7.546	127	54.7742	2479		49.125767	-127.912903
10	49	15.7665	128	5.5957	2426		49.262775	-128.093262
11	48	48.5447	127	13.1735	2036		48.809078	-127.219558
12	48	56.7359	127	23.4796	2058		48.945598	-127.391327
13	49	4.996	127	34.2215	1962		49.083267	-127.570358
14	49	13.171	127	44.9066	2474		49.219517	-127.748443
15	49	21.3245	127	55.7144	2435		49.355408	-127.928573
16	48	7.8127	126	11.9174	1670		48.130212	-126.198623
17	48	20.2597	126	23.768	1135		48.337662	-126.396133
18	48	29.7482	126	31.4896	1373		48.495803	-126.524827
19	48	36.335	126	42.8723	1335		48.605583	-126.714538
20	48	45.7949	126	52.2675	1382		48.763248	-126.871125
21	48	53.0209	127	4.9658	1716		48.883682	-127.082763
22	49	2.2968	127	14.4342	1563		49.038280	-127.240570
23	49	10.5135	127	26.2189	1685		49.175225	-127.436982
24	49	18.6763	127	34.0118	1787		49.311272	-127.566863
25	49	26.7616	127	43.7897	1937		49.446027	-127.729828
26	48	57.7901	126	57.0886	922		48.963168	-126.951477
27	49	6.3938	127	4.7662	939		49.106563	-127.079437
28	49	16.5289	127	17.1707	1275		49.275482	-127.286178
29	49	22.2173	127	23.9209	1255		49.370288	-127.398682
30	48	29.7359	126	56.2125	2143		48.495598	-126.936875
31	48	29.8808	126	56.5814	2141		48.498013	-126.943023
32	48	29.68	126	56.7975	2170		48.494667	-126.946625
33a	48	30.1563	126	57.2809	2112		48.502605	-126.954682
33b	48	30.0419	126	56.9092	2120		48.500698	-126.948487
34a	48	27.6141	126	58.5086	2559		48.460235	-126.975143
35a	48	40.2791	126	51.1349	1256		48.671318	-126.852248
W01	48	4.782	126	20.55	1688		48.0797	-126.3425
W02	48	15.555	126	29.808	2123		48.25925	-126.4968
W03	48	23.247	126	43.723	2479		48.38745	-126.72872
W04	48	31.903	126	53.447	2309		48.53172	-126.89078
W05	48	40.05	127	0.804	2002		48.6675	-127.0134
W06	48	10.965	126	3.883	992		48.18275	-126.06472
W07	48	22.48	126	16.935	1143		48.37467	-126.28225
W08	48	33.87	126	24.067	1018		48.5645	-126.40112
W09	48	41.282	126	34.621	1146		48.68803	-126.57702
W10	48	47.273	126	42.134	1061		48.78788	-126.70223

Table 2. Final locations of both short-period JAMSTEC OBSs and broadband Woods Hole instruments.

TABLE 3 : 2008007PGC OBS Deployment Log - Tully										
Navigation							Weather			COMMENTS
Day	UTC	Latitude	Longitude	Line # or	Water Depth		Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(kts)	(m)		
182	18:53				18	906	22	3	NS	SEAFLOOR PLUME
182	19:39	48.129835	-126.198407	OBS 16 RELEASED	12	1670.3	22	3	NS	1ST OBS
182	20:12	48.142399	-126.205350	SHUT OFF 12KHz		1649.8	25-30	3	NS	SHUT OFF 12KHz, BRIDGE TURNED
182	20:37	48.128537	-126.197631	OBS 16 START DRIFTING SOUTH OF SITE		1675.6	22	3	NS	
182	20:38	48.128956	-126.197294	OBS 16 PINGER DEPLOYED SOUTH OF SITE		1676.0	22	3	NS	
182	20:41	48.129890	-126.197771	OBS 16 PINGER UP SOUTH OF SITE		1671.3	22	3	NS	
182	20:50	48.127277	-126.191314	OBS 16 PINGER DEPLOYED EAST		1649.5	20	2	YSR	
182	20:52	48.127872	-126.192113	OBS 16 PINGER UP EAST		1654.8	20	2	YSR	
182	21:05	48.127317	-126.203459	OBS 16 PINGER DEPLOYED WEST		1715.6	20	2	YSR	
182	21:07	48.127982	-126.203691	OBS 16 PINGER UP WEST		1722.8	20	2	YSR	
182	22:53	48.337935	-126.3970046	OBS 17 released	12	1135.7	21	2	YSR	
182	22:58	48.336805	-126.396431	OBS 17 pinger deployed west	12	1137.6	20.8	2	YSR	
182	23:08	48.338864	-126.400879	OBS 17 at bottom	12	1142.8	17-20	2	YSR	
182	23:17	48.342219	-126.396014	OBS 17 pinger deployed north	12	1136.3	20	2	YSR	
182	23:19	48.342459	-126.396188	OBS 17 pinger up north	12	1136.3	20	2	YSR	
182	23:35	48.335085	-126.391098	OBS17 pinger deployed east	12	1127.3	18	2	YSR	
183	01:57	48.026389	-126.544742	OBS 01 released	12	2394	8.9	0.6	TZ	
183	02:00	48.026243	-126.543933	OBS 01 pinger deployed	12	2393	7.7	0.6	TZ	
183	02:28	48.030708	-126.547772	OBS 01 pinger range north	12	2399.9	5.7	0.2	TZ	600 m NW of deployment site
183	02:46	48.02330	-126.537767	OBS 01 pinger range east	12	2381.7	11.7	1	TZ	
183	03:04	48.023190	-126.549721	OBS 01 pinger range west	12	2399.6	10.7	1	TZ	
183	04:17	48.161228	-126.676227	OBS2 released	12	2518.9	18.5	2	TZ	
183	04:48	48.157219	-126.682784	OBS2 Pinger range west	12	2521.0	19.5	2	TZ	~750 m SW of deployment site
183	05:05	48.166226	-126.676471	OBS2 Pinger range north	12	2518.5	18.4	2	TZ	
183	05:21	48.158529	-126.669129	OBS2 PInger range east	12	2518.5	18.6	2	TZ	~50 m east of east triangulation position
183	06:53	48.302820	-126.856722	OBS 03 released	12	2560	14.6	1	TZ	12 and 18 kHz not working, depth taken from Bridge (1400 fathoms); wire slipped out of casing; power to A-frame lost, release-rope tangled
183	06:55	48.302461	-126.857469	echo sounder working again	12	2554.8	14.6	1	TZ	echo sounder working again
183	07:24	48.295871	-126.855630	OBS 03 pinger range south (no response	12	2555.1	14.8	1	TZ	unable to connect to transponder, moved to east site (we had drifted south and unable to connect to OBS)
183	07:41	48.299694	-126.847386	OBS 03 pinger range east (no response)	12	2553.5	17.2	2	TZ	no repsonse from OBS, moving to north site

Navigation							Weather			COMMENTS
Day	UTC	Latitude	Longitude	Line # or	Water Depth		Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(kts)	(m)		
183	08:21	48.299142	-126.853346	OBS 03 pinger range south successful	12	2554.6	15.8	1	TZ	very weak signal (discussion with bridge: release of clutch to reduce noise), no more noise problems after this
183	08:33	48.300898	-126.861509	OBS 03 pinger range west successful	12	2554.4	16.9	2	TZ	
183	08:47	48.308112	-126.855539	OBS 03 pinger range north successful	12	2555.8	14.5	1	TZ	
183	10:20	48.441378	-127.029459	OBS 04 released	12	2598.7	24	3	TZ	
183	10:53	48.430060	-127.022207	OBS 04 pinger range south	12	2579.7	24.5	3	TZ	~ 2km south of release site
183	11:08	48.437461	-127.035061	OBS 04 pinger range west	12	2578.7	20	2	TZ	
183	11:24	48.446001	-127.027475	OBS 04 pinger range north	12	2576.2	24	3	TZ	
183	11:53	48.460220	-126.975798	OBS 35a released	12	2560.0	17.5	2	MS	
183	12:25	48.9051	-126.970169	OBS35A PINGER RANGE SOUTH	12	2565.9	20.5	2	TZ	DRIFTED ABOUT 2.5KM SOUTH OF RELEASE SITE
183	12:39	48.456368	-126.983643	OBS35A PINGER RANGE WEST	12	2563.5	20	2	TZ	
183	12:55	48.463520	-126.978777	OBS35A PINGER RANGE NORTH	12	2559	23	3	TZ	
183	13:23	48.494765	-126.946790	OBS32 RELEASED	12	2162.7	25	3	NS	
183	13:50	48.485506	-126.941069	OBS32 PINGER RANGE SOUTH	12	2258	21	2	NS	1200m SSE OF DEPLOYMENT
183	14:12	48.502747	-126.955943	OBS33 RELEASED	12	2105	22	3	NS	
183	14:23	48.499405	-126.953142	OBS32 PINGER RANGE NW	12	2123	28	3 to 4	NS	600m NW OF DEPLOYMENT
183	14:40	48.483019	-126.949679	OBS33a PINGER RANGE SSE	12	2178	26(NW)	3	NS	1.2 km SSE OF DEPLOYMENT
183	15:00	48.500998	-126.948852	OBS34a RELEASED	12	2113	20	2	NS	
183	15:05	48.499086	-126.947976	OBS33a PINGER RANGE SSE	12	2120	25	3	NS	600m SSE OF DEPLOYMENT
183	15:27	48.490324	-126.943734	OBS34a PINGER RANGE SSE	12	2190	27(NW)	3	NS	1.2 km SSE OF DEPLOYMENT
183	15:48	48.498902	-126.942833	OBS31 RELEASED	12	2141	26	3	NS	
183	15:53	48.497057	-126.942347	OBS32 PINGER RANGE NE	12	2145	28	3 to 4	NS	350m NE OF DEPLOYMENT
183	16:17	48.488457	-126.936570	OBS31 ON SEAFLOOR	12	2221.3	25	3	NS	
183	16:19	48.487787	-126.936016	OBS31 PINGER RANGE SSE	12	2222	25	3	NS	1.3 km SSE OF DEPLOYMENT
183	16:31	48.495809	-126.936417	OBS30 RELEASED	12	2133.4	23	3	NS	
183	16:59	48.488173	-126.931036	OBS30 ON SEAFLOOR	12	2209	23	3	NS	
183	16:59	48.487967	-126.930911	OBS30 PINGER RANGE SE	12	2209	23	3	NS	1.3 km SE OF DEPLOYMENT
183	17:18	48.500841	-126.937286	OBS30 PINGER RANGE NORTH	12	2174	23	3	NS	
183	17:20	48.500326	-126.937202	OBS31 PINGER RANGE EAST	12	2170	22	3	NS	500 m EAST OF DEPLOYMENT
183	17:21	48.499850	-126.936855	OBS 34A PINGER RANGE SE	12	2169	22	3	NS	1 km SE OF DEPLOYMENT
183	17:47	48.507691	-126.954832	OBS33 PINGER RANGE NORTH	12	2123.3	24	3	NS	500 m NORTH OF DEPLOYMENT
183	17:48	48.507223	-126.954626	OBS34a PINGER RANGE NW	12	2128	22	3	NS	750 m NW OF DEPLOYMENT
183	17:50	48.506927	-126.954002	OBS31 PINGER RANGE NW	12	2127	22	3	NS	1.2 km NW OF DEPLOYMENT
183	17:51	48.506473	-126.954059	OBS30 PINGER RANGE NW	12	2124.8	22	3	NS	1.6 km NW OF DEPLOYMENT

Navigation							Weather			COMMENTS
Day	UTC	Latitude	Longitude	Line # or	Water Depth		Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(kts)	(m)		
183	20:01	48.496202	-126.526567	OBS18 RELEASED	12	1373.7	21	2	YSR	DID NOT EXTEND THE A-FRAME BEFORE LOWERING
183	20:18	48.489604	-126.520364	OBS18 PINGER RANGE EAST	12	1377.3	23	3	NS	900 m SE OF DEPLOYMENT
183	20:36	48.492519	-126.531836	OBS18 PINGER RANGE WEST	12	1369	22	3	NS	
183	21:01	48.499360	-126.525399	OBS18 PINGER RANGE NORTH	12		23(NW)	3	NS	
183	22:50	48.604741	-126.714177	OBS19 RELEASED	12	1339	25(WWN)	3	NS	
183	23:08	48.6015911	-126.705607	OBS19 PINGER RANGE EAST	12	1351.5	22	3	NS	700 m SE OF DEPLOYMENT
183	23:35	48.601497	-126.716863	0BS19 PINGER RANGE WEST	12	1359.1	25(NW)	3	NS	700 m SSW OF DEPLOYMENT
183	23:58	48.609359	-126.711736	OBS19 PINGER RANGE NORTH	12	1343.9	25	3	NS	
184	01:19	48.762908	-126.871500	OBS 20 RELEASED	12	1379.6	25.5	3	TZ	
184	01:37	48.759225	-126.861022	OBS 20 PINGER RANGE EAST	18	1385	20.5	2	TZ	~500 M EAST OF PROPOSED TRIANGULATION EAST SITE
184	02:06	48.760570	-126.874341	OBS 20 PINGER RANGE WEST	12	1376.6	24	3	TZ	
184	02:21	48.766449	-126.870097	OBS 20 PINGER RANGE NORTH	12	1380	20	2	TZ	
184	03:51	48.963133	-126.951048	OBS 26 RELEASED	18	922.8	25.5	3	TZ	
184	03:23			POSSIBLE PLUME LOCATION	12	972			TZ	POSSIBLE PLUME LOCATION SEEN ON 18 KHZ
184	04:03	49.960682	-126.9474716	OBS 26 PINGER RANGE EAST	18	919.7	21.6	3	TZ	
184	04:15	48.959753	-126.957010	OBS 26 PINGER RANGE WEST	18	957.7	22.7	3	TZ	
184	04:27	48.967729	-126.951304	OBS 26 PINGER RANGE NORTH	18	907.2	24	3	TZ	
184	05:36	49.106547	-127.079351	OBS 27 RELEASED	18	938	17.8	2	TZ	
184	05:48	49.102682	-127.075241	OBS 27 PINGER RANGE EAST	18	959.3	17.8	2	TZ	
184	06:04	49.103051	-127.085070	OBS 27 PINGER RANGE WEST	18	989.1	19.5	2	TZ	
184	06:20	49.111309	-127.079141	OBS 27 PINGER RANGE NORTH	18	910.9	17.5	2	TZ	
184	08:06	49.275379	-127.285949	OBS 28 RELEASED	18	1275	19.7	2	TZ	
184	08:23	49.270639	-127.280888	OBS 28 PINGER RANGE EAST	18	1280.8	15	1	TZ	
184	08:35	49.272245	-127.294048	OBS 28 PINGER RANGE WEST	18	1280.6	20	2	TZ	
184	08:50	49.281285	-127.285454	OBS 28 PINGER RANGE NORTH	18	1253.9	17	2	TZ	
184	09:45	49.370090	-127.398803	OBS 29 RELEASED	18	1255.4	18	2	TZ	
184	10:02	49.366933	-127.392748	OBS 29 PINGER RANGE EAST	18	1268.4	15	1	TZ	~150 m EAST OF PROPOSED EAST TRIANGULATION SITE
184	10:14	49.366803	-127.40955	OBS 29 PINGER RANGE WEST	18	1252.7	14.2	1	TZ	
184	10:26	49.374989	-127.399425	OBS 29 PINGER RANGE NORTH	18	1271.5	14.9	1	TZ	
184	12:17	49.445377	-127.730080	OBS25 RELEASED	18	1231.7	10.8	1	MS	
184	12:42	49.441562	-127.722950	OBS 25 PINGER RANGE EAST	18	1932.9	10.7	1	TZ	
184	12:55	49.452336	-127.731873	OBS 25 PINGER RANGE NORTH	18	1941.8	10.5	1	MS	100M NORTH OF PROPOSED NORTH TRIANGULATION SITE
184	13:07	49.442065	-127.736512	OBS 25 PINGER RANGE WEST	18	1868.7	8.8	0.6	NS	

Navigation							Weather			COMMENTS
Day	UTC	Latitude	Longitude	Line # or	Water Depth		Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(kts)	(m)		
184	14:13	49.354802	-127.927848	OBS 15 RELEASED	18	2424.8	9	0.6	NS	
184	14:44	49.356546	-127.916626	OBS 15 PINGER RANGE EAST	18	2427.3	6.8	0.6	NS	900 m EAST OF DEPLOYMENT
184	14:59	49.359260	-127.928864	OBS 15 PINGER RANGE NORTH	18	2424.4	8.5	0.6	NS	
184	15:12	49.351355	-127.934772	OBS 15 PINGER RANGE WEST	18	2424.9	8.2	0.6	NS	
184	16:12	49.262956	-128.091947	OBS 10 RELEASED	12	2426.1	7.3	0.6	NS	
184	16:43	49.265434	-128.082292	OBS 10 PINGER RANGE EAST	12	2428.8	8 (NW)	0.6	NS	1 km NE OF DEPLOYMENT
184	16:56	49.267092	-128.092244	OBS 10 PINGER RANGE NORTH	12	2435.5	8.5	0.6	NS	
184	17:10	49.259956	-128.098561	OBS 10 PINGER RANGE WEST	12	2425	8.2	O.6	NS	
184	18:22	49.126019	-127.912174	OBS 9 RELEASED	18	2479	7.8	O.6	NS	12kHz ECHO SOUNDER PICKS UNIDENTIFIED SIGNAL ABOVE SF
184	18:55	49.119280	-127.904913	OBS 9 PINGER RANGE EAST	18	2480.7	9.7	0.6	NS	900m SE OF DEPLOYMENT
184	19:10	49.123346	-127.919017	OBS9 PINGER RANGE WEST	18	2479.4	9.8	0.6	YSR	
184	19:27	49.130581	-127.913163	OBS9 PINGER RANGE NORTH	12	2305	10.8	0.6	YSR	
184	20:48	49.219473	-127.747704	OBS 14 RELEASED	18	2474.5	11.5 (NW)	1	NS	
184	21:19	49.215924	-127.742431	OBS 14 PINGER RANGE EAST	18	2476.2	11.6	1	NS	
184	21:35	49.215629	-127.753271	OBS 14 PINGER RANGE WEST	18	2474	12.7	1	NS	
184	21:49	49.225243	-127.746697	OBS 14 PINGER RANGE NORTH	18	2474.4	11.5	1	NS	
184	22:48	49.310999	-127.565333	OBS 24 RELEASED	12	1792	11.8	1	NS	
184	23:11	49.307673	-127.559645	OBS 24 PINGER RANGE EAST	12	1788	12	1	NS	
184	23:25	49.308474	-127.572241	OBS 24 PINGER RANGE WEST	12	1782	15.4	1	NS	
184	23:42	49.316186	-127.566425	OBS 24 PINGER RANGE NORTH	12	1801	14.4	1	NS	
185	00:53	49.174666	-127.435898	OBS 23 RELEASED	12	1673.6	17.5	2	YSR	
185	01:14	49.173747	-127.428744	OBS 23 PINGER RANGE EAST	18	1688.7	12.4	2	MS	
185	01:28	49.179414	-127.436676	OBS 23 PINGER RANGE NORTH	18	1676	17.3	1	TZ	
185	01:38	49.171484	-127.443163	OBS 23 PINGER RANGE WEST	18	1652	14.2	2	TZ	
185	02:36	49.082987	-127.568550	OBS 13 RELEASED	18	1956	10.9	1	TZ	
185	03:01	49.080351	-127.562716	OBS 13 PINGER RANGE EAST	18	1976.2	12.6	1	TZ	
185	03:15	49.087396	-127.569212	OBS 13 PINGER RANGE NORTH	18	1948.4	12.6	1	TZ	
185	03:25	49.079718	-127.575007	OBS 13 PINGER RANGE WEST	18	1949.8	11.6	1	TZ	
185	04:32	48.990687	-127.733858	OBS 08 RELEASED	18	2503.7	11.6	1	TZ	
185	05:03	48.989722	-127.721326	OBS 08 PINGER RANGE EAST	18	2503.9	9.8	1	TZ	
185	05:21	48.994685	-127.732724	OBS 08 PINGER RANGE NORTH	18	2503.1	11.6	1	TZ	
185	05:34	48.987337	-127.741067	OBS 08 PINGER RANGE WEST	18	2503.0	12.5	1	TZ	DEPTH VALUE MAYBE OFF - 18 KHZ IS JUMPING 10-20 M BETWEEN READINGS
185	06:50	48.853265	-127.557563	OBS 07 RELEASED	18	2343	15	1	TZ	
185	07:21	48.849544	-127.544558	OBS 07 PINGER RANGE EAST	18	2170.3	13.3	1	TZ	
185	07:35	48.850446	-127.562423	OBS 07 PINGER RANGE WEST	18	2405.1	14	1	TZ	

Navigation							Weather			COMMENTS
Day	UTC	Latitude	Longitude	Line # or	Water Depth		Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(kts)	(m)		
185	07:45	48.857913	-127.556679	OBS 07 PINGER RANGE NORTH	18	2158.1	18	2	TZ	
185	08:46	48.945709	-127.391581	OBS 12 RELEASED	18	2058.6	16.4	1	TZ	
185	09:13	48.945776	-127.378380	OBS 12 PINGER RANGE EAST	18	2052.3	16	1	TZ	1.125 KM DUE EAST OF DEPLOYMENT SITE
185	09:34	48.943039	-127.396432	OBS 12 PINGER RANGE WEST	18	2061.2	17.7	2	TZ	
185	09:44	48.951369	-127.389964	OBS 12 PINGER RANGE NORTH	18	2052.5	18	2	TZ	
185	10:42	49.038420	-127.240686	OBS 22 RELEASED	18	1560.8	16.4	1	TZ	
185	11:03	49.034362	-127.228829	OBS 22 PINGER RANGE EAST	18	1729.4	19.8	2	TZ	
185	11:17	49.033798	-127.246811	OBS 22 PINGER RANGE WEST	18	1590.1	17.2	2	TZ	
185	11:29	49.042888	-127.240804	OBS 22 PINGER RANGE NORTH	18	1575.3	18.6	2	TZ	
185	12:42	48.883383	-127.083250	OBS 21 RELEASED	18	1730.5	19.8	2	TZ	
185	13:05	48.879602	-127.071830	OBS 21 PINGER RANGE EAST	12	1709.6	15.3	1	YSR	1 km SW TO DEPLOYMENT
185	13:19	48.887688	-127.082698	OBS 21 PINGER RANGE NORTH	18	1653.3	19.2	2	YSR	
185	13:28	48.880441	-127.089842	OBS 21 PINGER RANGE WEST	18	1739.8	16.2	1 to 2	NS	
185	14:22	48.809294	-127.219132	OBS 11 RELEASED	18	2028.7	20.1	2	YSR	
185	14:47	48.802187	-127.209979	OBS 11 PINGER RANGE EAST	18	2019	21.5	2 to 3	YSR	
185	15:02	48.813095	-127.220394	OBS 11 PINGER RANGE NORTH	18	2033.5	20.5	2 to 3	NS	
185	15:12	48.804665	-127.224609	OBS 11 PINGER RANGE WEST	18	2019.6	17.5	2	YSR	
185	17:12	48.578052	-127.205232	OBS 5 RELEASED	18	2545.7	21.9	2 to 3	YSR	
185	19:38	48.577620	-127.201881						NS	TURNING OFF OF THE ECHO SOUNDERS
187	00:55	48.458786	-126.977066	OBS 35A RELEASE COMMAND SENT	18	2549	20	3	MR	
187	01:53	48.549712	-126.975093	OBS 35A SURFACED	18	2546	20	2	MR	OBS AT SURFACE
187	01:59	48.46322	-126.976067	OBS35A RECOVERED ON DECK	18	2549	20	2	MR	
187	02:32	48.497028	-126.948890	OBS 34A RELEASE COMMAND SENT	18	2138.7	20	2	TZ	
187	02:47	48.493323	-126.944336	OBS34A COMING UP, RELEASED FRO	18	2116.6	23	3	TZ	
187	03:21	48.500331	-126.949324	OBS 34A SURFACED	18	2113	19.5	3	MR	
187	03:27	48.50111	-126.949153	OBS34A ON DECK	18	2116	20	3	MR	
187	03:34	48.501284	-126.947874	OBS 33A RELEASE COMMAND SENT	18	2116	20	3	MS	
187	03:48	48.496937	-126.943812	OBS 33A COMING UP, RELEASED FRO	18	2139	20	3	MR	
187	04:23	48.502467	-126.953848	OBS33A ON SURFACE	18	2109	22	3	MR	
187	04:30	48.50229	-126.955423	OBS33A ON DECK	18	2110	25	3	MR	
188	07:26	48.673805	-126.841012	PLUME-7	18	1253	17.8	2	TZ	
188	07:33	48.671873	-126.851825	ONS33B DEPLOYED	18	1256	12.3@356	1	TZ	
188	07:49	48.667822	-126.848977	OBS33B PINGER RANGE SOUTH	18	1261.4	10@0	1	TZ	
188	07:51	48.667266	-126.848407	PLUME-8	18	1265	15.5@0	1	TZ	
188	08:04	48.677656	-126.852260	OBS33B PINGER RANGE NORTH	18	1244	14@356	1	TZ	

Navigation							Weather			COMMENTS
Day	UTC	Latitude	Longitude	Line # or	Water Depth		Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(kts)	(m)		
188	08:13	48.669830	-126.857930	OBS33B PINGER RANGE WEST	18	1263	14.5@355	1	TZ	
188	10:56	48.708052	-127.384214	OBS 06 DEPLOYED	18	2530	17@350	2	TZ	
188	11:28	48.698519	-127.382029	OBS 06 PINGER RANGE SOUTH	18	2530	18@355	2	TZ	
188	11:45	48.712872	-127.385030	OBS 06 PINGER RANGE NORTH	18	2529.8	18.5@358	2	TZ	
188	11:58	48.704688	-127.391124	OBS 06 PINGER RANGE WEST	18	2530	17@0	2	TZ	
188	13:11	48.578080	-127.205304	OBS5 RELEASED	18	2545	11.9	1	YSR	
188	13:43	48.570675	-127.199667	OBS 5 PINGER RANGE EAST	18	2547	13.4	1	YSR	ABOUT 1km SSE OF SITE
188	13:55	48.575872	-127.2105514	OBS5 PINGER RANGE WEST	18	2547	13.8	1	YSR	
188	14:13	48.583636	-127.204627	OBS5 PINGER RANGE NORTH	18	2546	11.2	1	YSR	

4. Seismic airgun shooting and recording

George Spence

4.1 Seismic airgun source

The seismic source was a 120 cu. in. airgun (**Figure 10**). The airgun was deployed from the aft port corner of the ship, using a cable through a block on the A-frame driven by a port winch; the airgun was secured during towing by attaching the cable to the port capstan. The airgun was towed at a distance of ~25 m behind the stern. The airgun was fired by time at an interval of 7 s.

The compressor used was the Sulzer. The Sulzer compressor supplies air at a nominal pressure P of 1900 psi at a supply rate F of about 110 standard cu. ft. per min. The maximum firing interval C is given by C = 2.75*P*V/(1000*F). For a total volume V of 210 cu. in., C is 10.0 s, while for a total volume of 90 cu. in., C is 4.3 s. This was the first extended use of the Sulzer since 2005, after which it was rebuilt – but it performed well. The airgun and compressor were fired over a period of about 33 hours, for a total of about 17,000 shots.

A 40 cu. in. airgun, and the smaller Rix compressor, were brought along as backup. They were not required.

Figure 10. 120 cu. in. airgun, with support bracket. The shot hydrophone as clamped to the outside of the airgun (note the clamp broke after several hours of firing).

4.2 Seismic data recording systems

Reflections were recorded on a Benthos streamer (50 hydrophones at ~6-inch spacing). The preferred Teledyne Model 178 single channel array was not working; although it responded positively to a tap test while on deck, no signal could be obtained when deployed and so under stress. The Benthos streamer was towed over the rail on the starboard aft corner. The head of the array was about 12 m from the stern of the ship, so the centre of the array was about 15 m from the ship (or ~5 m from the airgun). The depth of the array was uncertain, but estimated as about 3 m.

The seismic data from the hydrophone streamer were recorded on the GeoDig system, at a sample rate of 1 ms. Record length was 5 s (i.e. 5000 samples), and a deep water delay of 2 s was applied. Navigation data from the GPS system were incorporated into the data headers, and the data were written in true SEGY format as REAL*4. Note that the GPS antenna (the ship's antenna) is located 35.3 m from the stern of the ship.

A blast hydrophone attached to the airgun was recorded on a second GeoDigs system. The sample rate was 50 μs, with a record length of 250 ms (i.e. 5000 samples) and a deep water delay of 0 ms.

For a few lines, the seismic data were also displayed on an EPC recorder. Numerous problems were encountered with the 2 EPCs available – on one, the head only wrote for half the width of the paper; for the other, the "Trigger in" A and B inputs appear to be interchanged. When working, the EPCs were set at a Scan Rate of 4 s, a Delay of 0, a Gain of 9.6, a Threshold of 1.8V, and an External Trigger Level of 4.1V. Before display on the EPC, the seismic data passed through a Kronhite filter – set to a single Hipass filter with a cutoff of 30 Hz.

NOTE: On the Tully, it is necessary to ask the engineers to disable the Cathodic Protection System. This removes noise at a frequency of 60 Hz and particularly at 120 Hz, and this gave a huge improvement to data quality for the small Benthos hydrophone array. However, for projects where there are extended periods of seismic recording, the engineers indicated that they would be reluctant to turn off the protection system for extended periods of time. A solution to this problem should be investigated.

4.3 Seismic refraction lines

We acquired a series of airgun lines that were recorded on the OBS grid only (**Figure 11**, blue lines). There was no simultaneous recording of vertical incidence data on a short streamer, due to problems with the Teledyne streamer. However, these refraction lines were repeated with the recording of coincident reflection lines, several days later, on the backup Benthos streamer. The watchkeeper log for all seismic lines, giving the start-of-line (SOL) and end-of-line (EOL) for all lines, is given in **Table 4**.

Lines 1, 2 and 3 were nominally perpendicular to the frontal ridge or the deformation front. These lines form a nominal 2D profile that should be recorded on OBSs 4, 35a, 32 and 31. They should also be recorded on OBSs 33a, 34a and 30 to give some offline information.

Line 4 is located along the crest of the ridge, and airgun shots were recorded out to offsets of approximately 10 km from the OBS grid. The line forms a 2D profile recorded on OBSs 33a, 34a, 31 and 30.

OBSs 33a, 34a and 35a were recovered during the deployment cruise, for subsequent re-deployment on the main seismicity grid at OBS positions 5, 6 and 33b (located about 200 m from the continuously recording broadband seismometer at NEPTUNE site 889 near Bullseye vent). The OBS data from this deployment, which lasted approximately 26 hours, were copied to a hard disk (see **Figure 7**). They will be available for analysis once they are converted from their internal format.

4.4 Seismic reflection lines

We acquired a series of reflection lines on the Benthos streamer after OBSs 33a, 34a and 35 were recovered. Line 1A is a repeat of refraction lines 1, 2 and 3, but without the transit lines connecting the 3 segments. Line 4A is a repeat of refraction line 4. Lines 16, 18 and 20 crossed the subtle north-south bathymetric feature to test if the feature is also associated with sediment deformation. Line 15 is perpendicular to the frontal ridge, and crosses a feature just seaward of the ridge crest that could indicate incipient slumping. Lines 9 and 11 are also perpendicular to the frontal ridge and pass through different segments of the prominent landslide. Screen dumps of all reflection lines are shown in **Figures 12** to **20**.

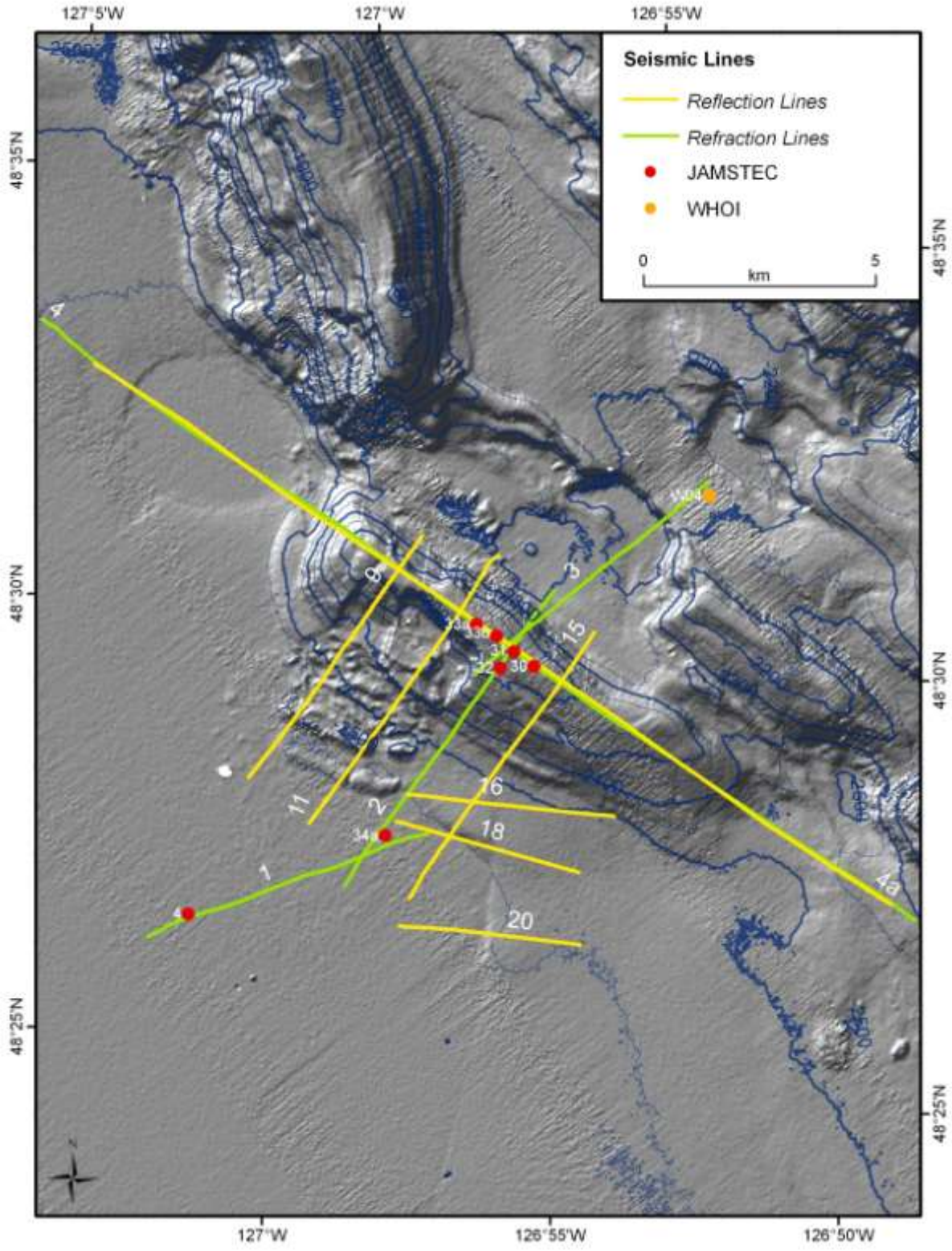

Figure 11. Map showing location of OBSs deployed during cruise PGC2010005 as part of a small grid to record refraction data on the frontal ridge adjacent to a large landslide. OBSs 33a, 34a and 35a were only deployed for about 26 hours, and data from these OBSs have been recovered, while data from the remaining OBSs will only be available in about 3 months after recovery of all OBSs on the main seismicity grid.

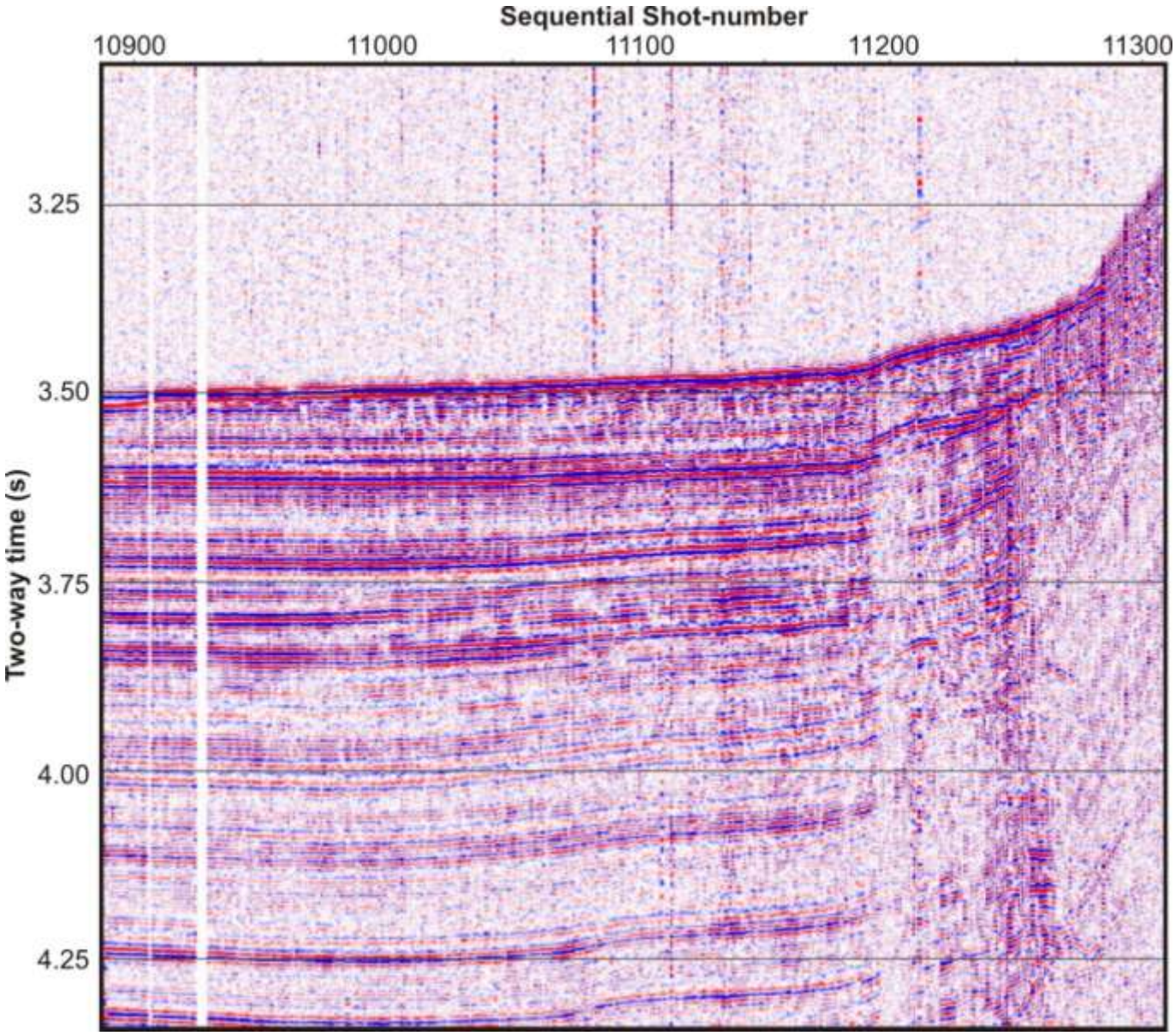

Figure 12. Western half of single-channel reflection line 1a, perpendicular to the frontal ridge. Line 1a is coincident with refraction lines 1, 2 and 3, which pass through OBSs 4, 35a, 32 and 31; however, at the time when line 1a was recorded, OBS 35a had been recovered.

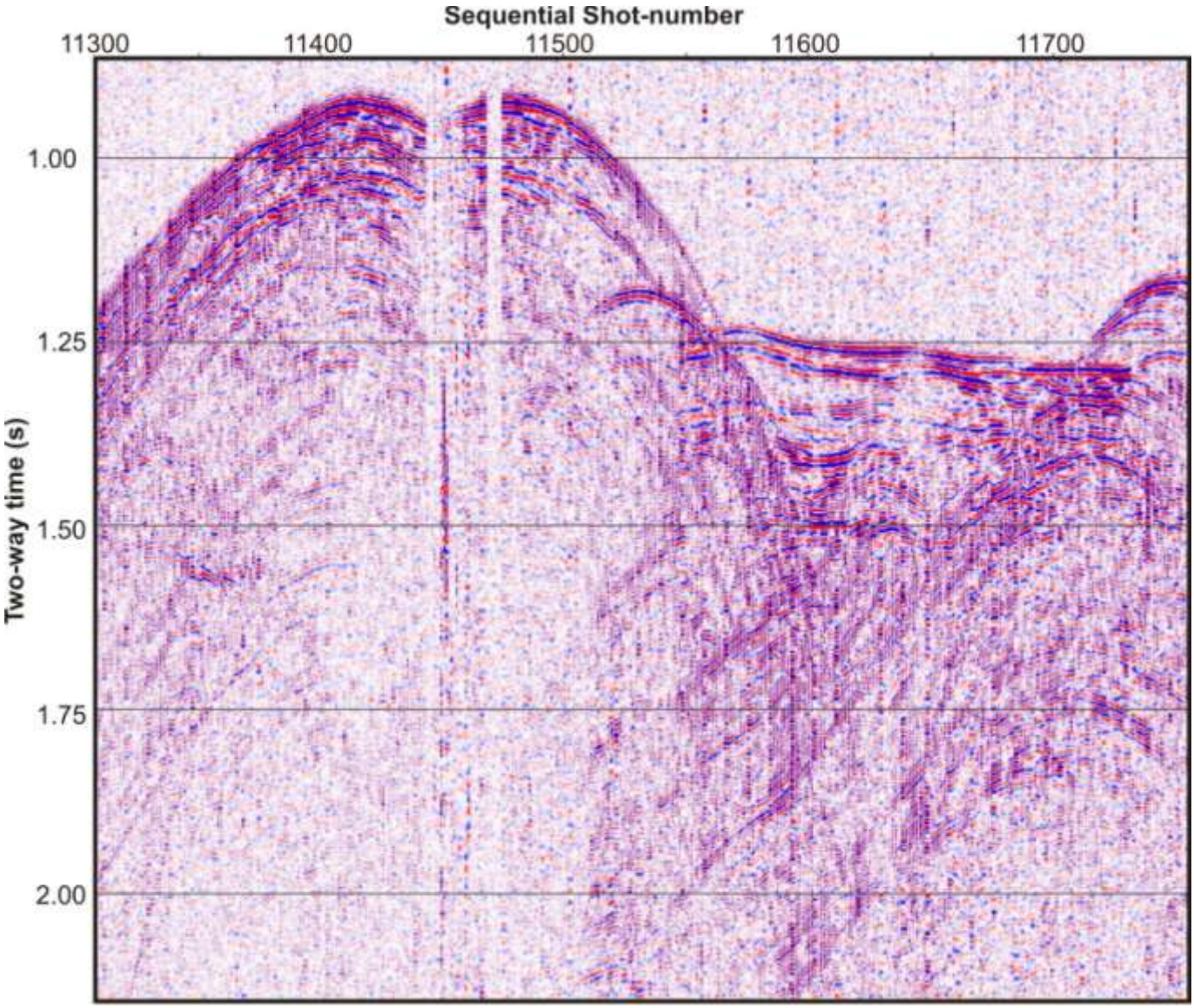

Figure 13. Eastern half of single-channel reflection line 1a, perpendicular to the frontal ridge.

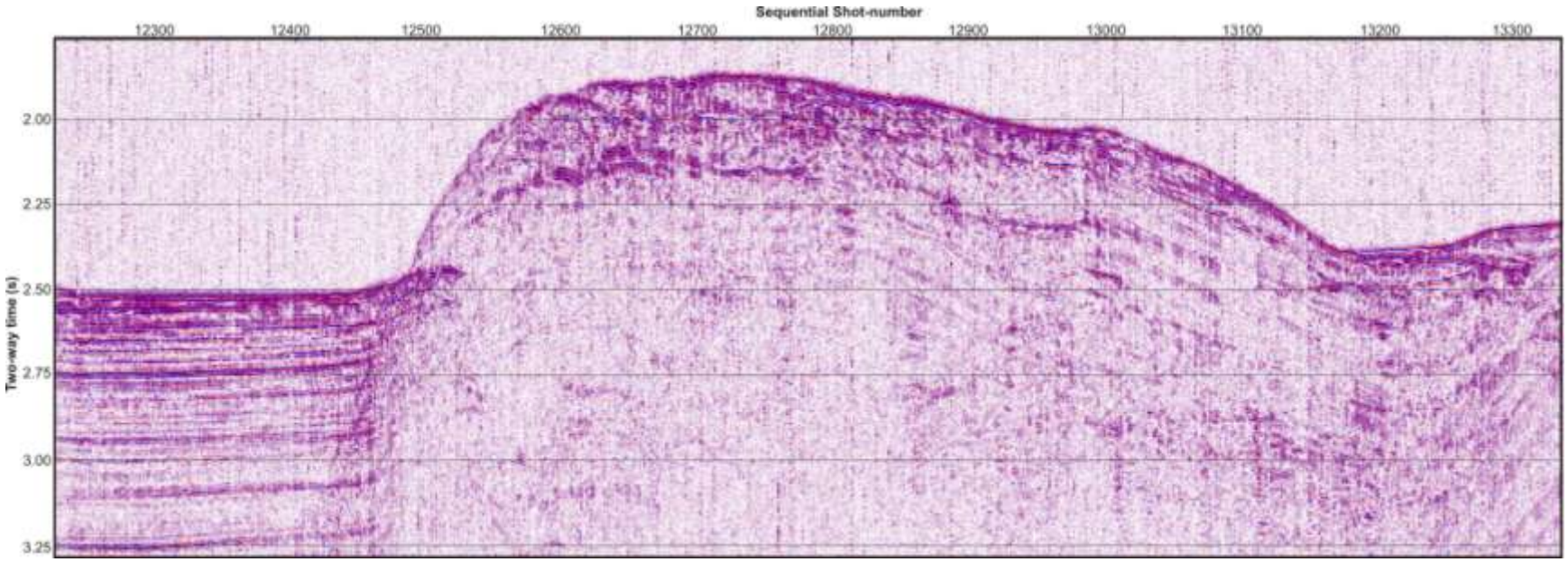

Figure 14. Single-channel reflection line 4a, along the crest of the frontal ridge. Line 4a is coincident with refraction line 4, which passed through OBSs 33a, 34a, 31 and 30; however, at the time that line 4a was recorded, OBSs 33a and 34a had already been recovered.

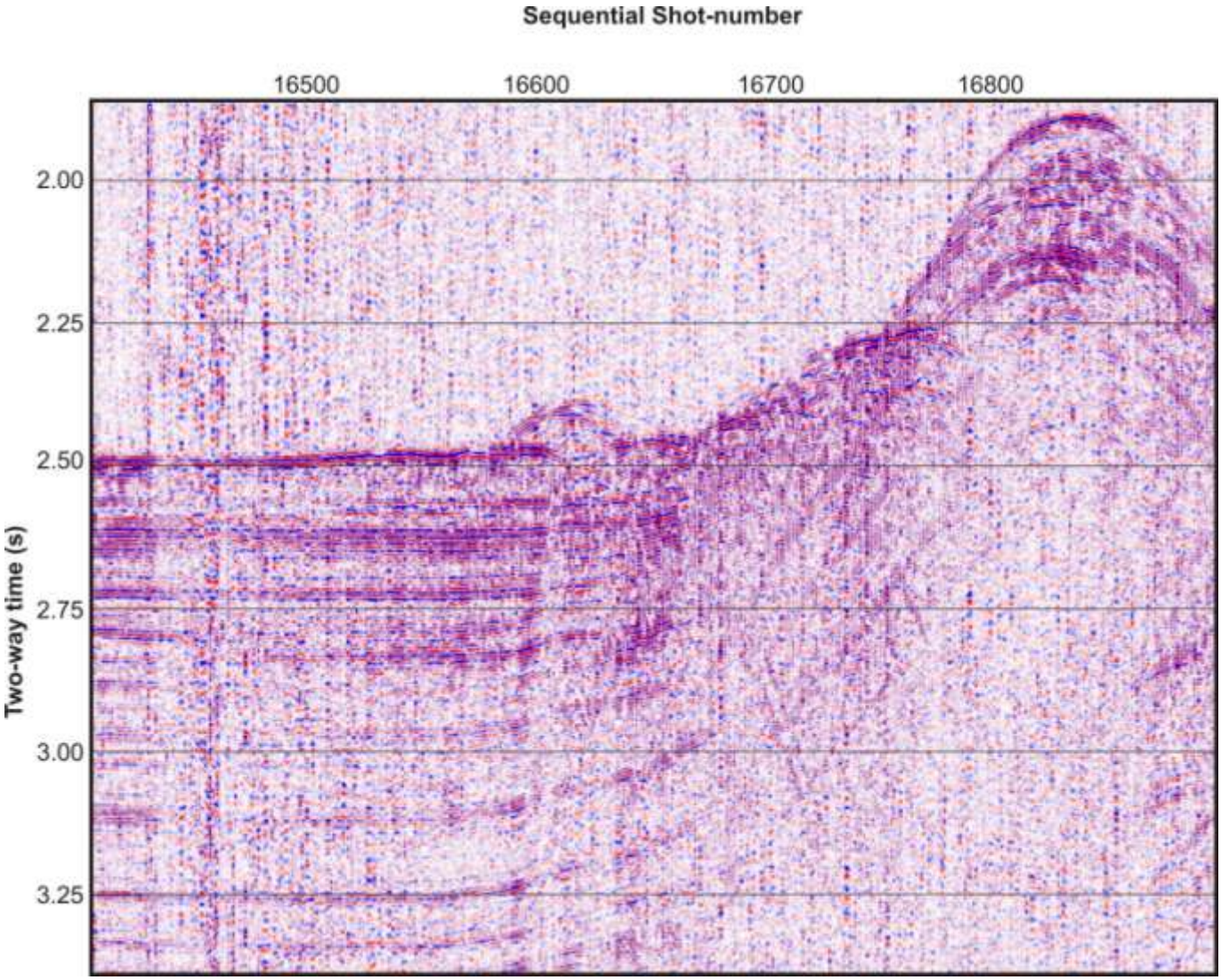

Figure 15. Single-channel reflection line 9, perpendicular to the frontal ridge and through the western portion of Slipstream slide. A large slide block, centred at shot number 16610, has a height above the seafloor of about 100 ms, or 75 m.

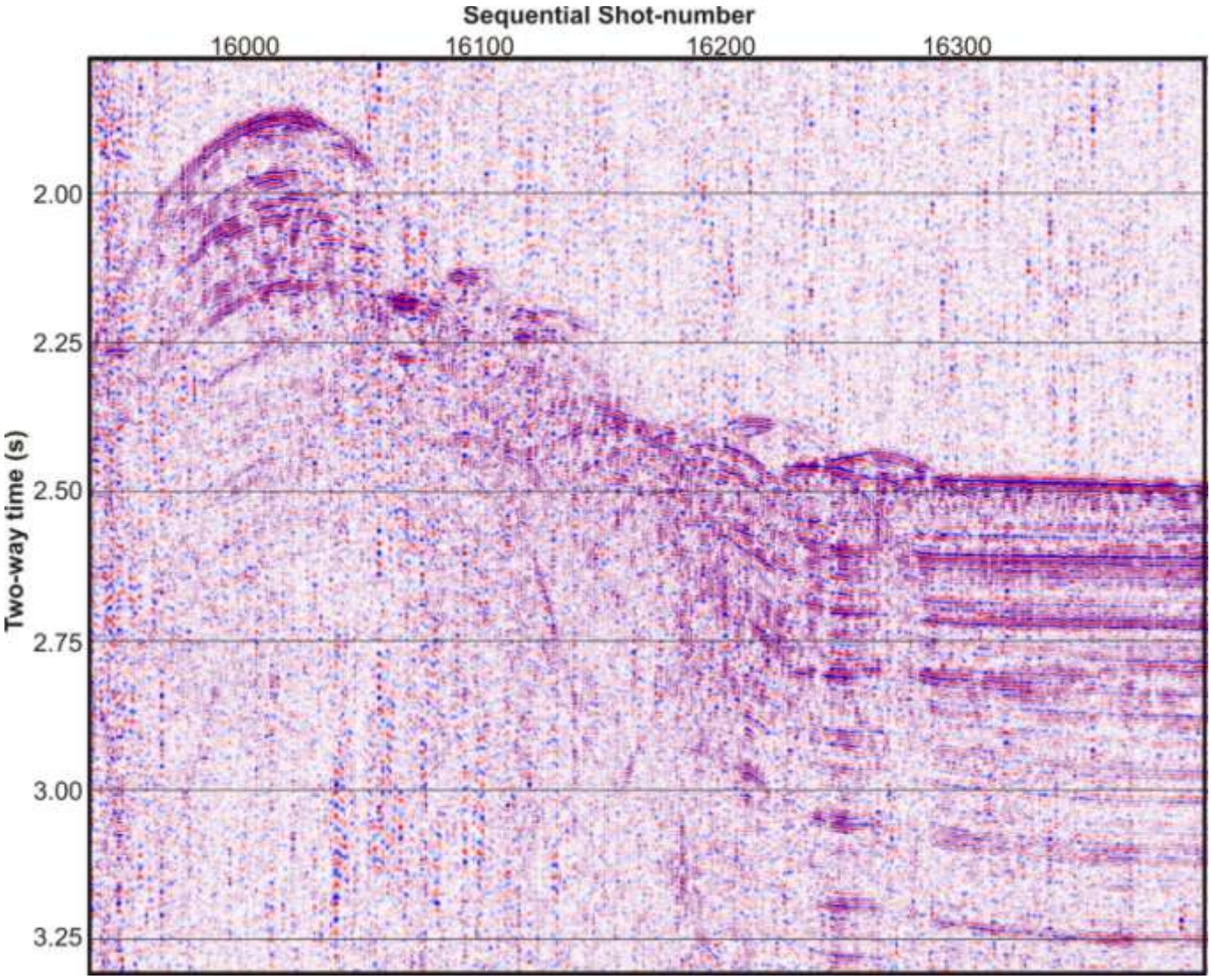

Figure 16. Single-channel reflection line 11, perpendicular to the frontal ridge and through the eastern portion of Slipstream slide.

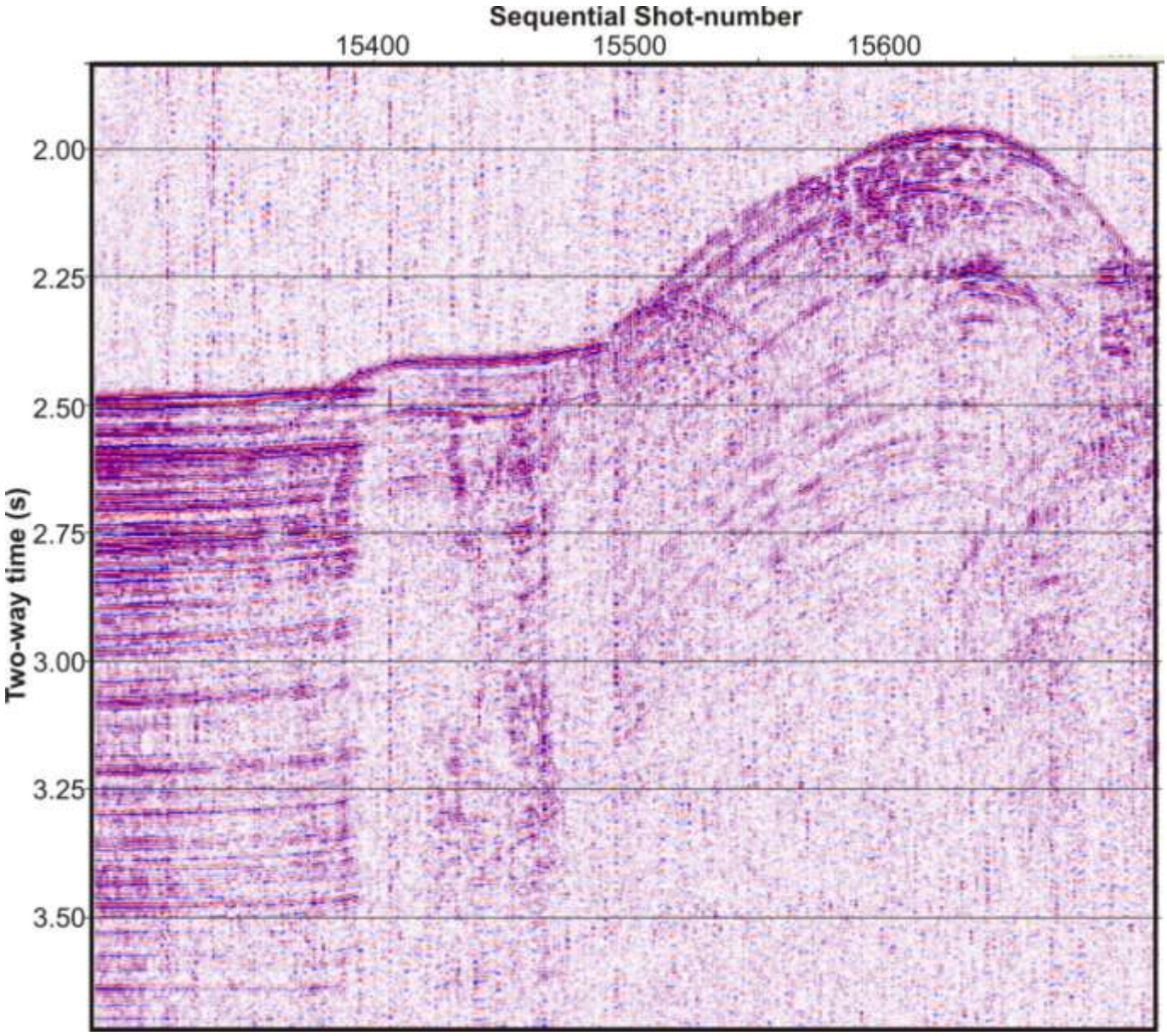

Figure 17. Single-channel reflection line 15, perpendicular to the frontal ridge. Line 15 does not cross through Slipstream slide, but does cross a bathymetric feature near shot number 15580, just seaward of the crest of the frontal ridge, that could indicate an incipient slump. The foot of the frontal ridge is located near shot number 15490, while a new ridge is starting to form at the current deformation front near shot number 15380.

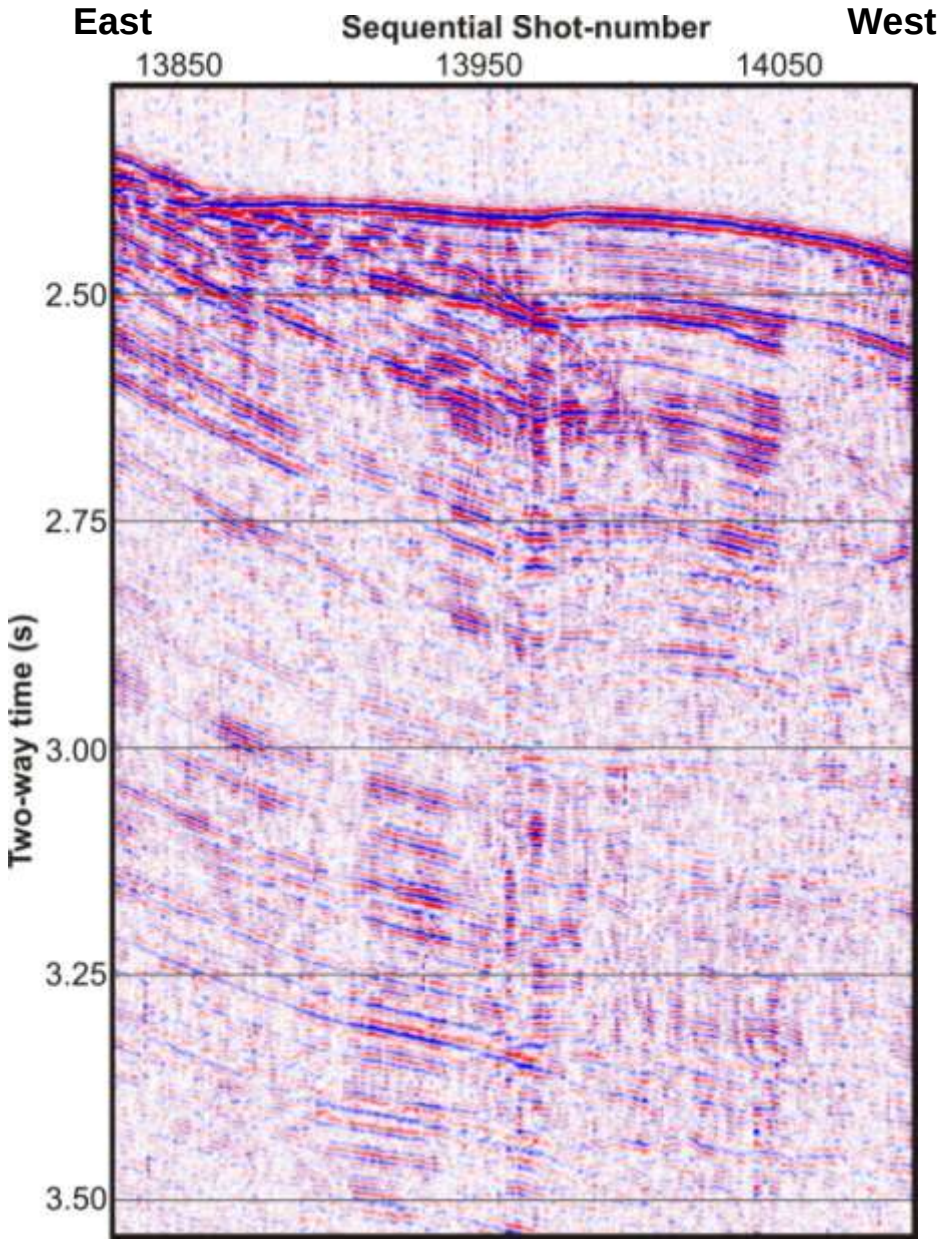

Figure 18. Single-channel reflection line 16, perpendicular to a north-south bathymetric feature in the ocean basin, located near shot number 13965, that represents the surface expression of a fault penetrating through the entire sediment section that is imaged.

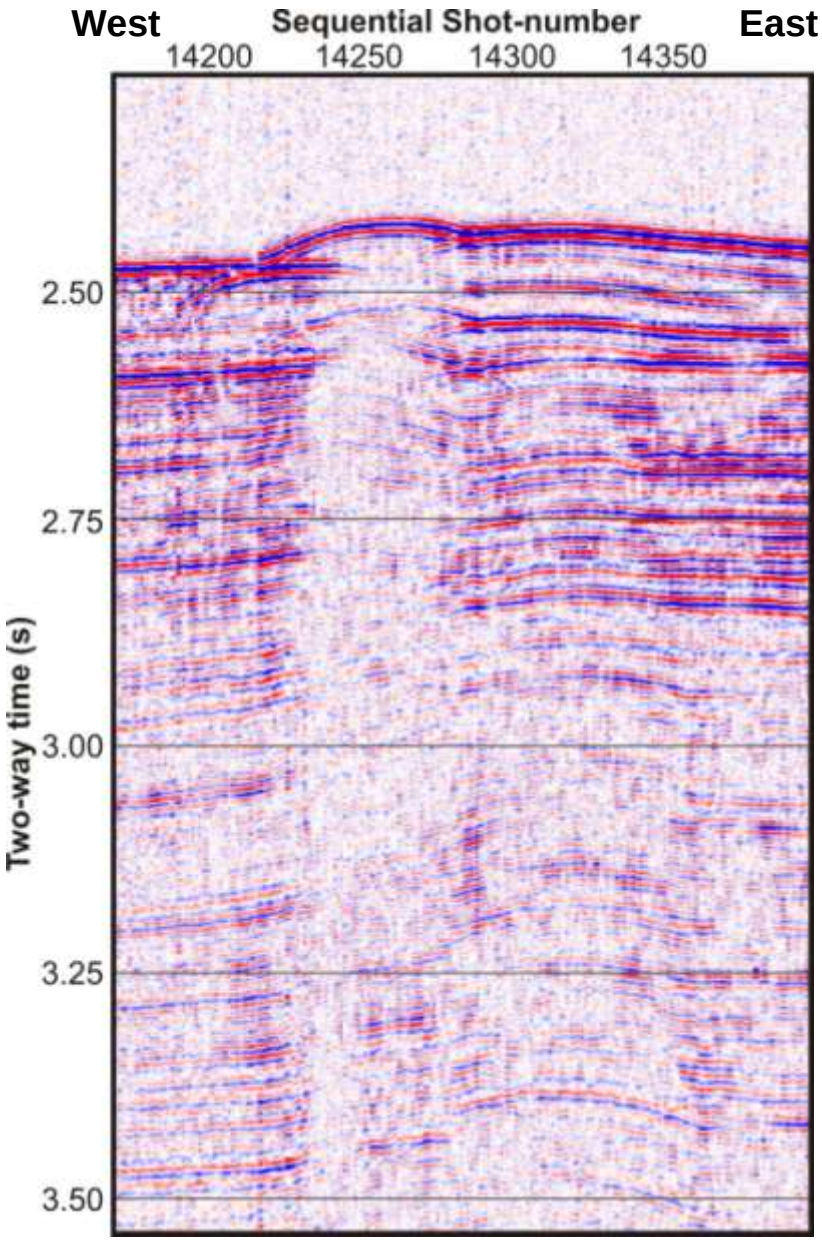

Figure 19. Single-channel reflection line 18 is nearly perpendicular to a north-south fault, located near shot number 14280

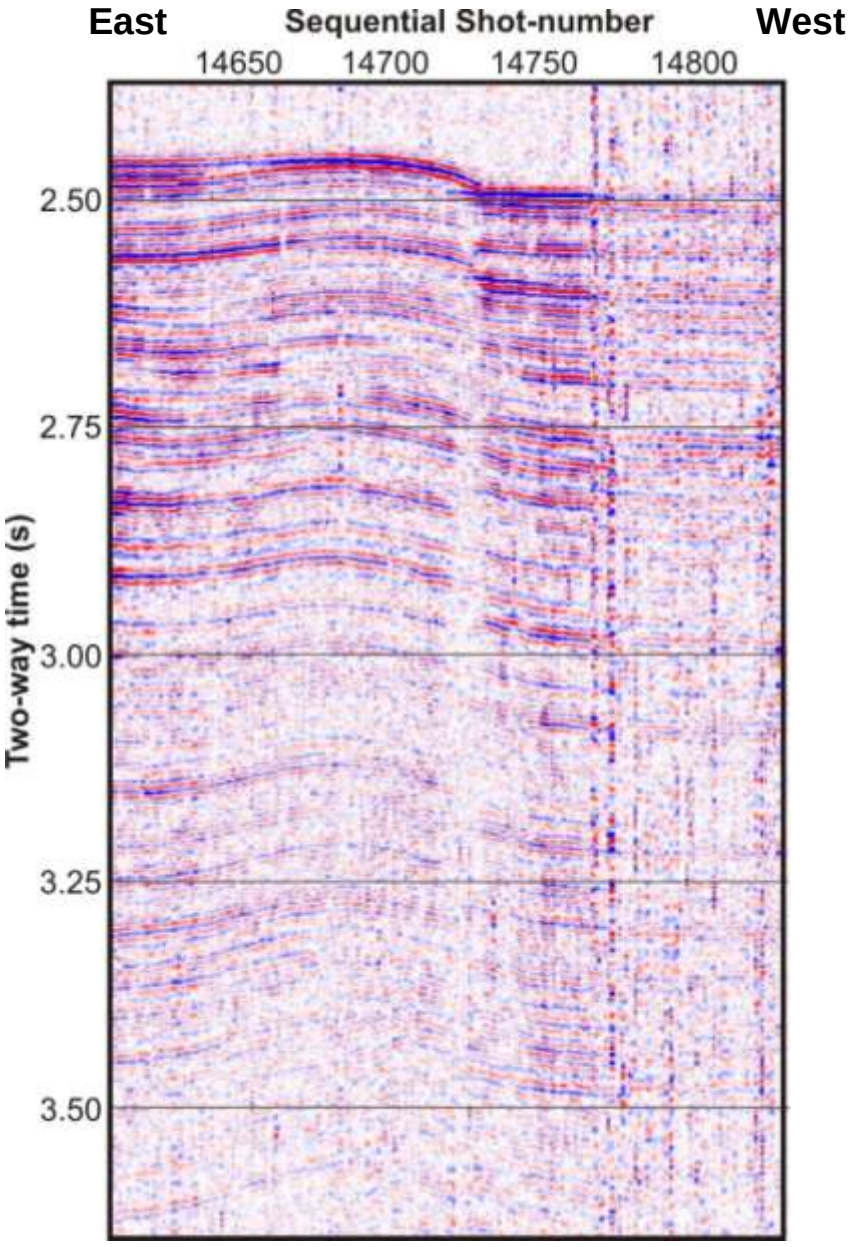

Figure 20. Single-channel reflection line 20 is perpendicular to a north-south bathymetric feature, located near shot number 14730, that represents a currently active, deep-penetrating fault.

TABLE 4: 2010005PGC Seismic and Plume Log - Tully																	
SAMP RATE: 50 μs (Blast) 1 ms (Hydro)				RECORD LENGTH: 250 ms (Blast) 5000 ms (Hydro)					SHOT INTERVAL: 7 s				DEEP WATER DELAY: 0 ms (Blast) 2000 ms (Hydro)				
Navigation									Seismic				Weather			COMMENTS	
Day	UTC	Latitude	Longitude	Line # or	Water Depth		COG	SOG	Tape #	Filename	Filename	Shot #	Shot #	Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(°)	(kn)	DAT	(Blast)	(Hydro)	(Blast)	(Hydro)	(kts)	(m)		
186	00:18	48.407604	-127.041234														30 MINUTES WITHOUT MAMMALS
186	00:50	48.43075	-127.073612	STARTOFAIRGUN													
186	01:06	48.454866	-127.091964	STREAMERDEPLOYED			324	4.9						22.6	3	MS	
186	01:50	48.418371	-127.103366	BP_LSO1_SOL		2527	074	4.5	1			7570		23	3	TZ	
186	02:14	48.430664	-127.059840	MAMMALSIGHTING			060	4.7	1			7708		22	3	MS	STOP FIRING
186	03:29	48.427070	-127.070184	BP_CONTINUE_SHOOTING			060	4.6	1	06_32	31_19	7746	51	26.4	3	MS	BLASTFILENAME 06_32; TELEDYNEFILENAME 31_19
186	03:33	48.429353	-127.063861	12-18_SOUNDERSON			061	4.8	1					25.3	3	MS	
186	03.44	48.435692	-127.044124	MAMMALSIGHTING	18	2566	066	4.8	1			7873	177	23.3	3	MS	STOP FIRING
186	03:49	48.438942	-127.036719	LINE 1 SOUNDER OFF (DELETED EVENT)			022	2.8	1					25.3	3	MS	
186	04:04	48.440669	-127.049311	STREAMER IN			258	2.2	1					27.8	4	MS	
186	05:04	48.432127	-127.071792	BP_LS01_CONTINUESHOOTING			163	5.3	1	03_39	31_19	8354	648	29.9	4		
186	05:23	48.436346	-127.041121	AGS_LS01_SOL			049	2.4	1			8519	648	28.2	4	TZ	TEST IF STREAMER WORKING
186	05:35	48.442631	-127.022529	AGS_BP_LS01_30MINCHECK			064	4.9	1	03_39	30_52	8620	691	28.7	4	TZ	
186	06:06	48.460810	-126.965191	AGS_BP_LS01_EOL	18	2540.1	067.7	4.9	1	06_16	30_52	8884	955	24.5	3	TZ	
186	06:38	48.450387	-126.984986	AGS_BP_LS02_SOL	18	2551.6	023	5.9	2	38_49	38_46	9164	1235	28	4	TZ	STARTED AT S36, NOT S3
186	07:08	48.495429	-126.955299	AGS_BP_LS02_30MINCHECK	18	2404.9	036	5.0	2	38_49	38_46	9421	1491	24.1	3	TZ	STARTED AT S36, NOT S3
186	07:29	48.509459	-126.934279	AGS_BP_LS02_EOL	18	2943.8	038	4.7	2	38_49	38_46	9600	1670	26.4	3	TZ	STARTED AT S36, NOT S3
186	07:33	48.513437	-126.932240	AGS_BP_LS02T	12	2567.4	254	2.2	2	29_27	29_29	9633	1703	26.8	3	TZ	TURNING TO S4 TO START LINE 3
186	08:01	48.492920	-126.953861	AGS_BP_LS03_SOL	12	2863.9	035.7	3.8	2	01_41	01_38	9876	1946	33.5	5.5	TZ	
186	08:31	48.520895	-126.911575	AGS_BP_LS03_30MINCHECK	12	2892.4	055	4.6	2	01_41	01_38	10132	2202	27.1	3	TZ	
186	08:43	48.534106	-126.892066	AGS_BP_LS03_EOL	18	2341.8	045	5.6	2	01_41	01_38	10240	2311	28.2	4	TZ	
186	08:44	48.535030	-126.890870	AGS_BP_LS03T	12	2929.0	037	5.4	2	44_11	44_05	10247	2318	32.2	4	TZ	TURNING
186	09:14	48.543630	-126.941308	AGS_BP_LS03T_30MINCHECK	18	2520.4	282	4.9	2	44_11	44_05	10504	2574	30	4	TZ	
186	09:44	48.551508	-127.008070	AGS_BP_LS03T-60MINCHECK	12	2798.1	287.7	4.7	3	44_11	44_05	10763	2833	27.3	3	TZ	
186	10:14	48.555975	-127.067684	AGS_BP_LS03T-90MINCHECK	18	2648.1	273	5.2	3	44_11	44_05	11015	3085	28.2	3	TZ	
186	10:27	48.553247	-127.089846	AGS_BP_LS04_SOL	18	2535.1	117	4.6	3	27_30	27_23	11128	3199	29.4	4	TZ	
186	10:57	48.531902	-127.036067	AGS_BP_LS04_30MINCHECK	18	2570	115	5.1	3	27_30	27_23	11385	3455	26.4	3	TZ	
186	11:27	48.512040	-126.979037	AGS_BP_LS04_60MINCHECK	18	2116.6	120	5.2	3	27_30	27_23	11642	3712	28.3	4	TZ	
186	11:57	48.491763	-126.926104	AGS_BP_LS04_90MINCHECK	18	2182.8	119	4.7	3	27_30	27_23	11900	3970	23.3	3	TZ	
186	12:27	48.472849	-126.873228	AGS_BP_LS04_120MINCHECK	18	2439.8	114	5.2	3	27_30	27_23	12158	4228	31.1	4	TZ	
186	12:55	48.454517	-126.821135	AGS_BP_LS04_EOL	18	2371.5	223	4.8	4	56_01	55_47	12408	4474	29.1	4	NS	
186	12:59	48.450549	-126.814749	MARINE_MAMMALS												NS	SEAL IN WATER
186	13:53	48.461236	-126.846815	MARINE_MAMMALS_1												NS	MORE MAMMALS
186	18:02	48.67412	-126.840767	SEAFLOOR PLUMES_1	18	1270								27.7	3 to 4	YSR	SEAFLOOR PLUMES
186				ECHO SOUNDER STOPPED WORKING												YSR	~ AFTER 30MINS
186	22:38	48.67542	-126.83759	ECHO SOUNDER STARTED WOR	18	1281.6								18.5	2	YSR	
186	22:42	48.676218	-126.838563	WP_10	18	1263.4								20.2	2	YSR	
186	22:44	48.675555	-126.839897	PLUME_2	18	1247								18.3	2	YSR	GROUP OF PLUMES
186	22:51	48.673287	-126.843768	PLUME_2_WEST_EDGE	18	1252								20.4	2	YSR	
186	22:58	48.670348	-126.848348	PLUME_3	18	1253								21.9	2	YSR	
186	23:06	48.672911	-126.843508	PLUME_4_WEST	18	1254								22	2	NS	SAME AS PLUME_2?
186	23:15	48.676297	-126.839026	PLUME_5_EAST	18	1280								23	3	NS	
188	07:26	48.673805	-126.841012	PLUME-7	18	1253								17.8	2	TZ	
188	07:51	48.667266	-126.848407	PLUME-8	18	1265								15.5@0	1	TZ	

SAMP RATE: 50 μs (Blast) 1 ms (Hydro)				RECORD LENGTH: 250 ms (Blast) 5000 ms (Hydro)					SHOT INTERVAL: 7 s	DEEP WATER DELAY: 0 ms (Blast) 2000 ms (Hydro)							
Navigation										Seismic				Weather			COMMENTS
Day	UTC	Latitude	Longitude	Line # or	Water Depth		COG	SOG	Tape #	Filename	Filename	Shot #	Shot #	Wind	Waves	Init	
	Time			Station #	(kHz)	(m)	(°)	(kn)	DAT	(Blast)	(Hydro)	(Blast)	(Hydro)	(kts)	(m)		
188	15:04	48.488125	-127.103266	ECHO SOUNDERS OFF_188												NS	
188	15:59			TAPE 4 STARTS												NS	
188	16:14			ON LINE 1a (LS01a)												NS	
188	16:55	48.461016	-126.975317	AGS_BP_LS01a_atOBS35b			028	4.7	4	04_54	31_05	19055	11148	10	1	NS	
188	17:14	48.48340	-126.956246	DELAY CHANGED TO 2s					4							YSR	
188	17:27	48.497834	-126.942472	AGS_BP_LS01a_atOBS31			37	5.0	4	04_54	31_05	19334	11429	10.3	1	YSR	
188	17:30	48.501175	-126.938568	GUN STOPPED			36	3.2	4	04_54	31_05	19348	11442	10.1	1	YSR	SAR
189	02:16	48.488329	-126.942385	BP_AIRGUNSINWATER					4							TZ	
189	02:38	48.495825	-126.954410	AGS_BP_GUNSON					4							TZ	
189	02:40	48.495328	-126.9522291	AGS_BP_GUNSOFF					4							TZ	
189	02:41	48.495191	-126.949425	AGS_BP_LS01A_SOL					4	04_54	31_05					TZ	DELAY TO EPC CHANGED TO 2 SECONDS AT 3:08 utc
189	03:11	48.522199	-126.909359	AGS_BP_LS01A_30MINCHECK			043	4.8	4	04_54	31_05	19611	11702	15.1@340	1	TZ	
189	03:17	48.528574	-126.900771	AGS_BP_LS01A_MAMMALSIGHTED_EOL			043	4.8	4	04_54	31_05	19664	11755	14.9@340	1	TZ	ALMOST AT END OF LINE, GOING TO LINE 5A (S7)
189	04:17	48.542281	-126.979855	AGS_BP_LS01AT			228	5.7	4	17_02	16_54	19664	11755	15@340	1	TZ	DELAY CHANGE TO 1 SECOND ON RECORDER AND TELEDYNE AT 4:27 (DELAY CHANGE TO 2 SECONDS AT 4:41)
189	04:47	48.544645	-127.035427	AGS_BP_LS01AT_30MINCHECK			294	4.8	4	17_02	18_41	19917	12008	13.7@333	1	TZ	
189	04:50	48.546027	-127.041314	CATHODIC PROTECTION REMOVED					4							TZ	NEW TAPE PUT IN AT 04:55, STARTING LINE NOT AT S7, BUT FURTHER INTO THE LINE AT 4:58)
189	05:07	48.545560	-127.072869	AGS_BP_LS04A_SOL			117	5.0	5	17_02	07_31	20092	12184	14@331	1	TZ	
189	05:37	48.526739	-127.021240	AGS_BP_LS04A_30MINCHECK			118	4.8	5	17_02	07_31	20346	12437	12@328	1	TZ	
189	06:04	48.509334	-126.972212	18 KhZ SOUNDER ON	18	2103.3								11.1@329	1	TZ	
189	06:07	48.507756	-126.967719	AGS_BP_LS04A_60MINCHECK	18	2102.4	117	5.0	5	17_02	07_31	20605	12696	10.3@330	1	TZ	MISSED TRIGGER TIME 06:07?
189	06:37	48.488285	-126.914124	AGS_BP_LS04A_90MINCHECK	18	2219	119	5.0	5	17_02	07_31	20862	12954	13@325	1	TZ	
189	07:07	48.467552	-126.859109	AGS_BP_LS04A_120MINCHECK	18	2474.3	117	5.1	5	17_02	07_31	21121	13211	13.2@325	1	TZ	
189	07:24	48.456384	-126.826261	AGS_BP_LS04A_EOL	18	2403.4	117	5.0	5	17_02	07_31	21271	13360	11.3@311	1	TZ	
189	07:28	48.453239	-126.820593	AGS_BP_LS04AT	18	2398	164	4.7	5	27_09	24_51	21304	13394	11.8@314	1	TZ	
189	07:58	48.459994	-126.868715	AGS_BP_LS04AT_30MINCHECK	18	2488.9	293	5.2	6	27_09	24_51	21558	13641	12@311	1	TZ	
189	08:18	48.468301	-126.910288	AGS_BP_LS16_SOL	18	2455.6	269	4.8	6	19_13	19_05	21737	13828	13@315	1	TZ	
189	08:36	48.468341	-126.945825	EPC-CHANGED					6							TZ	EPC PRINT WAS NOT ADVANCING, SWAPPED OUT FOR OTHER PRINTER
189	08:48	48.468590	-126.967470	AGS_BP_LS16_30MINCHECK	18	2528.0	267	4.7	6	19_13	19_05	21987	14079	13@316	1	TZ	
189	08:49	48.468481	-126.971073	AGS_BP_LS16_EOL	18	2517.4	267	5.4	6	19_13	19_05	22003	14094	13@312	1	TZ	
189	08:50	48.467429	-126.973241	AGS_BP_LS16T	18	2517.4	267	5.4	6	50_09	50_05	22011	14103	13@312	1	tz	
189	08:58	48.463150	-126.971896	AGS_BP_LS18_SOL	18	2540	100	5.4	6	58_34	58_36	22077	14168	11.4@310	1	TZ	
189	09:25	48.456776	-126.917674	AGS_BP_LS18_EOL	18	2524.3	101	4.7	6	58_34	58_36	22310	14401	11.3@312	1	TZ	
189	09:26	48.456453	-126.915125	AGS_BP_LS18T	18	2525.0	100	4.7	6	25_44	25_40	22321	14412	11.4@313	1	TZ	
189	09:49	48.442852	-126.916614	AGS_BP_LS20_SOL	18	2532	272	4.8	6	49_45	49_40	22517	14607	13.3@320	1	TZ	
189	10:15	48.443137	-126.969402	AGS_BP_LS20_EOL	18	2555.3	272	4.9	6	49_45	49_40	22741	14833	16@310	1	TZ	
189	10:18	48.443243	-126.974200	AGS_BP_LS20T	18	2555.4	253	5.1	6	16_00	15_53	22762	14853	16@314	1	TZ	

SAMP RATE: 50 μs (Blast) 1 ms (Hydro)				**RECORD LENGTH:** 250 ms (Blast) 5000 ms (Hydro)					**SHOT INTERVAL:** 7 s		**DEEP WATER DELAY:** 0 ms (Blast) 2000 ms (Hydro)					
Navigation									**Seismic**				**Weather**			**COMMENTS**
Day	UTC	Latitude	Longitude	Line # or	Water Depth		*COG*	*SOG*	Tape #	Filename	Filename	Shot #	Shot #	**Wind**	**Waves**	**Init**	
	Time			Station #	(kHz)	(m)	(°)	(kn)	DAT	(Blast)	(Hydro)	(Blast)	(Hydro)	**(kts)**	**(m)**		
189	10:48	48.429617	-126.975336	AGS_BP_LS20T_30MINCHECK	18	2559.7	022	3.5	6	16_00	15_53	23018	15110	13@310	1	TZ	
189	11:09	48.448392	-126.966566	AGS_BP_LS15_SOL	18	2550.8	024	3.5	7	09_19	09_16	23200	15291	12@310	1	TZ	
189	11:40	48.484167	-126.936641	AGS_BP_LS15_30MINCHECK	18	2230	033	4.7	7	09_19	09_16	23473	15564	12@320	1	TZ	
189	11:57	48.503692	-126.920064	AGS_BP_LS15_EOL	18	2360.1	025	4.5	7	09_19	09_16	23617	15709	9.8@313	1	TZ	
189	11:58	48.504418	-126.919505	AGS_BP_LS15T	18	2362.2	019	4.7	7	57_47	57_44	23623	15714	10@317	1	TZ	AT 12:18 TURNED OFF 18 KhZ SOUNDER
189	12:24	48.516285	-126.949662	AGS_BP_LS11_SOL			237	5.5	7	24_14	24_10	23844	15935	12@325	1	TZ	
189	12:54	48.480434	-126.980492	AGS_BP_LS11_30MINCHECK			214	4.7	7	24_14	24_10	24263	16354	10	1	NS	
189	13:20	48.45042	-126.999042	AGS_BP_LS11_EOL			210	4.9	7	24_14	24_10	24317	16405	12.5	1	NS	
189	13:32	48.469581	-127.015893	AGS_BP_LS9_SOL			035	5.2	7	18_55	19_22	24436	16527	13	1	NS	
189	14:02	48.502444	-126.996895	AGS_BP_LS9_30MINCHECK			029	4.7	8	18_55	19_22	24686	16772	10	1	NS	
189	14:16	48.578745	-126.973075	TURNGUNOFF_MAMMALS			028	4.5	8	18_55	19_22	24812	16902	10@350	1	NS	
189	16:04			MAMMALS				are those last file-sames switched?								NS	

5. Water-column plumes recorded on ship's echosounders *George Spence*

In cruises on the Tully in 2006 and 2008, water-column plumes had been observed on the ship's 12 kHz or 18 kHz echosounders. The plumes extended from the seafloor to water depths near 500 m. Since 500 m is the minimum depth of stability for methane hydrate, it is thought that the plumes represent methane bubbles that are coated with a thin layer of hydrate, which prevents the bubbles from disappearing quickly by dissolving into the low-methane-concentration seawater.

The objective was to map the plumes near Bullseye vent more methodically. In previous cruises the ship's tracks and ship's speed were irregular, so improved accuracy in plume location and in plume identification could be obtained by recording the echosounders on two perpendicular grids of uniformly spaced lines. Line spacing was selected as 75 m, less than half of the seafloor footprint size of the multi-frequency sonar in water depths near 1200 m.

Unfortunately, only a few lines could be obtained, due to time limitations, high wind conditions, equipment problems and initial difficulties in setting up the echosounder recording. The 12 kHz echosounder was not useable except in ideal wind conditions. The problem was traced to the transponder ram not being fully extended; it was initially thought that the plate covering the ram had not been removed, and although the engineers subsequently discovered from their records that the plate was removed, it was too late.

Water-column plumes were recorded in three locations (**Figure 21**) : a) on the southeast side of Barkley Canyon (Plume 1), b) near the location of the seafloor sector-scanning sonar deployed by NEPTUNE in May 2010 about 500 m northeast of the Site 889 (Bullseye vent) junction box (plumes 2 and 4, likely the same plume) and near the Site 889 junction box.

Only the locations of the plume centres are shown in **Figure 21**. Unfortunately, no echosounder records of the plumes were saved digitally. A more systematic plume study is part of the plans for the OBS recovery cruise, in late September 2010.

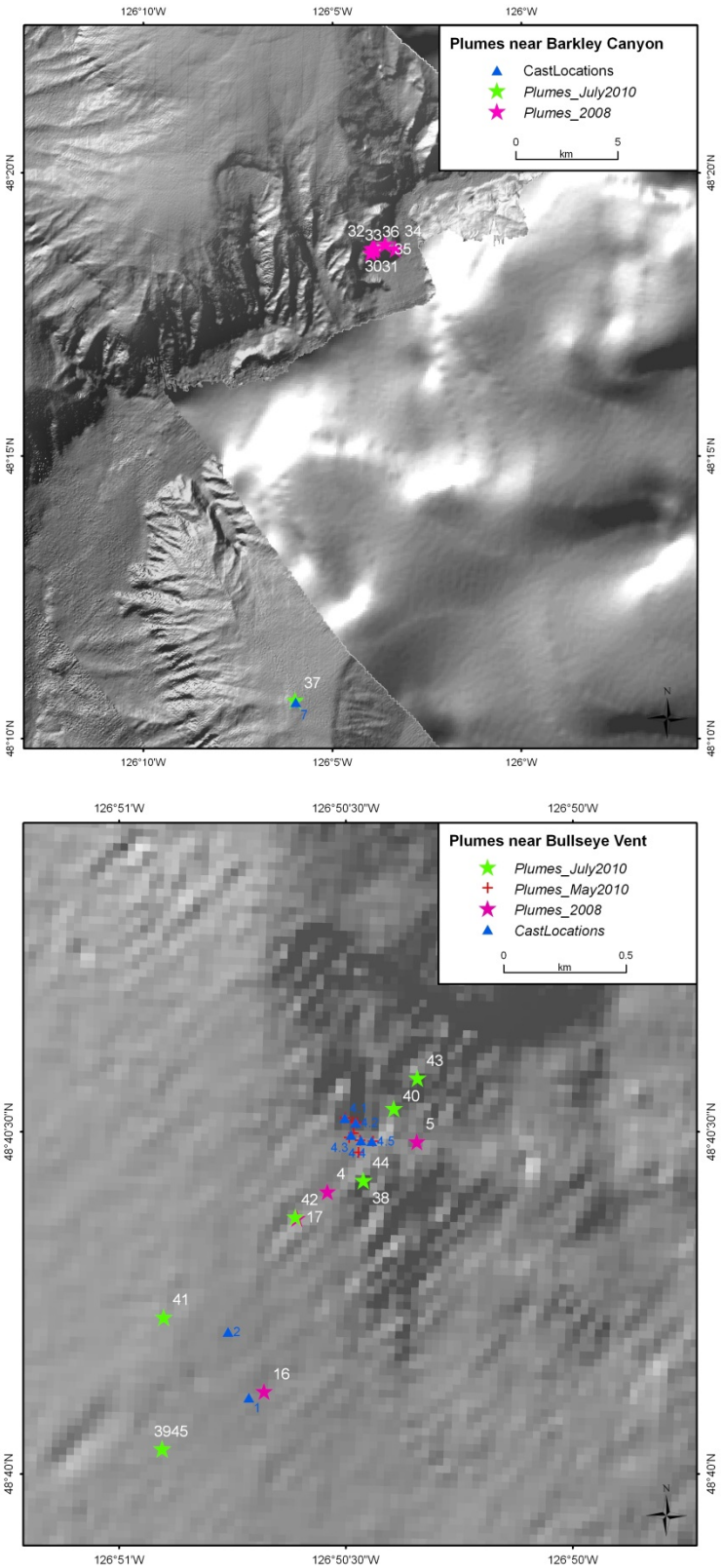

Figure 21. Location of water-column plumes imaged during cruise, a) Barkley Canyon and b) Bullseye vent.

Table 5. CCGS Tully Crew.

Position	Name
Commanding Officer	**Simon Schwarz**
Chief Officer	**Corrie Cole**
Second Officer	**Rhona Lettau**
Third Officer	**Bill McIndoe**
Bosun	**Glen McKechnie**
Seaman #1	**Kirk Smith**
Seaman #2	**Sarah Ball**
Seaman #3	**Gord Boettcher**
Seaman #4	**Jim Hartnell**
Seaman #5	**Nicole Zeirier**
Seaman #6	**Brad Smeaton**
Chief Engineer	**Khan Tran**
Senior Engineer	**Eric Zwarich**
Second Engineer	**Dave Wilhelmson**
Oiler #1	**Dennis Boivin**
Oiler #2	**Dave Walsh**
Chief Cook	**Alex Wright**
2nd Cook	**Phil May**
Steward A	**Vince Gabas**
Steward B	**Ryan Harrison**
Steward C	**Cam Dean**
Supernumerary 1	**Mitchel Wiebenga**
Supernumerary 2	**Erica Murton**
Supernumerary 3	**Conrad Swetlikoff**
Supernumerary 4	**Mark Michaluk**

TABLE 6. Science Personnel : Cabin Assignments and Duties

Cabin	Name	Shift	Duties
A (Chief Sci)	Rhonda Reidy		Marine Mammal Observer
B	Jacklyn Barrs		Marine Mammal Observer
	Kyla Graham		Marine Mammal Observer
C	Martin Scherwath	6 pm – 6 am	Lab
	Subbarao Yelisetti	6 am – 6 pm	Watchkeeper
D	Nastasja Scholz	6 am – 6 pm	Watchkeeper
	Tess Zyla	6 pm – 6 am	Watchkeeper
E	Shuichi Kodaira	12 noon – 12 mid	OBS management
	Koichiro Obana	12 mid – 12 noon	OBS management
F	Ikumasa Terada	12 noon – 12 mid	OBS technician
	Takuya Maekawa	12 mid – 12 noon	OBS technician
G	Michael Riedel	6 pm – 6 am	Co-Chief / Lab / Compressor
	George Spence	6am – 11 pm	Co-Chief / Lab
H	Greg Middleton	6 am – 6 pm	Mechanical
	Peter Neelands	6 pm – 6 am	Lab / navigation / computers

Meal times

Breakfast	7 am – 7:30 am
	7:30 am – 8 am
Lunch	11:30 am – 12 noon
	12 noon – 12:30 pm
Dinner	5 pm – 5:30 pm
	5:30 pm – 6 pm

If on watch, coordinate your mealtimes with other watchkeepers to ensure that instruments in the lab are never left unattended.