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Report on Cruise 2010007PGC

C.C.G. Vessel John P. Tully 30 June–10 July 2010

SeaJade-I Seafloor Earthquake Array - Japan Canada Cascadia Experiment
Ocean bottom seismometer recovery, methane gas-plume acoustic imaging, and CTD-water sampling program

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

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1. Summary

1.1 Objectives

This expedition 2010007 is the second cruise of a major international collaboration of NRCan ("Public Safety Geoscience" (PSG) Program) with Japan (JAMSTEC) and the Woods Hole Oceanographic Institution (WHOI). The main objective of this collaboration is to acquire passive seismic data using Ocean Bottom Seismometers (OBS) for earthquake studies. The OBS monitoring will 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.

In total, 33 OBSs were deployed during the cruise 2010005-PGC (SeaJade-I) from June 30 to July 10, 2010. The objective of cruise 2010007 was to collect back these OBS.

Secondary objectives of the expedition included acoustic imaging of known methane vent sites (plumes). This imaging was combined with conducting casts using a Conductivity-Temperature-Depth (CTD) measurement-unit attached to a 24-Niskin-bottle rosette for water-sampling. The water-sampling was conducted to measure the concentration of dissolved methane in the water. The analyses of the water samples are carried out in collaboration with Prof. Dr. Michael Whiticar from the School of Earth and Ocean Sciences, University of Victoria.

1.2 Accomplishments and Results

Despite extreme weather conditions due to a storm at the beginning of the cruise forcing a major shutdown of all operations for 60 hours (2.5 days) from Friday evening, September 24th to Monday morning, September 27th the OBS were all, except one, recovered. OBS Station 11 did not respond to the acoustic release commands, and the station was abandoned after 4 hours of trials to recover the system.

All 32 OBS were physically (from the outside) in good shape, all transponders and light-strobes worked making the identification of floating instrument and recovery relatively simple, despite, in part, heavy seas. All OBS were brought back to the Pacific Geoscience Centre (PGC), where the glass spheres were opened and all data recovered. Copies of the data set were distributed to the different scientific parties involved.

Due to the weather interruption, only 3.5 days remained in the program to complete the acoustic imaging and water-sampling program. In total, 84 lines were acquired over seven (7) plume locations (2 grids at Bullseye Vent, 2 grids at Spinnaker Vent, 2 grids at Amnesiac Vent, and 2 cross-lines at Barkley Canyon). Out of these lines seven (7) locations for CTD casts and water-sampling were chosen. Onboard analyses of some samples showed overall very small amounts of dissolved methane (not exceeding 20 n-moles/l). However, sufficient volumes of gas were collected allowing for post-cruise analyses including isotope measurements at all seven vent locations.

2. Narrative

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

Wednesday, September 22nd

10:00 Loading begins

16:30 Leave PGC dock
Heading into Saanich Inlet (48°39.028'N, 123° 30.3054'W) for a first test of water-sampling rosette and CTD and METS sensor with Scott Rose (DFO) and Michael Whiticar (UVic) onboard for training.

17:50 On station for test of CTD and rosette; STN SI-1; 190 m water depth

18:00 CTD at bottom, 10 m above seafloor, start firing bottles on up-cast

18:15 Unit back on deck; METS sensor response potentially delayed; will need re-interpretation and more testing for response time of sensor for future deployments;

19:20 Zodiac away with Scott Rose and Michael Whiticar

19:35 Zodiac back on deck

19:40 Under way to first station in Barkley Canyon area to image plume location previously identified in July 2010 expedition

Thursday, September 23rd

Transit through the night, start to hit rough weather at exist of Juan de Fuca Straight; 3 m wave height and above 25 kts of wind

12:00 Arrival on station to start first acoustic lines to re-image plume

13:00 Schedule safety training, life-boat, and fire-drill

14:00 Drill completed
Start of imaging acoustic line BC_02 (N-S crossing)
Plume location verified, very close to previous location seen in July, 2010

15:30 Decision was made to go for OBS location 16 instead of a CTD cast to allow for 2 OBS recoveries during day-light to give crew a better feel for the operation
Operations for all OBS recovery are summarized in Table 1

OBS recovery continued through the night. Peter Neelands took night shift to assist in the recovery operation.

22:00 Fire-alarm (not a drill)
All Scientific personnel on Muster-Station (Starboard breeze-way)
The smoke alarm was triggered by a fire extinguisher, that got knocked loose and opened in heavy seas; Fire alarm was de-activated 15 minutes after start.

Friday, September 24th

Continued OBS recovery through day time; sea-state and wind are increasing (gale force with over 40 kts speed);

19:00 After recovery of OBS STN 6 we stop operation for the night; weather too rough and dangerous for personnel to operate on deck; Captin decided to steam towards more northern-located OBS STN 25 through the night at a course that will be better for a stable ship and re-evaluate weather condition in the morning.

Saturday, September 25th

07:00 At OBS STN 25; seas and wind have increased, we are near 7 m wave height and steady winds over 45 kts; heavy rain with low visibility
Decision to abandon recovery and hide at shore until storm system has moved;
08:00 Start course to go into Kyuquot Inlet
13:00 Arriving at shore
Discovery of lost Kayak-team and giving assistance and guidance for team to return to Fair Harbor
15:00 Setting Anchor in Kyuquot Inlet.

Sunday, September 26th

Weather has increased offshore with maximum wave heights at 9m;
decision was made to not leave inlet until Monday morning

13:00 Test of CTD and rosette for fine-tuning of operation and sub-sampling protocol

Monday, September 27th

05:00 Leave Inlet to go to OBS STN 25
12:00 on STN OBS 25
Waves are still around 3-4 meter, winds around 20-25 kts;
operation is safe to continue

OBS recovery sequence continued

Tuesday, September 28th

08:00 Weather much more calm, winds down to below 10 kts; waves 2-3 meter
09:30 OBS STN 8 recovered, 10 more to go
22:00 OBS STN 11; no acoustic return signal from OBS;
Continued sending command and awaiting return-signal but no reply from OBS
This sequence continued for 2.5 hours until 01:00am when STN was declared officially lost

Wednesday, September 29th

01:00 OBS STN 11 declared lost;
continue recovery of remaining OBS
06:30 LAST OBS STN 33b recovered
Switch to Plume imaging and water sampling

Acquisition of 10 lines over potential plume locations
Area BV1
(see **Table 2**, **Figure 2**, and **Figure 3a** for all line locations at this location)

11:15 Completion of 10 acoustic lines
The addition of an extra 0.5 nautical miles ahead and after each line made the time for acquisition of the lines almost three times longer. The additional length was a requirement added by the Captain to help ensuring that the boat is along the course and on the intended line; However, the ship was still not very well positioned over the

intended line locations and drifted as much as 60 m away; the lines were initially planned to be just 20 m apart.

Define location for the first real CTD Cast (BV1-1) based on acoustic images using the highest point of acoustic return as guide for proximity to vent location:
Location: 48.668525°N 126.845227°W

13:15 Start CTD Cast-1 (BV1-1)
14:45 Completion of CTD Cast 1
Start water sub-sampling
While sampling is under way, we added 4 extra lines North of the grid of acoustic lines of Area BV1

While CTD was taken, ship is drifting considerably of almost 100 m (**Figure 4a**)
The crew is not using the thrusters to help aid in position keeping!
While drifting, we loose acoustic echo-strength of plume
METS signal shows an abrupt anomaly at 1150 m below sea surface but after this sudden increase the signal is steadily returning to "zero", indicating that we might have over-saturated the membrane.
We did not fire a bottle at this depth, hoping to get similar signal on up-cast.
This turned out to be a wrong decision - we are still learning how to use this METS sensor ...

16:45 Start re-setting of rosette

Picking of location for 2nd CTD cast of the day BV1-2
Location: 48.670126°N 126.845986°W

18:00 Start of CTD Cast 2 (BV1-2)
19:20 CTD back on deck
20:00 Start of lines of acoustic lines in Area BV2
over night acquisition of acoustic lines over are BV2 and Spinnaker Vent area SV1 and SV2 (see **Table 2** for times of completion and **Figure 3** for locations of lines)
21:30 Completed water sampling

<u>Thursday, September 30th</u>

01:50 Start of imaging lines in area SV1
Imaging of area SV1 (southern grid, where cores were taken in 2008 and AUV data were acquired and ROV dives complete din 2009) showed no plumes ...
06:00 Start of lines in area SV2
Picking of location for 3rd CTD cast SV2-1
08:20 Adding a cross-line to verify plume location
Cast-location defined:
Location: 48.723681°N 126.918400°W

Thursday, September 30th

08:50 Start of Cast-3 (SV2-1)
Ship is drifting significantly;
Again: crew is not using the thrusters to aid in position-keeping

10:20 CTD cast complete, rosette on deck
While water sampling is underway, we added a few lines of acoustic imaging in the Spinnaker SV2 area

11:30 Start transect at 6 kts south to re-position to Bubbly-Gulch;
The line location is going over other known vents (from AUV bottom morphology) but no plumes detected

13:45 At position in bubbly Gulch to do Cast-4 (BG-1);
Here, we have previous knowledge of vents from ROPOS
5 positions, spread over 100 m were picked for special sampling
At each Site we take 4 water-samples at 10,20, 30 and 40 meter above seafloor
the remaining bottles are taken at Station 5 in the shallower water column
Station keeping here is much improved to before!

Locations

STN1	48.675330	126.841700	(North)
STN2	48.675220	126.841300	(Middle)
STN3	48.674894	126.841283	
STN4	48.674790	126.841100	(SE2)
STN5	48.674770	126.840700	(SE1)

15:50 Completed all stations
BBQ for dinner!

19:10 Start acoustic lines at Amnesiac vent area AV1
20:30 finished water-sampling

Friday, October 1st

Over night finished all lines at both area AV1 and AV2
Plume at AV1 are clear, but much subdued at AV2
Plume at AV1 is clearly associated with a small topographic high (pinnacle on seafloor) also seen on the multibeam EM300 map
AV1 plume appears slanted, but highest point is 450 m below sea surface
Picking location for Cast 5 (AV1-1)
5 sub-stations picked across the slanted plume
Locations

AM1	48.660370	126.917019
AM2	48.659890	126.916559
AM3	48.659447	126.916131
AM4	48.658968	126.915679
AM 5	48.658525	126.915255

07:40 Start Cast-5 (AV1-1)
08:50 CTD back on deck

Selection of 2^{nd} plume location at AV2 area is difficult
S.T. created locations from the acoustic records that well match observations from the 2008 expedition;

09:55 Start X-line across plume locations
We see a plume and decide on location
Upon turn and re-positioning the plume disappeared and only some near-bottom bubble-trains can be seen

We decide to do a cast no matter what ...

11:50 Cast-6 (AV2-1)

Location
48.665603 126.901830

12:55 CTD unit back on deck

13:00 Steam towards Barkley Canyon (4 hours)

18:00 Upon arrival on station the plume seen previously has disappeared!
We see some side-echoes though
Start drifting a little to various locations and start picking up stronger signal especially in the south
Started a mini-drift south and with the cooperation of the bridge we found "optimal" location for the cast where plume is strongest.
Re-positioning of vessel only takes a few minutes
18:30 Ready for Cast-7 (BC-1)

Location
48.177396 126.099285

19:30 Unit back on deck!

Steaming home!

21:30 Water sampling for Cast-7 (BC-1) completed

<u>Saturday, October 2nd</u>

13:30 Alongside dock at IOS/PGC

3. OBS recovery procedures

The locations of the 33 OBS stations are summarized in **Table 1**.
Example images of the recovery sequence are shown in **Figure 4**.

An OBS is equipped with an acoustic transponder system which controls the release mechanism and also is used for measuring the range between an OBS and the ship. An OBS is released from its anchor by electric corrosion of stainless plates when a release command is sent from the vessel. A radio beacon (43.5880 M Hz) and flashlight were attached for assisting to find an OBS at the sea-surface when it is recovered.

Standard procedure for the recovery included the following steps:
(1) Upon arrival on station, a transponder was set over the starboard side (about mid-ships across the wet-lab) and lowered to approximately 10 m below the sea-surface;
(2) An acoustic signal was sent to the OBS, which typically acknowledges the command by sending a specific return signal. This is to control that the OBS is still at the location, the transponder is identified correctly and is functional;
(3) Upon receiving the return signal the release command is sent; After the release command is sent, the corrosion process to release the OBS from the anchor takes about 15 minutes;
(4) The OBS rises with a speed of approximately 1m per second (60 meters per minute). Estimated arrival times on the surface were communicated to the bridge for optimal use of time of the required deckhands.
(5) The OBS can be seen during day-light relatively easily by it's bright yellow color. Also, as soon as the OBS surfaced, the radio beacon starts operating, aiding in locating the unit. At night, the flash-light makes locating the OBS very easy. Weak ocean currents ensured that OBS surfaced very close to bottom location.
(6) Once the OBS is seen on the surface, the vessel is position carefully so that the OBS is on the lee-side and starboard side of the aft-deck. Quick-release hooks were attached to the OBS-mounted recovery-hook using long poles (Figure 4b) and then attached to the crane's hook. The crane turned further out-board to hold OBS away from ship's hull, and a second attached rope hold tight prevented swaying the OBS (Figure 4c), thus avoiding collision with the hull. The unit is then lifted on deck (Figure 4d) and handed over to the OBS technicians for offloading.
(7) The OBS was secured, rinsed thoroughly with fresh water, then the OBS recorder was stopped and synchronized with GPS, all attached parts were removed, and the unit was leached on deck.

In order to help keeping the vessel on station during the OBS ascent, the transponder was typically brought back on deck within 1-2 minutes once the release of the OBS from the anchor was confirmed. Several times the OBS ascent was monitored on the 12 and 18 kHz echosounder system (**Figure 5**), which help predicting the time when the OBS was to arrive on the sea-surface.

4. Acoustic Imaging of gas plumes

Using the ship-board 12 kHz echosounder, as well as the dual-frequency 18+38 kHz sounder, we collected several profiles across known vent locations in the area of Bullseye Vent, and IODP Expedition 311 boreholes. In previous cruises on the CCGS *John P. Tully* in 2006 and 2008, water-column plumes had been observed using the same systems. The plumes often extended from the seafloor to water depths near 500 m.

During this cruise, the 12 kHz was used with the RAM extended, giving much better images than during previous cruises (esp. 2010005 June 30 - July 10, 2010). The two echosounder systems have different beam-widths (12 kHz: 7°; 18+38 kHz: 5°) and depending on the water depth, create a relatively large foot-print (up to 300 m across). Therefore, the plumes are imaged only in a side-view.

Several sets of parallel lines (typically 20 m, once 40 m, apart) were designed to image the plumes and when necessary, cross-lines through the points of highest-plume-echo (measured from seafloor up) were added to verify the location. Seven areas were covered (**Figure 2, 3**): A set of two crossing lines were completed at the beginning of the expedition at a vent first identified in July 2010. Six (6) additional areas were covered for detailed plume-identification: Two (2) grids at Bullseye Vent and Bubbly-Gulch, where 2 distinct large plumes were seen; Two (2) grids at Spinnaker vent (North and South), and two (2) grids at Amnesiac Vent (East and West). Examples of plumes from each location are shown in **Figure 6**.

Typically, after acquisition of the acoustic lines, the points of highest plume-echo were chosen and transferred to the GIS computer for mapping. Additional crossing lines through those points were acquired to verify the plume location (and to get the best position for a CTD cast) at Spinnaker Vent Area 2, Amnesiac Vent Area 1, and Amnesiac Vent Area 2. Two cross-lines through the area of Bullseye Vent were coincidentally acquired while approaching and leaving the OBS location 33b (near the NEPTUNE-Canada node 889 seismometer).

<u>Detailed specifications of sounders:</u>
- Simrad EK60 Multi-frequency Scientific Echo Sounder using an ES18-11 18kHz Split-beam Transducer with a 3-db Beam Width of 11 degrees,
- ES38-12 38kHz Split-beam Transducer with a 3-db Beam Width of 12.5 degrees.

Both transducers are hull-mounted. Output power is 2000W at 2.048 msec pulse length.

- Simrad EA600 Single-Frequency Hydrographic Echo Sounder using a 12-16 12kHz Single-beam Transducer with a 3-db Beam Width of 15.2 degrees. Transducer is mounted on an extended ram. Output power is 2000W at 2.048 msec pulse length.

5. CTD and Water Sampling

The 24 Niskin bottle rosette (SBE carousel) and Seabird SBE911plus CTD unit from the IOS Water-properties lab were used during the cruise to collect water samples for dissolved methane analyses in collaboration with Prof. Dr. Michael Whiticar from the School of Earth and Ocean Sciences, University of Victoria.
The CTD unit has the following sensors:

- Dual Temperature sensors, ITS-90
- Dual Salinity sensors - PSU
- Digiquartz Pressure sensor - Depth salt water
- Seapoint Fluorometer
- Transmissometer, Chelsea/Seatch/WET Lab CStar
- SBE 43 Oxygen sensor
- Altimeter

Additionally, a CAPSUM METS Methane Gas detector (METS) was used to help guide water-sampling locations. The METS sensor was borrowed from Bob Collier, Oregon State University through collaboration with Dr. Michael Whiticar. The installation of the METS sensor and connection to the CTD was achieved and a regular channel of the CTD (in our case optical water transmissivity) was used to display the methane concentrations. The METS provides 2 Voltages - Gas Concentration and Gas Temperature at 24 samples/second. The SBE 911plus was loaded with the METS configuration data to automatically calculate and plot Methane Concentration in micromoles/l and Gas Temperature in degrees C. All data were captured and displayed by Seasave 7.20g software.

The methane concentrations are calculated using the internally-measured temperature using the following equation:

$$[CH_4] = \exp\left[D * \ln\left\{ \left(B0 + B1 * \exp - \frac{V_t}{B2} \right) * \left(\frac{1}{V_m} - \frac{1}{(A0 - A1 * V_t)} \right) \right\} \right]$$

$[CH_4]$ = Methane concentration $[\mu mol / L]$
V_m = methane concentration voltage [V]
V_t = temperature concentration voltage [V]

A0 = 4.055
A1 = 2.303
B0 = -0.016
B1 = 1.247
B2 = 0.808
D = 1.783

T1 = 22.78
T2 = -4.62

Water sampling procedure:

From each Niskin bottle water was removed using syringes. Each time a sample was taken, the syringes were rinsed three times before a real sample was collected from the bottle. After water (typically 50-60 ml) was collected in a syringe, excess air-bubbles were removed (syringes were tapped slightly to help evacuate air) and excess water was released until exactly 30 ml of water remained in the syringe. After that, air was added back into the syringe to the maximum volume of the syringe itself (62 - 64 ml, the exact volume was recorded for each syringe). When sampling for isotope measurements, larger syringes were used where 70 ml of water were collected per sample, and an extra 70 ml of air was added.

After that, each syringe was shaken vigorously for one (1) minute and allowed to rest for at least one (1) minute. The head-space gas was either analyzed in the Gyro or transferred into evacuated Wheaton bottles for onshore analyses and stores at 4°C.

Selected samples were immediately measured onboard using the Gyro™ optical spectrometer by Isometric Instruments. If elevated methane concentrations were detected, additional sub-sets (30 ml as well as 70 ml) were taken for later onshore analyses, including measurements for carbon-isotopes.

The Gyro was regularly calibrated by running air-samples (known methane concentrations in air are around 1.8 ppm or 2 n-mol/l dissolved in water).

Station-keeping of the vessel at the cast location was not always easy to achieve due to the different wind and current conditions. For the last three cast locations the bow-thrusters were used, which improved the quality of station keeping immensely. Images of the vessel track-line during the CTD casts are shown in **Figure 7**.

All CTD-casts measurements are shown in **Figure 8** and each methane profile from the METS sensor is again shown in a separate figure (**Figure 9**).

Examples of the CTD unit and water-sampling rosette are shown in **Figure 10**.

One complication on interpreting the different signals of the echosounders and the location of the CTD/rosette is related to their physical location onboard the vessel relative to the position of the navigation GPS antennae. The location of the sounders, CTD-winch, and GPS antennae is shown in **Figure 11**.

Table 1

(a) Recovered OBS stations (in sequence of actual recovery)

OBS Number	Date	Day	Time (UTC)	Depth (m)	Latitude	Longitude
16	23-Sep	266	23:06	1675	48.130212	-126.198623
1	24-Sep	267	1:56	2380	48.027020	-126.544403
2	24-Sep	267	4:10	2522	48.161472	-126.677780
17	24-Sep	267	6:36	1132	48.337662	-126.396133
18	24-Sep	267	8:47	1385	48.495803	-126.524827
3	24-Sep	267	12:11	2553	48.302632	-126.857162
4	24-Sep	267	14:23	2573	48.441407	-127.029847
30	24-Sep	267	16:53	2155	48.495598	-126.936875
31	24-Sep	267	18:09	2142	48.498013	-126.943023
32	24-Sep	267	19:42	2162	48.494667	-126.946625
5	24-Sep	267	22:22	2560	48.577882	-127.204620
6	25-Sep	268	1:33	2548	48.707447	-127.384658
25	27-Sep	270	19:45	1941	49.446027	-127.729828
15	27-Sep	270	22:02	2431	49.355408	-127.928573
10	28-Sep	271	0:16	2427	49.262775	-128.093262
9	28-Sep	271	2:43	2493	49.125767	-127.912903
14	28-Sep	271	4:53	2487	49.219517	-127.748443
24	28-Sep	271	6:54	1792	49.311272	-127.566863
29	28-Sep	271	8:31	1270	49.370288	-127.398682
28	28-Sep	271	10:07	1275	49.275482	-127.286178
23	28-Sep	271	12:06	1674	49.175225	-127.436982
13	28-Sep	271	14:05	1947	49.081919	-127.570952
8	28-Sep	271	16:21	2515	48.990487	-127.733520
7	28-Sep	271	18:33	2341	48.852920	-127.556580
12	28-Sep	271	20:29	2067	48.945598	-127.391327
22	28-Sep	271	22:26	1565	49.038260	-127.240570
27	29-Sep	272	0:19	938	49.106563	-127.079437
26	29-Sep	272	1:56	926	48.963168	-126.951477
21	29-Sep	272	3:38	1720	48.883682	-127.082763
11	29-Sep	272	6:45	2031	48.809078	-127.219558
20	29-Sep	272	10:12	1376	48.763248	-126.871125
19	29-Sep	272	12:09	1334	48.605583	-126.714538
33b	29-Sep	272	13:48	1257	48.671318	-126.852248

Table 1

(b) Sequence OBS recovery events

Day	Time (UTC)	Event	Latitude	Longitude	Depth (m)	Sonar (kHz)
266	22:20	OBS16_Pinger	48.130486	-126.198355	1675	18
266	22:22	OBS16_Signal	48.130986	-126.198784	1675	18
266	22:39	OBS16_Release	48.130830	-126.199457	1675	18
266	23:06	OBS16_Surface	48.129979	-126.198413	1675	18
266	23:11	OBS16_Deck	48.129979	-126.200552	1671	18
267	01:05	OBS1_Signal	48.027790	-126.544230	2383	18
267	01:19	OBS1_Release	48.027883	-126.544675	2386	18
267	01:56	OBS1_Surface	48.027465	-126.543269	2380	18
267	02:07	OBS1_Deck	48.028599	-126.542385	2372	18
267	03:15	OBS2_Signal	48.161972	-126.676478	2507	18
267	03:30	OBS2_Release	48.161017	-126.674077	2521	18
267	04:10	OBS2_Surface	48.162641	-126.677828	2522	18
267	04:21	OBS2_Deck	48.162229	-126.675866	2519	18
267	06:02	OBS17_Pinger	48.338665	-126.393286	1133	18
267	06:03	OBS17_Signal	48.338318	-126.394622	1130	12
267	06:18	OBS17_Release	48.337993	-126.395033	1134	12
267	06:36	OBS17_Surface	48.338132	-126.394228	1132	12
267	06:57	OBS17_Deck	48.341270	-126.390577	1131	12
267	08:09	OBS18_Pinger	48.495790	-126.524783	1372	12
267	08:10	OBS18_Signal	48.496532	-126.526070	1373	12
267	08:26	OBS18_Release	48.498774	-126.525111	1386	12
267	08:47	OBS18_Surface	48.500849	-126.520117	1385	12
267	09:09	OBS18_Deck	48.495637	-126.525923	1372	12
267	11:10	OBS3_Pinger	48.303745	-126.856742	2548	18
267	11:17	OBS3_Release	48.302948	-126.857027	2548	18
267	12:11	OBS3_Surface	48.306867	-126.837655	2553	12
267	12:22	OBS3_Deck	48.305260	-126.860840	2553	12
267	13:27	OBS4_Pinger	48.438306	-127.028543	2575	12
267	13:29	OBS4_Signal	48.438881	-127.028540	2575	12
267	13:42	OBS4_Release	48.446957	-127.029584	2573	12
267	14:23	OBS4_Surface	48.443458	-127.032086	2573	12
267	14:37	OBS4_Deck	48.443636	-127.031634	2573	12
267	16:07	OBS30_Pinger	48.493050	-126.941777	2162	12

Table 1 (ctd.)
(b) Sequence OBS recovery events

Day	Time (UTC)	Event	Latitude	Longitude	Depth (m)	Sonar (kHz)
267	16:08	OBS30_Signal	48.493653	-126.941296	2161	12
267	16:22	OBS30_Release	48.503642	-126.935352	2011	12
267	16:53	OBS30_Surface	48.497231	-126.934726	2155	12
267	17:00	OBS30_Deck	48.497875	-126.938022	2160	12
267	17:21	OBS31_Pinger	48.497088	-126.943659	2145	12
267	17:23	OBS31_Signal	48.496844	-126.943030	2146	12
267	17:31	OBS31_Release	48.499076	-126.943888	2143	12
267	18:09	OBS31_Surface	48.498702	-126.942537	2142	12
267	18:32	OBS31_Deck	48.50 5807	-126.940947	2211	12
267	18:51	OBS32_Pinger	48.491908	-126.950178	2187	12
267	18:57	OBS32_Signal	48.495591	-126.949394	2158	12
267	19:11	OBS32_Release	48.499877	-126.946994	2130	18
267	19:42	OBS32_Surface	48.495127	-126.946674	2162	12
267	19:50	OBS32_Deck	48.496415	-126.948079	2137	12
267	21:25	OBS5_Pinger	48.576225	-127.205429	NA	NA
267	21:27	OBS5_Signal	48.576596	-127.203902	NA	NA
267	21:42	OBS5_Release	48.577821	-127.193770	NA	NA
267	22:22	OBS5_Surface	48.578720	-127.204918	2560	12
267	22:31	OBS5_Deck	48.578057	-127.204245	2560	12
268	00:33	OBS6_Pinger	48.703603	-127.389493	2540	18
268	00:37	OBS6_Signal	48.703941	-127.390848	2545	12
268	00:52	OBS6_Release	48.704842	-127.384620	2546	12
268	01:33	OBS6_Surface	48.708985	-127.383337	2548	12
268	02:09	OBS6_Deck	48.710711	-127.378830	2542	12
270	19:00	OBS25_Pinger	49.445291	-127.731545	1935	12
270	19:02	OBS25_Signal	49.445901	-127.731316	1938	12
270	19:28	OBS25_Release	49.445666	-127.726294	1947	12
270	19:45	OBS25_Surface	49.447030	-127.731141	1941	12
270	19:52	OBS25_Deck	49.446125	-127.731638	1935	12
270	21:11	OBS15_Pinger	49.356099	-127.928794	2436	12
270	21:13	OBS15_Signal	49.355269	-127.929214	2436	12
270	21:27	OBS15_Release	49.355924	-127.930146	2436	12
270	22:02	OBS15_Surface	49.356531	-127.928717	2431	18
270	22:11	OBS15_Deck	49.357928	-127.929935	2430	18

Table 1 (ctd.)

(b) Sequence OBS recovery events

Day	Time (UTC)	Event	Latitude	Longitude	Depth (m)	Sonar (kHz)
270	23:22	OBS10_Pinger	49.263106	-128.094595	2427	12
270	23:24	OBS10_Signal	49.263111	-128.093299	2427	12
270	23:38	OBS10_Release	49.262532	-128.094880	2427	12
271	00:16	OBS10_Surface	49.263756	-128.093095	2427	12
271	00:25	OBS10_Deck	49.264613	-128.094600	2426	12
271	01:51	OBS9_Pinger	49.126625	-127.911872	2492	12
271	01:53	OBS9_Signal	49.126121	-127.910790	4993	12
271	02:08	OBS9_Release	49.126439	-127.911977	2493	12
271	02:43	OBS9_Surface	49.126148	-127.911762	2493	12
271	02:49	OBS9_Deck	49.125575	-127.911039	2493	12
271	03:56	OBS14_Pinger	49.219659	-127.747376	2488	12
271	03:59	OBS14_Signal	49.220519	-127.747772	2487	12
271	04:12	OBS14_Release	49.219881	-127.747043	2487	12
271	04:53	OBS14_Surface	49.219550	-127.746913	2487	12
271	05:07	OBS14_Deck	49.220773	-127.747646	2487	12
271	06:11	OBS24_Pinger	49.312626	-127.565917	1793	12
271	06:13	OBS24_Signal	49.312335	-127.566947	1792	12
271	06:28	OBS24_Release	49.311848	-127.566148	1792	12
271	06:54	OBS24_Surface	49.311024	-127.565063	1792	12
271	07:01	OBS24_Deck	49.311572	-127.566329	1791	12
271	07:55	OBS29_Pinger	49.370947	-127.398009	1257	12
271	07:56	OBS29_Signal	49.370783	-127.397640	1253	12
271	08:10	OBS29_Release	49.369907	-127.397175	1260	12
271	08:31	OBS29_Surface	49.368984	-127.396332	1270	12
271	08:39	OBS29_Deck	49.370540	-127.397546	1250	12
271	09:33	OBS28_Pinger	49.275254	-127.288659	1275	12
271	09:35	OBS28_Signal	49.275363	-127.287180	1275	12
271	09:49	OBS28_Release	49.276474	-127.285867	1275	12
271	10:07	OBS28_Surface	49.274825	-127.283489	1275	12
271	10:15	OBS28_Deck	49.275498	-127.285152	1273	12
271	11:25	OBS23_Pinger	49.176163	-127.435466	1678	12
271	11:26	OBS23_Signal	49.175687	-127.435377	1677	12
271	11:41	OBS23_Release	49.174875	-127.435558	1679	12
271	12:06	OBS23_Surface	49.174967	-127.435718	1674	12

Table 1 (ctd.)

(b) Sequence OBS recovery events

Day	Time (UTC)	Event	Latitude	Longitude	Depth (m)	Sonar (kHz)
271	12:17	OBS23_Deck	49.176276	-127.436454	1680	12
271	13:21	OBS13_Pinger	49.083915	-127.569458	1967	12
271	13:22	OBS13_Signal	49.083636	-127.569409	1971	12
271	13:38	OBS13_Release	49.082666	-127.568830	1955	12
271	14:05	OBS13_Surface	49.081919	-127.570952	1947	12
271	14:17	OBS13_Deck	49.084612	-127.565909	1969	12
271	15:27	OBS8_Pinger	48.991244	-127.732702	2515	12
271	15:29	OBS8_Signal	48.990819	-127.732940	2517	12
271	15:43	OBS8_Release	48.989436	-127.732949	2515	12
271	16:21	OBS8_Surface	48.990273	-127.731409	2515	12
271	16:30	OBS8_Deck	48.991177	-127.730512	2515	12
271	17:41	OBS7_Pinger	48.852883	-127.555989	2340	12
271	17:42	OBS7_Signal	48.852644	-127.556705	2340	12
271	17:57	OBS7_Release	48.852933	-127.555354	2340	12
271	18:33	OBS7_Surface	48.851650	-127.555670	2341	12
271	18:40	OBS7_Deck	48.853728	-127.553927	2236	18
271	19:42	OBS12_Pinger	48.945195	-127.391896	2067	12
271	19:44	OBS12_Signal	48.945038	-127.391520	2068	12
271	19:58	OBS12_Release	48.944895	-127.389530	2067	12
271	20:29	OBS12_Surface	48.944895	-127.390895	2067	12
271	20:44	OBS12_Deck	48.946068	-127.389044	2064	12
271	21:47	OBS22_Pinger	49.038246	-127.239845	1565	12
271	21:48	OBS22_Signal	49.038328	-127.239919	1564	12
271	22:02	OBS22_Release	49.037877	-127.239548	1565	12
271	22:26	OBS22_Surface	49.037155	-127.240365	1565	12
271	22:34	OBS22_Deck	49.037758	-127.240485	1572	12
271	23:45	OBS27_Pinger	49.106252	-127.078176	935	12
271	23:46	OBS27_Signal	49.106750	-127.078754	937	12
271	23:59	OBS27_Release	49.105964	-127.078254	938	12
272	00:19	OBS27_Deck	49.105876	-127.079341	938	12
272	01:26	OBS26_Pinger	48.962811	-126.950320	922	12
272	01:27	OBS26_Signal	48.962541	-126.951507	923	12
272	01:42	OBS26_Release	48.962563	-126.951813	927	12
272	01:56	OBS26_Surface	48.962102	-126.951202	926	12
272	01:59	OBS26_Deck	48.962586	-126.951576	919	12

Table 1 (ctd.)

(b) Sequence OBS recovery events

Day	Time (UTC)	Event	Latitude	Longitude	Depth (m)	Sonar (kHz)
272	02:59	OBS21_Pinger	48.883085	-127.082291	1715	12
272	03:00	OBS21_Signal	48.882425	-127.084063	1720	12
272	03:13	OBS21_Release	48.881935	-127.081885	1723	12
272	03:38	OBS21_Surface	48.882402	-127.082292	1720	12
272	03:45	OBS21_Deck	48.881278	-127.081194	1736	12
272	04:44	OBS11_Pinger	48.808807	-127.218365	2034	12
272	04:54	OBS11_Signal	48.809056	-127.219667	2031	12
272	05:14	OBS11_Pinger2	48.087617	-127.219501	2030	12
272	05:20	OBS11_Signal2	48.807513	-127.219020	2030	12
272	05:40	OBS11_Signal3	48.808513	-127.219741	2033	12
272	06:00	OBS11_Signal4	48.80810	-127.219891	2032	12
272	06:20	OBS11_Signal5	48.808925	-127.219661	2031	12
272	06:45	OBS11_Reset_Signal	48.808325	-127.218788	2031	12
272	09:35	OBS20_Pinger	48.763129	-126.871153	1379	12
272	09:36	OBS20_Signal	48.763383	-126.871202	1378	12
272	09:52	OBS20_Release	48.762139	-126.872233	1376	12
272	10:12	OBS20_Surface	48.762230	-126.871688	1376	12
272	10:19	OBS20_Deck	48.763110	-126.869565	1380	12
272	11:33	OBS19_Pinger	48.606299	-126.713470	1334	12
272	11:34	OBS19_Signal	48.606587	-126.712476	1333	12
272	11:48	OBS19 Release	48.604175	-126.714322	1334	12
272	12:09	OBS19_Surface	48.604064	-126.714715	1335	12
272	12:17	OBS19_Deck	48:603464	-126.713112	1334	12
272	13:11	OBS33b_Pinger	48.671505	-126.853377	1259	12
272	13:14	OBS33b_Signal	48.670741	-126.853192	1259	12
272	13:27	OBS33b_Release	48.668680	-126.854263	1261	12
272	13:48	OBS33b_Surface	48.670000	-126.852442	1257	12
272	13:55	OBS33b_Deck	48.669948	-126.850851	1258	12

Table 2

Lines of acoustic imaging across plumes

Day	Time (UTC)	Line Number	Latitude	Longitude	Depth (m)	Sonar (kHz)
Barkley Canyon						
266	18:58	BC_EW_SOL	48.193729	-126.062813	947	12
266	19:44	BC_EW_EOL	48.160715	-126.140043	1352	18
266	21:13	BC_NS_SOL	48.186522	-126.108296	1415	18
266	21:27	BC_NS_EOL	48.170570	-126.092464	909	12
Bullseye Vent 1						
272	14:25	BV1_1_SOL	48.670005	-126.842434	1269	18
272	14:30	BV1_1_EOL	48.665757	-126.848249	1240	18
272	14:51	BV1_2_SOL	48.665402	-126.85043	1267	18
272	14:55	BV1_2_EOL	48.669462	-126.844348	1264	18
272	15:13	BV1_3_SOL	48.670010	-126.842468	1267	18
272	15:17	BV1_3_EOL	48.665655	-126.848034	1270	18
272	15:36	BV1_4_SOL	48.665411	-126.850426	1267	18
272	15:41	BV1_4_EOL	48.669655	-126.844675	1264	18
272	16:00	BV1_5_SOL	48.670089	-126.842542	1267	18
272	16:04	BV1_5_EOL	48.665772	-126.848201	1269	18
272	16:23	BV1_6_SOL	48.665694	-126.850842	1265	18
272	16:28	BV1_6_EOL	48.669745	-126.844822	1262	18
272	16:48	BV1_7_SOL	48.670193	-126.842810	1262	18
272	16:53	BV1_7_EOL	48.665943	-126.848549	1270	18
272	17:12	BV1_8_SOL	48.665883	-126.851193	1264	18
272	17:17	BV1_8_EOL	48.670126	-126.855093	1262	18
272	17:37	BV1_9_SOL	48.670331	-126.843001	1264	18
272	17:41	BV1_9_EOL	48.666125	-126.848801	1268	18
272	17:59	BV1_10_SOL	48.665280	-126.851049	1264	18
272	18:03	BV1_10_EOL	48.670010	-126.845233	1268	18
272	21:57	BV1_11_SOL	48.671084	-126.844257	1261	18
272	22:03	BV1_11_EOL	48.666811	-126.849968	1266	18
272	22:27	BV1_12_SOL	48.666107	-126.851582	1264	18
272	22:34	BV1_12_EOL	48.670321	-126.845752	1261	18
272	23:04	BV1_13_SOL	48.671221	-126.844461	1269	18
272	23:11	BV1_13_EOL	48.667049	-126.850359	1265	18
272	23:41	BV1_14_SOL	48.666274	-126.851773	1264	18
272	23:49	BV1_14_EOL	48.670291	-126.845673	1260	18

Table 2 (ctd.)

Lines of acoustic imaging across plumes

Day	Time (UTC)	Line Number	Latitude	Longitude	Depth (m)	Sonar (kHz)
Bullseye Vent 2						
273	02:58	BV2_1_SOL	48.677202	-126.834389	1299	12
273	03:07	BV2_1_EOL	48.671478	-126.843138	1257	12
273	03:28	BV2_2_SOL	48.671618	-126.845006	1250	12
273	03:36	BV2_2_EOL	48.677513	-126.837223	1276	12
273	03:59	BV2_3_SOL	48.677415	-126.834885	1292	12
273	04:06	BV2_3_EOL	48.671715	-126.842961	1256	12
273	04:27	BV2_4_SOL	48.671965	-126.845249	1251	12
273	04:34	BV2_4_EOL	48.677233	-126.837178	1275	12
273	04:53	BV2_5_SOL	48.677657	-126.835065	1288	12
273	05:00	BV2_5_EOL	48.671880	-126.843104	1256	12
273	05:20	BV2_6_SOL	48.671762	-126.845446	1251	12
273	05:27	BV2_6_EOL	48.677593	-126.837659	1268	12
273	05:45	BV2_7_SOL	48.677723	-126.235365	1284	12
273	05:52	BV2_7_EOL	48.372128	-126.843432	1253	12
273	06:11	BV2_8_SOL	48.672056	-126.845600	1249	12
273	06:17	BV2_8_EOL	48.677597	-126.837662	1268	12
273	06:34	BV2_9_SOL	48.677961	-126.835611	1281	12
273	06:41	BV2_9_EOL	48.672118	-126.843564	1253	12
273	07:00	BV2_10_SOL	48.671964	-126.846044	1249	12
273	07:07	BV2_10_EOL	48.677860	-126.837943	1264	12
273	07:25	BV2_11_SOL	48.678105	-126.835744	1279	12
273	07:32	BV2_11_EOL	48.672350	-126.843745	1253	12
273	07:50	BV2_12_SOL	48.672126	-126.846443	1248	12
273	07:57	BV2_12_EOL	48.677908	-126.838333	1267	12

Table 2 (ctd.)
Lines of acoustic imaging across plumes

Day	Time (UTC)	Line Number	Latitude	Longitude	Depth (m)	Sonar (kHz)
Spinnaker Vent 1						
273	08:48	SV1_1_SOL	48.711113	-126.900169	1317	12
273	08:52	SV1_1_EOL	48.714233	-126.904065	1321	12
273	09:08	SV1_2_SOL	48.716028	-126.903978	1322	12
273	09:12	SV1_2_EOL	48.712951	-126.900035	1316	12
273	09:29	SV1_3_SOL	48.710949	-126.900449	1317	12
273	09:33	SV1_3_EOL	48.714105	-126.904302	1321	12
273	09:50	SV1_4_SOL	48.715956	-126.904128	1323	12
273	09:53	SV1_4_EOL	48.712795	-126.900177	1317	12
273	10:11	SV1_5_SOL	48.710867	-126.900593	1317	12
273	10:14	SV1_5_EOL	48.713962	-126.904587	1321	12
273	10:31	SV1_6_SOL	48.715801	-126.904368	1323	12
273	10:34	SV1_6_EOL	48.712773	-126.900311	1318	12
273	10:50	SV1_7_SOL	48.710771	-126.900802	1318	12
273	10:55	SV1_7_EOL	48.714380	-126.905236	1322	12
273	11:13	SV1_8_SOL	48.715592	-126.904392	1323	12
273	11:16	SV1_8_EOL	48.712617	-126.900618	1317	12
273	11:32	SV1_9_SOL	48.710662	-126.901020	1318	12
273	11:36	SV1_9_EOL	48.713782	-126.904912	1322	12
273	11:52	SV1_10_SOL	48.715589	-126.904787	1323	12
273	11:56	SV1_10_EOL	48.712466	-126.900880	1318	12
273	12:12	SV1_11_SOL	48.710584	-126.901157	1318	12
273	12:15	SV1_11_EOL	48.713660	-126.905109	1322	12
273	12:32	SV1_12_SOL	48.715407	-126.905048	1323	12
273	12:36	SV1_12_EOL	48.712316	-126.901096	1319	12
273	12:52	SV1_13_SOL	48.710355	-126.901982	1318	12
273	12:56	SV1_13_EOL	48.713516	-126.905329	1322	12
273	13:14	SV1_14_SOL	48.715310	-126.905139	1323	12
273	13:17	SV1_14_EOL	48.712251	-126.901235	1318	12

Table 2 (ctd.)
Lines of acoustic imaging across plumes

Day	Time (UTC)	Line Number	Latitude	Longitude	Depth (m)	Sonar (kHz)
Spinnaker Vent 2						
273	13:47	SV2_1_SOL	48.721528	-126.915846	1335	12
273	13:50	SV2_1_EOL	48.724673	-126.919881	1351	12
273	14:08	SV2_2_SOL	48.726418	-126.919038	1347	12
273	14:11	SV2_2_EOL	48.723312	-126.915232	1334	12
273	14:29	SV2_3_SOL	48.721216	-126.915885	1333	12
273	14:33	SV2_3_EOL	48.725133	-126.920615	1349	12
273	14:49	SV2_4_SOL	48.726372	-126.919404	1347	12
273	14:52	SV2_4_EOL	48.723218	-126.915472	1334	12
273	15:09	SV2_5_SOL	48.721161	-126.916063	1334	12
273	15:12	SV2_5_EOL	48.724318	-126.919967	1349	12
273	15:20	SV2_6_SOL	48.729643	-126.915369	1366	12
273	15:29	SV2_6_EOL	48.720258	-126.920361	1338	12
273	17:45	SV2_7_SOL	48.726193	-126.919706	1340	12
273	17:48	SV2_7_EOL	48.723062	-126.915765	1332	12
273	18:05	SV2_8_SOL	48.721316	-126.916665	1334	12
273	18:08	SV2_8_EOL	48.724155	-126.920302	1340	12
273	18:26	SV2_9_SOL	48.725849	-126.919546	1340	12
273	18:29	SV2_9_EOL	48.722723	-126.915578	1340	12
273	18:32	SV2-BV2_SOL	48.719789	-126.912581	1333	12
273	19:55	SV2_BV2_EOL	48.670881	-126.836840	1301	12

Table 2 (ctd.)
Lines of acoustic imaging across plumes

Day	Time (UTC)	Line Number	Latitude	Longitude	Depth (m)	Sonar (kHz)
Amnesiac Vent 1						
274	02:08	AV1_1_SOL	48.666548	-126.918733	1292	12
274	02:17	AV1_1_EOL	48.657081	-126.913307	1300	12
274	02:33	AV1_2_SOL	48.655478	-126.914724	1297	12
274	02:40	AV1_2_EOL	48.664966	-126.920146	1289	12
274	02:58	AV1_3_SOL	48.666642	-126.919057	1293	12
274	03:07	AV1_3_EOL	48.657028	-126.913497	1301	12
274	03:25	AV1_4_SOL	48.655227	-126.914961	1306	12
274	03:34	AV1_4_EOL	48.664865	-126.920450	1290	12
274	03:52	AV1_5_SOL	48.666552	-126.919388	1292	12
274	04:01	AV1_5_EOL	48.656935	-126.913855	1302	12
274	04:09	AV1_6_SOL	48.655198	-126.915129	1303	12
274	04:18	AV1_6_EOL	48.664835	-126.920502	1288	12
274	04:27	AV1_7_SOL	48.666416	-126.919707	1292	12
274	04:35	AV1_7_EOL	48.656784	-126.914162	1304	12
274	04:45	AV1_8_SOL	48.655096	-126.915485	1306	12
274	04:55	AV1_8_EOL	48.664663	-126.921204	1290	12
274	05:04	AV1_9_SOL	48.666432	-126.919917	1291	12
274	05:14	AV1_9_EOL	48.656848	-126.914250	1305	12
274	05:24	AV1_10_SOL	48.654998	-126.915629	1306	12
274	05:34	AV1_10_EOL	48.664627	-126.921247	1289	12
274	05:44	AV1_11_SOL	48.666392	-126.920048	1289	12
274	05:53	AV1_11_EOL	48.656793	-126.914438	1305	12
274	06:03	AV1_12_SOL	48.654978	-126.915990	1306	12
274	06:13	AV_1_12_EOL	48.664605	-126.921359	1289	12
274	06:23	AV1_13_SOL	48.666250	-126.920523	1289	12
274	06:32	AV1_13_EOL	48.656709	-126.914831	1306	12
274	06:42	AV1_14_SOL	48.654897	-126.916082	1307	12
274	06:51	AV1_14_EOL	48.664876	-126.921893	1290	12
274	07:08	AV1_15_SOL	48.666165	-126.920717	1288	12
274	07:17	AV1_15_EOL	48.656598	-126.915033	1306	12
274	07:35	AV1_16_SOL	48.654864	-126.916420	1309	12
274	07:45	AV1_16_EOL	48.664449	-126.921989	1290	12

Table 2 (ctd.)

Lines of acoustic imaging across plumes

Day	Time (UTC)	Line Number	Latitude	Longitude	Depth (m)	Sonar (kHz)
Amnesiac Vent 2						
274	07:58	AV2_1_SOL	48.670395	-126.905579	1204	12
274	08:07	AV2_1_EOL	48.659476	-126.899057	1264	12
274	08:18	AV2_2_SOL	48.657562	-126.900980	1252	12
274	08:28	AV2_2_EOL	48.668505	-126.907288	1269	12
274	08:36	AV2_3_SOL	48.670878	-126.903612	1180	12
274	08:45	AV2_3_EOL	48.659961	-126.897128	1266	12
274	08:54	AV2_4_SOL	48.658051	-126.898954	1261	12
274	09:05	AV2_4_EOL	48.669044	-126.905297	1209	12
274	09:13	AV2_5_SOL	48.671040	-126.902986	1175	12
274	09:23	AV2_5_EOL	48.660103	-126.896585	1268	12
274	09:31	AV2_6_SOL	48.657948	-126.899245	1261	12
274	09:40	AV2_6_EOL	48.668910	-126.905766	1266	12
274	09:47	AV2_7_SOL	48.670827	-126.903797	1185	12
274	09:58	AV2_7_EOL	48.659851	-126.897528	1268	12
274	10:06	AV2_8_SOL	48.657825	-126.899952	1255	12
274	10:15	AV2_8_EOL	48.668770	-126.906368	1264	12
274	10:24	AV2_9_SOL	48.670032	-126.904150	1190	12
274	10:34	AV2_9_EOL	48.659687	-126.898185	1267	12
274	10:41	AV2_10_SOL	48.657711	-126.900454	1254	12
274	10:51	AV2_10_EOL	48.668622	-126.906765	1267	12
274	10:58	AV2_11_SOL	48.670541	-126.904990	1196	12
274	11:08	AV2_11_EOL	48.659598	-126.898600	1265	12
274	11:16	AV2_12_SOL	48.657419	-126.901493	1250	12
274	11:26	AV2_12_EOL	48.668353	-126.907852	1270	12
274	11:34	AV2_13_SOL	48.671184	-126.902428	1170	12
274	11:44	AV2_13_EOL	48.660224	-126.896057	1270	12
274	11:51	AV2_14_SOL	48.657305	-126.901826	1251	12
274	12:01	AV2_14_EOL	48.668240	-126.908252	1272	12
274	12:09	AV2_15_SOL	48.671298	-126.901900	1167	12
274	12:19	AV2_15_EOL	48.660374	-126.895403	1270	12
274	12:26	AV2_16_SOL	48.659305	-126.894165	1272	12
274	12:36	AV2_16_EOL	48.670207	-126.900576	1165	12
274	16:36	AV1_WP19-20_North_SOL	48.655131	-126.914962	1304	12
274	16:57	AV1_WP19-20_North_EOL	48.664887	-126.920388	1291	12
274	17:07	AV1_WP19-20_South_SOL	48.665918	-126.921104	1287	12
274	17:23	AV1_WP19-20_South_EOL	48.656042	-126.915374	1308	12
274	18:07	AV1_CrossLine_SOL	48.65969	-126.904551	1249	12
274	18:16	AV1_CrossLine_EOL	48.669268	-126.900034	1163	12

Table 3
CTD Cast Locations

Date	Day	Start Time (UTC)	Site	Latitude	Longitude	Depth (m)
29-Sep	272	20:21	Bullseye Vent - Cast 1	48.668640	-126.844027	1264
30-Sep	273	1:10	Bullseye Vent - Cast 2	48.669953	-126.845895	1256
30-Sep	273	16:02	Spinnaker Vent	48.723144	-126.918511	1340
30-Sep	273	20:42	Bubbly-Gulch	48.675446	-126.841580	1250
		21:08	Bubbly-Gulch - Station 3	48.674489	-126.841984	1250
		21:40	Bubbly-Gulch - Station 5	48.674985	-126.841707	1255
		21:53	Bubbly-Gulch - Station 4	48.674998	-126.841641	1252
		22:16	Bubbly-Gulch - Station 2	48.674792	-126.841310	1251
		22:49	Bubbly-Gulch - Station 1	48.675726	-126.841433	1248
1-Oct	274	14:39	Amnesiac Vent - Cast 1	48.660390	-126.916560	1280
		15:03	Amnesiac Vent - Station 1	48.660913	-126.917482	1277
		15:13	Amnesiac Vent - Station 2	48.660245	-126.917520	1279
		15:26	Amnesiac Vent - Station 3	48.659819	-126.917060	1276
		15:35	Amnesiac Vent - Station 4	48.659378	-126.916598	1284
		15:41	Amnesiac Vent - Station 5	48.658800	-126.916105	1289
1-Oct	274	18:50	Amnesiac Vent - Cast 2	48.665612	-126.900967	1235
2-Oct	275	1:31	Barkley Canyon	48.175417	-126.100500	910

Table 4a-1
Depths of water bottles taken at Bullseye Vent, CTD Cast-1, BV1-1

Station Number		**BV1-1**
Water depth: 1260 m		
Water Bottle #	**Depth from bottom (m)**	**Depth from surface (m)**
1	10	1250
2	15	1245
3	20	1240
4	30	1230
5	40	1220
6	50	1210
7	75	1185
8	100	1160
9	125	1135
10	150	1110
11	200	1060
12	250	1010
13	300	960
14	350	910
15	400	860
16	475	785
17	550	710
18	625	635
19	700	560
20	775	485
21	850	410
22	1000	260
23	1150	110
24	1259	1

Table 4a-2
Depths of water bottles taken at Bullseye Vent, CTD Cast-2, BV1-2

Station Number		**BV1-2**
Water depth: 1260 m		
Water Bottle #	**Depth from bottom (m)**	**Depth from surface (m)**
1	10	1250
2	15	1245
3	20	1240
4	30	1230
5	40	1220
6	50	1210
7	75	1185
8	100	1160
9	125	1135
10	150	1110
11	200	1060
12	250	1010
13	300	960
14	350	910
15	400	860
16	475	785
17	550	710
18	625	635
19	700	560
20	775	485
21	850	410
22	1000	260
23	1150	110
24	1259	1

Table 4a-3
Depths of water bottles taken at Spinnaker Vent, CTD Cast-3, SV2-1

Station Number		SV2-1
Water depth: 1330 m		
Water Bottle #	Depth from bottom (m)	Depth from surface (m)
1	10	1330
2	15	1325
3	20	1320
4	30	1310
5	40	1300
6	50	1290
7	75	1265
8	100	1240
9	125	1215
10	150	1190
11	200	1140
12	250	1090
13	300	1040
14	350	990
15	400	940
16	475	865
17	550	790
18	625	715
19	700	640
20	775	565
21	850	490
22	1000	340
23	1150	190
24	1339	1

Table 4a-4
Depths of water bottles taken at Bubbly-Gulch, CTD Cast-4, BG-1

Station Number		**BG-1**	
Water depth: 1250 m			
Water Bottle #	**Depth from bottom (m)**	**Depth from surface (m)**	**Comments**
1	10	1240	Station 3
2	20	1230	Station 3
3	30	1220	Station 3
4	40	1210	Station 3
5	10	1240	Station 5, SE1
6	20	1230	Station 5, SE1
7	30	1220	Station 5, SE1
8	40	1210	Station 5, SE1
9	12	1238	Station 4, SE2
10	22	1228	Station 4, SE2
11	32	1218	Station 4, SE2
12	42	1208	Station 4, SE2
13	16	1234	Station 2, Middle
14	26	1224	Station 2, Middle
15	36	1214	Station 2, Middle
16	46	1204	Station 2, Middle
17	10	1240	Station 1, North
18	20	1230	Station 1, North
19	30	1220	Station 1, North
20	40	1210	Station 1, North
21	100	1150	Above Station 1
22	200	1050	Above Station 1
23	300	950	Above Station 1
24	400	850	Above Station 1

Table 4a-5
Depths of water bottles taken at Amnesiac vent, CTD Cast-5, AV1-1

Station Number		**AV1-1**	
Water depth: 1280 m			
Water Bottle #	**Depth from bottom (m)**	**Depth from surface (m)**	**Comments**
1	10	1270	Station 1
2	15	1265	Station 1
3	20	1260	Station 1
4	30	1250	Station 1
5	40	1240	Station 1
6	50	1230	Station 1
7	75	1205	Station 2
8	100	1180	Station 2
9	125	1155	Station 2
10	150	1130	Station 2
11	200	1080	Station 2
12	250	1030	Station 2
13	300	980	Station 3
14	350	930	Station 3
15	400	880	Station 3
16	475	805	Station 3
17	550	730	Station 4
18	625	655	Station 4
19	700	580	Station 5
20	775	505	Station 5
21	850	430	Station 5
22	1000	280	Station 5
23	1150	130	Station 5
24	1279	1	Station 5

Table 4a-6
Depths of water bottles taken at Amnesiac Vent, CTD Cast-6, AV2-1

Station Number		**AV2-1**
Water depth: 1240 m		
Water Bottle #	**Depth from bottom (m)**	**Depth from surface (m)**
1	10	1230
2	15	1225
3	20	1220
4	25	1215
5	30	1210
6	40	1200
7	50	1190
8	75	1165
9	100	1140
10	125	1115
11	150	1090
12	175	1065
13	200	1040
14	225	1015
15	250	990
16	275	965
17	300	940
18	375	865
19	450	790
20	525	715
21	600	640
22	800	440
23	1000	240
24	1239	1

Table 4a-7
Depths of water bottles taken at Barkley Canyon, CTD Cast-7, BC-1

Station Number		**BC-1**
Water depth: 910 m		
Water Bottle #	**Depth from bottom (m)**	**Depth from surface (m)**
1	10	900
2	15	895
3	20	890
4	25	885
5	30	880
6	40	870
7	50	860
8	75	835
9	100	810
10	125	785
11	150	760
12	175	735
13	200	710
14	225	685
15	250	660
16	275	635
17	300	610
18	375	535
19	450	460
20	525	385
21	600	310
22	700	210
23	800	110
24	892.5	17.5

Table 4b-1.
Sub-Samples taken from water-samples at Cast-1, Bullseye Vent Area 1 (Cast BV1-1).

	30ml Wheaton 1		**30ml Wheaton 2**		**30ml Wheaton 3**	
Syr. Size	60ml		60ml		60ml	
Bottle - #	Vol. air added	left	added	left	added	left
1	31	4	33	4		
2	33	5	33	5		
3	33	9	32	6		
4	33	7	32	6		
5	33	6	33	5		
6	34	7	33	5		
7	33	4	33	6		
8	33	11	33	7		
9	33	4	33	6		
10	33	6	33	5		
11	34	5	33	5		
12	33	4	33	6		
13	34	8	33	5		
14	33	7	33	5		
15	33	9	33	4		
16	33	4	33	6		
17	33	8	33	6		
18	33	5	33	7		
19	32	5	33	5		
20	32	7	33	5		
21	33	3	33	7		
22	33	5	32	5		
23	32	7	32	7	33	12
24	33	4	33	9	33	7
Air outside		140				

Table 4b-2.
Sub-Samples taken from water-samples at Cast-2, Bullseye Vent Area 1 (Cast BV1-2).

	30ml Wheaton 1		**30ml Wheaton 2**		**120ml Wheaton**	
Syr. Size	60ml		60ml		140ml	
Bottle - #	Vol. air added	left	added	left	added	left
1	34	4	33	5	68	7
2	34	6	33	2		
3	33	7	33	7		
4	33	5	33	4	67	0
5	33	5	33	5	66	0
6	33	5	33	5	67	10
7	33	5	33	6	67	10
8	32	4	33	6	67	9
9	33	6	33	4		
10	33	7	33	5		
11	33	5	34	5	67	5
12	33	5	33	6		
13	32	5	33	5		
14	33	5	33	4		
15	33	5	34	5		
16	32	4	33	5		
17	33	5	33	5		
18	33	4				
19	33	5				
20	33	5				
21	33	5				
22	34	4				
23	33	5				
24	33	4				
Air outside		110				

Table 4b-3.
Sub-Samples taken from water-samples at Cast-3, Spinnaker Vent (Cast SV2-1).

	30ml Wheaton 1		**30ml Wheaton 2**		**120ml Wheaton**	
Syr. Size	60ml		60ml		140ml	
Bottle - #	Vol. air added	left	added	left	added	left
1	33	4				
2	33	4				
3	33	3				
4	33	5				
5	33	4				
6	34	7				
7	33	4				
8	33	6				
9	33	6				
10	33	4				
11	33	8				
12	33	5				
13	34	5				
14	33	6				
15	33	6				
16	33	6				
17	33	8				
18	33	6				
19	33	6				
20	33	6				
21	33	6				
22	34	5				
23	33	5				
24	33	4				
Air outside						

Table 4b-4.
Sub-Samples taken from water-samples at Cast-4, Bubbly Gulch (Cast BG-1).

	30ml Wheaton 1		**30ml Wheaton 2**		**120ml Wheaton**			
Syr. Size	60ml		60ml		140ml		140ml	
Bottle - #	Vol. air added	left	added	left	added	left	added	left
1	33	6	32	6	67	16	67	0
2	34	7	34	7				
3	34	6	32	9	67	0	67	7
4	32	4	33	4	66	3	67	7
5	34	7	34	6				
6	33	6	33	6				
7	33	4	33	5	67	6	69	5
8	32	4	33	4	67	5	68	7
9	33	7	33	6				
10	33	4	32	3				
11	33	4	33	5	67	0	67	7
12	33	6	34	6	67	7	67	3
13	33	5	33	5				
14	33	3	33	7				
15	34	3	33	5	67	5	66	11
16	32	5	34	5	67	0	67	15
17	33	4	33	6				
18	33	5	33	5				
19	30	3	32	4	67	0	66	11
20	34	5	34	6	67	6	70	5
21	33	5	34	5				
22	33	4	33	5				
23	33	5	34	5				
24	34	5	33	4				
Air outside	110							

Table 4b-5.

Sub-Samples taken from water-samples at Cast-5, Amnesiac Vent Area 1 (Cast SV1-1).

	30ml Wheaton 1		30ml Wheaton 2		120ml Wheaton			
Syr. Size	60ml		60ml		140ml		140ml	
Bottle - #	Vol. air added	left	added	left	added	left	added	left
1	33	6	33	4	67	0	67	15
2	32	5	33	4	67	9	67	4
3	33	4	33	5	67	7	67	4
4	33	4						
5	33	6						
6	33	6						
7	33	5						
8	33	5						
9	33	5						
10	33	6						
11	33	5						
12	33	5						
13	33	6						
14	33	6						
15	33	4						
16	33	6						
17	33	6						
18	32	6						
19	33	4						
20	33	5						
21	33	7						
22	33	4						
23	33	4						
24	33	5						
Air outside	110							

Table 4b-6.
Sub-Samples taken from water-samples at Cast-6, Amnesiac Vent Area 2 (Cast SV2-1).

	30ml Wheaton 1		**30ml Wheaton 2**		**120ml Wheaton**			
Syr. Size	60ml		60ml		140ml		140ml	
Bottle - #	Vol. air added	left	added	left	added	left	added	left
1	33	7						
2	33	5	32	4	66	5	67	5
3	33	5						
4	33	5						
5	32	5						
6	33	4						
7	32	5						
8	32	4						
9	33	5						
10	33	6						
11	33	4						
12	32	6						
13	33	7						
14	33	5						
15	34	5						
16	34	5						
17	33	4						
18	33	5						
19	33	7						
20	33	6						
21	32	5						
22	33	4						
23	33	7						
24	33	4						
Air outside	110							

Table 4b-7.
Sub-Samples taken from water-samples at Cast-7, Barkley Canyon (Cast BC-1).

	30ml Wheaton 1		30ml Wheaton 2		120ml Wheaton			
Syr. Size	60ml		60ml		140ml		140ml	
Bottle - #	Vol. air added	left	added	left	added	left	added	left
1	33	5	33	6	67	3	67	10
2	32	3	34	6				
3	33	6	33	5	68	2	67	7
4	32	5	33	7				
5	33	4	33	5	68	0	69	6
6	33	5	33	4				
7	33	6	33	6	67	0	67	5
8	33	6						
9	33	5						
10	33	4						
11	33	4						
12	34	4						
13	34	4						
14	33	4						
15	34	4						
16	33	5						
17	33	5						
18	33	5						
19	32	4						
20	33	4						
21	33	4						
22	33	4						
23	32	5						
24	34	4						
Air outside	110							

Table 5
Science Crew, Cabin-assignments and shift/duty roster

Cabin	Name	Shift	Duties
A	Michael Riedel	07:00 – 22:00	Chief Scientist
S-N. cabin	Michelle Coté	06:00 – 18:00	Water-sampling, Watchkeeper
B	Rita Wania	06:00 – 18:00	Water-sampling
	Andrea Price	06:00 – 18:00	Water-sampling
C	Nastasja Scholz	06:00 – 18:00	Watchkeeper, OBS
	Kathrin Naegeli	18:00 – 06:00	Watchkeeper, OBS
D	Steve Taylor	06:00 – 18:00	Lab / echo-sounders
E	Yojiro Yamamoto	24:00 – 12:00	OBS technician
	Koichiro Obana	12:00 – 24:00	OBS management
F	Ikumasa Terada	12:00 – 24:00	OBS technician
	Kaoru Tsukuda	24:00 – 12:00	OBS technician
G	Peter Neelands	06:00 – 18:00 (CTD)	Lab/navigation/OBS
		18:00 – 06:00 (OBS)	Water-sampling
H	Martin Scherwath	18:00 – 06:00	Watchkeeper, OBS

Table 6
CCGS *John P. Tully* Crew

Position Title	Name
Commanding Officer	Quaye, Andy H.
Chief Officer	Gibson, Donald D.
2nd Officer	Lovelace, R. Shane S.
3rd Officer	Garrett, James
Boatswain	Sanderson, Randy
Leading Seaman	Harris, Piper
Leading Seaman	Burdon, Michael
Deckhand	Harrison, Ryan
Deckhand	Lahaise, Matt
Deckhand	Hyde, Zachariah
Deckhand	Brunet, Jesse
Chief Engineer	Horton, Roger D.
Engineer	Bellyk, Scott
Engineer	Owens, Vaughan A.
Oiler	Creelman, Ron G.
Oiler	MacRae, Michael J.
Chief Cook	Zettell, Samuel
2nd Cook	Gamblin, James D.
Steward	Quast, Colin
Steward	Schwarz, Megan
Steward	Watson, Kristina

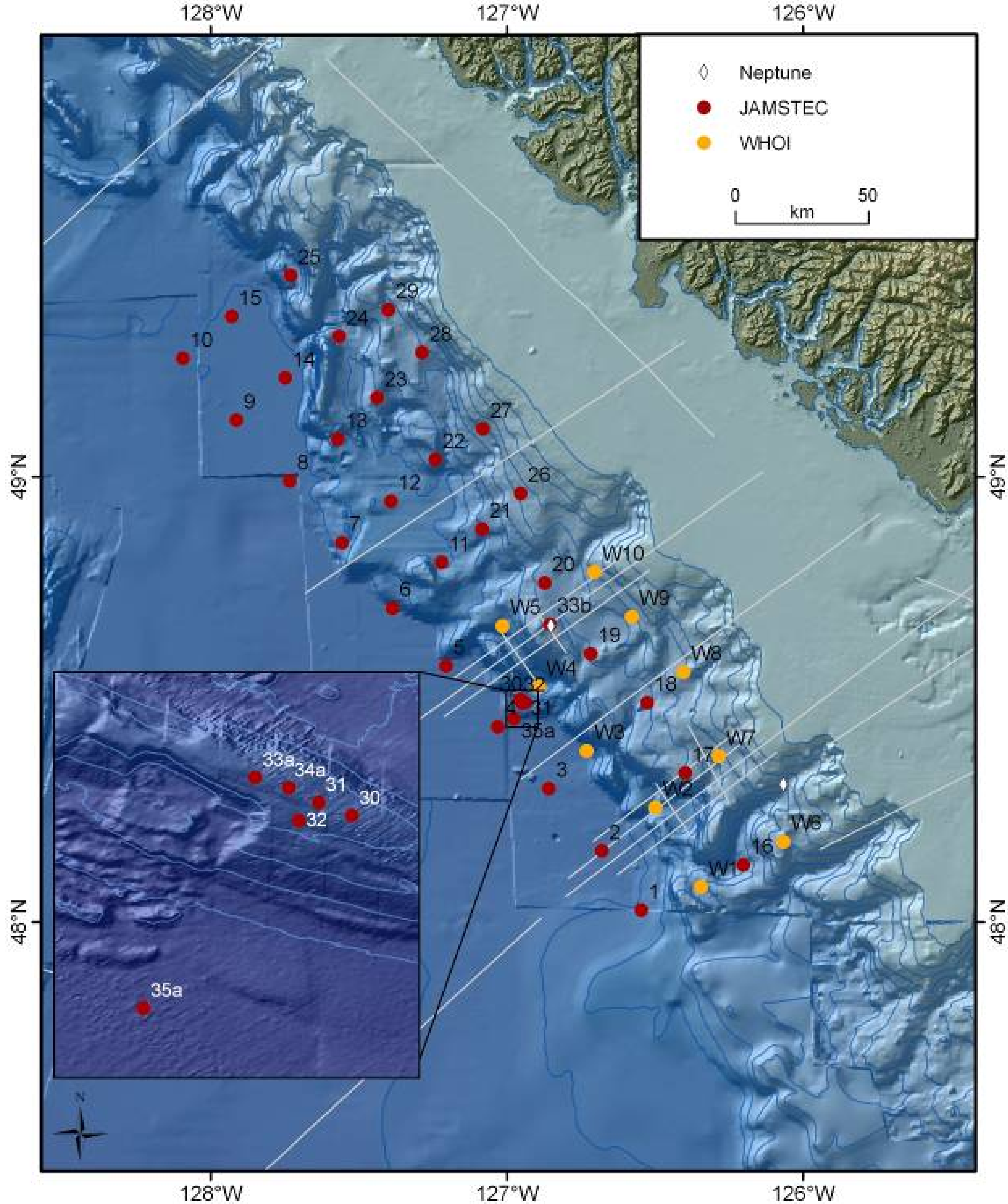


Figure 1

(a) Map of OBS locations. The OBS stations with instruments from WHOI will remain until early summer of 2011. (White lines represent location of vintage multi-channel seismic data, 1985, 1989, 1999). OBS stations 33a, 34a, and 35a were previously recovered during cruise 2010005PGC in July 2010.

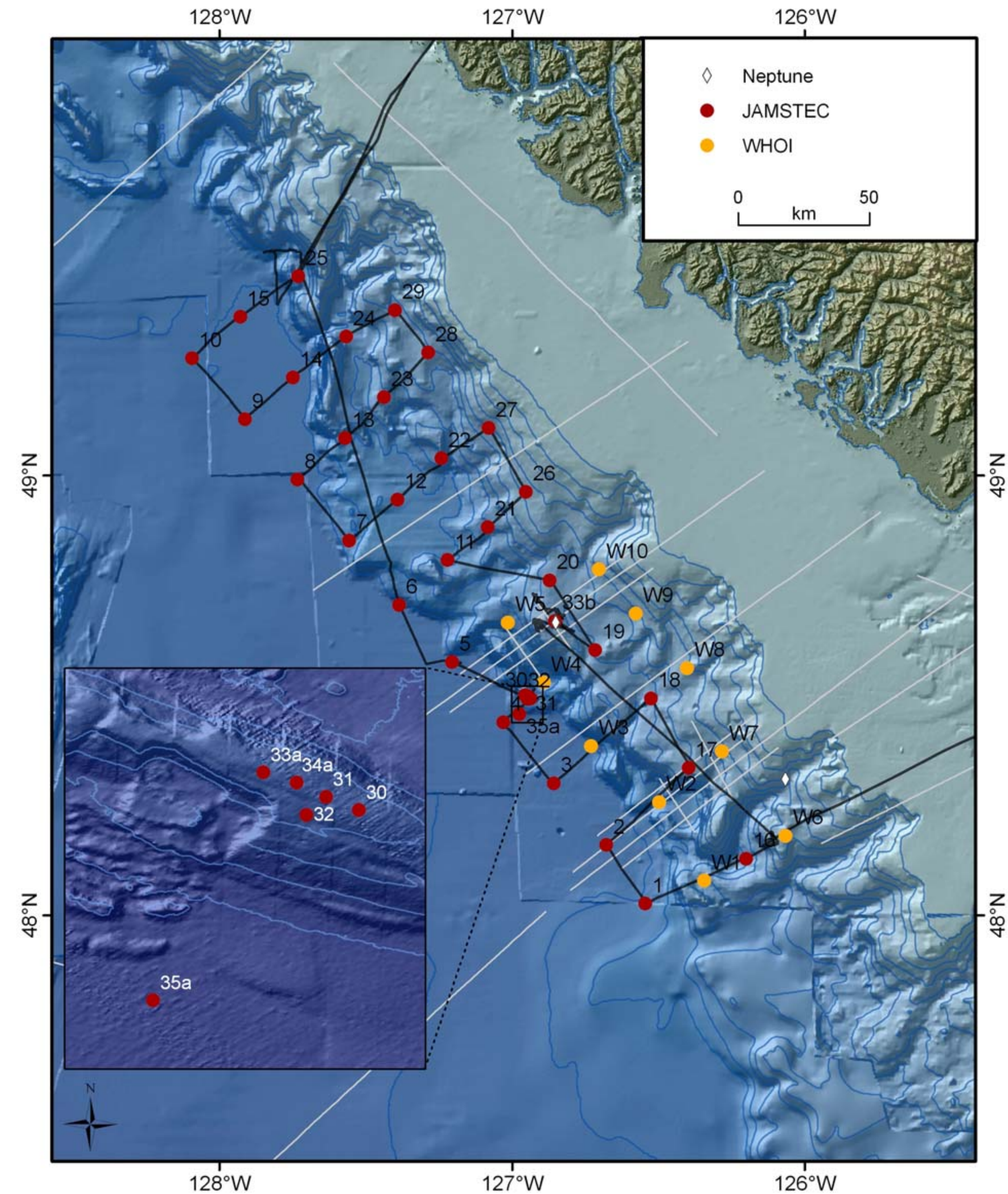


Figure 1
(b) Map of OBS locations as shown in (a) but with track-line of recovery-sequence.

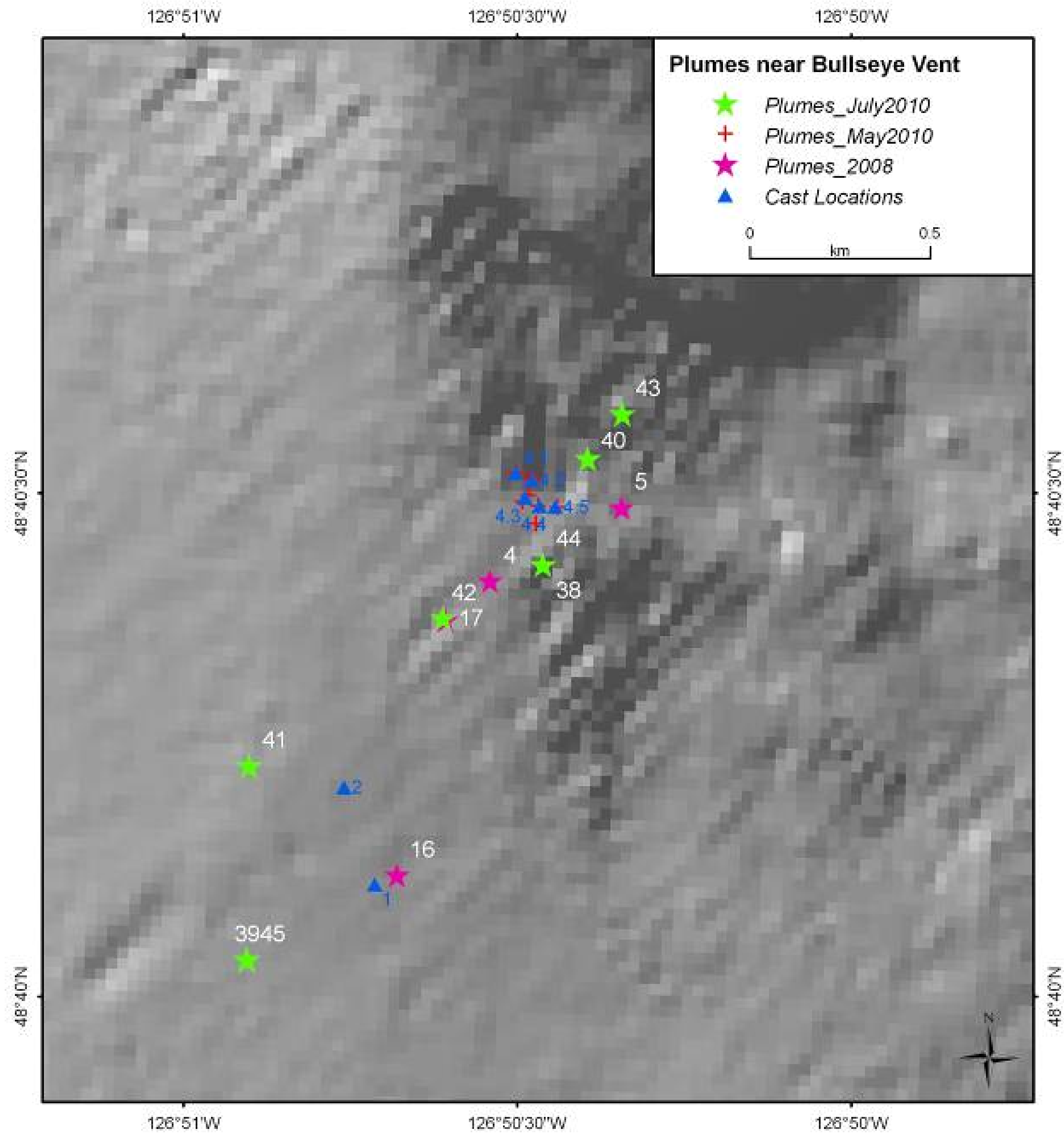


Figure 2
Map of vent-locations visited during the expedition 2010007
(a) Bullseye Vent and Bubbly Gulch

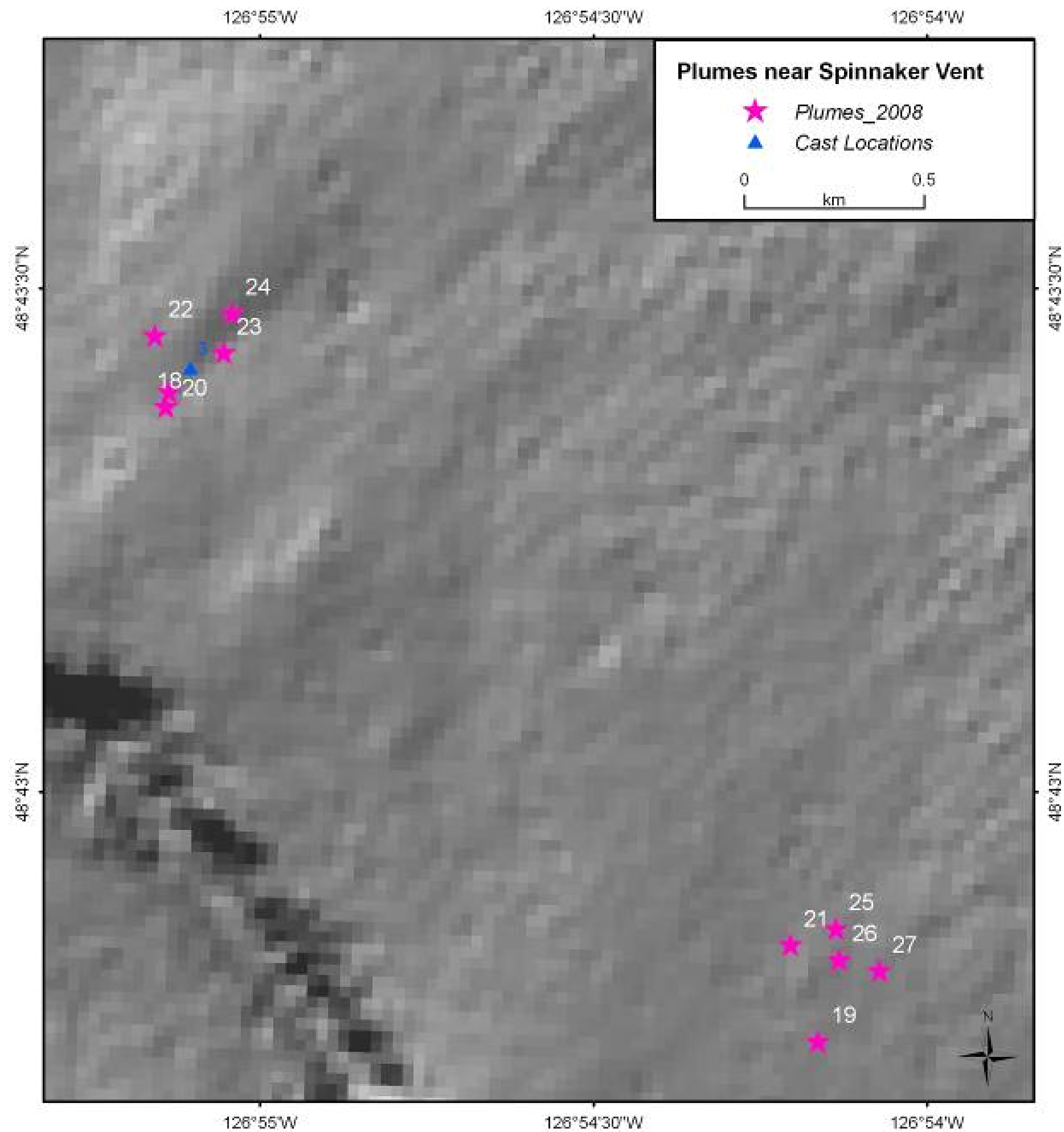


Figure 2
Map of vent-locations visited during the expedition 2010007
(b) Spinnaker Vent

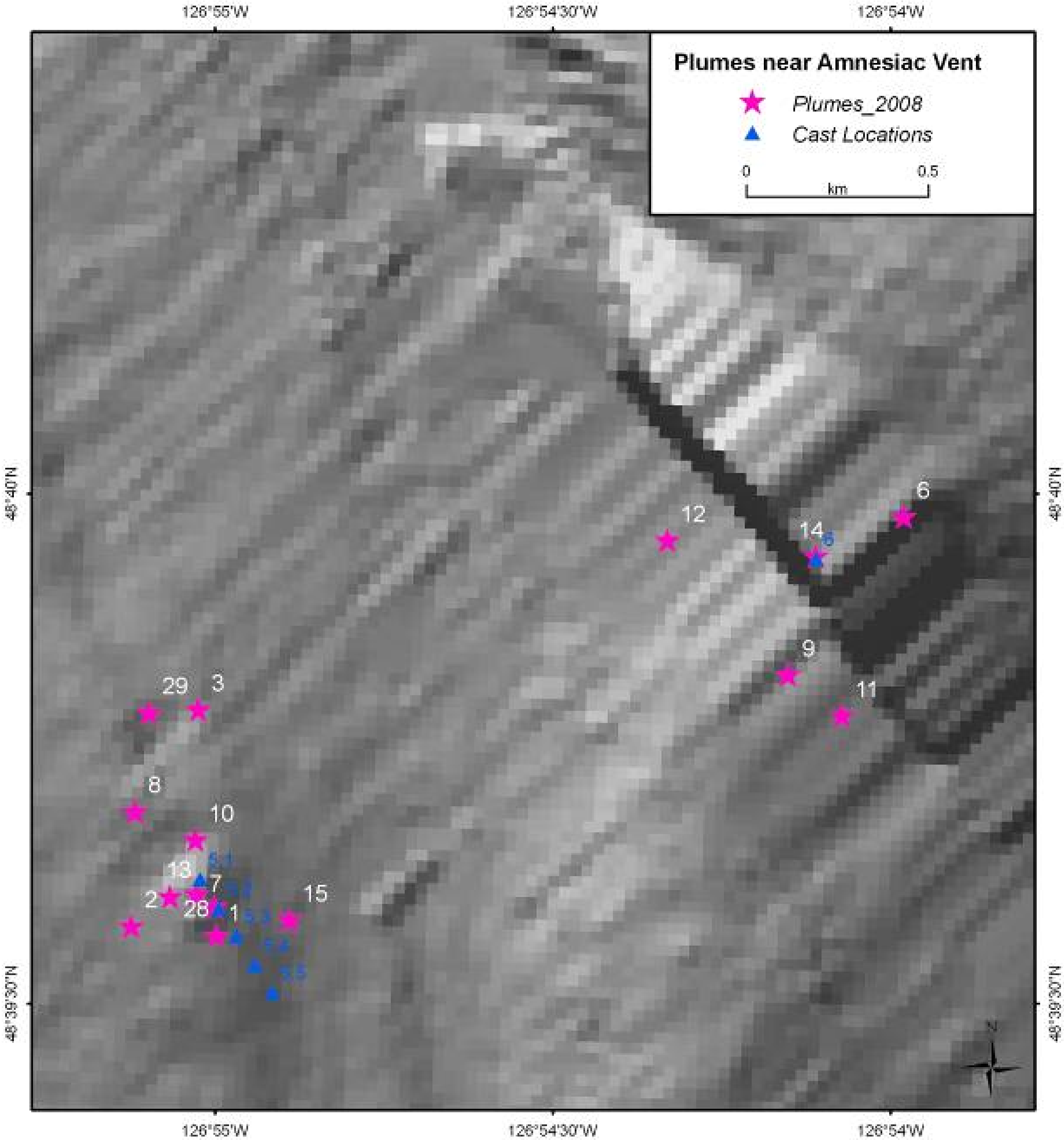


Figure 2
Map of vent-locations visited during the expedition 2010007
(c) Amnesiac Vent

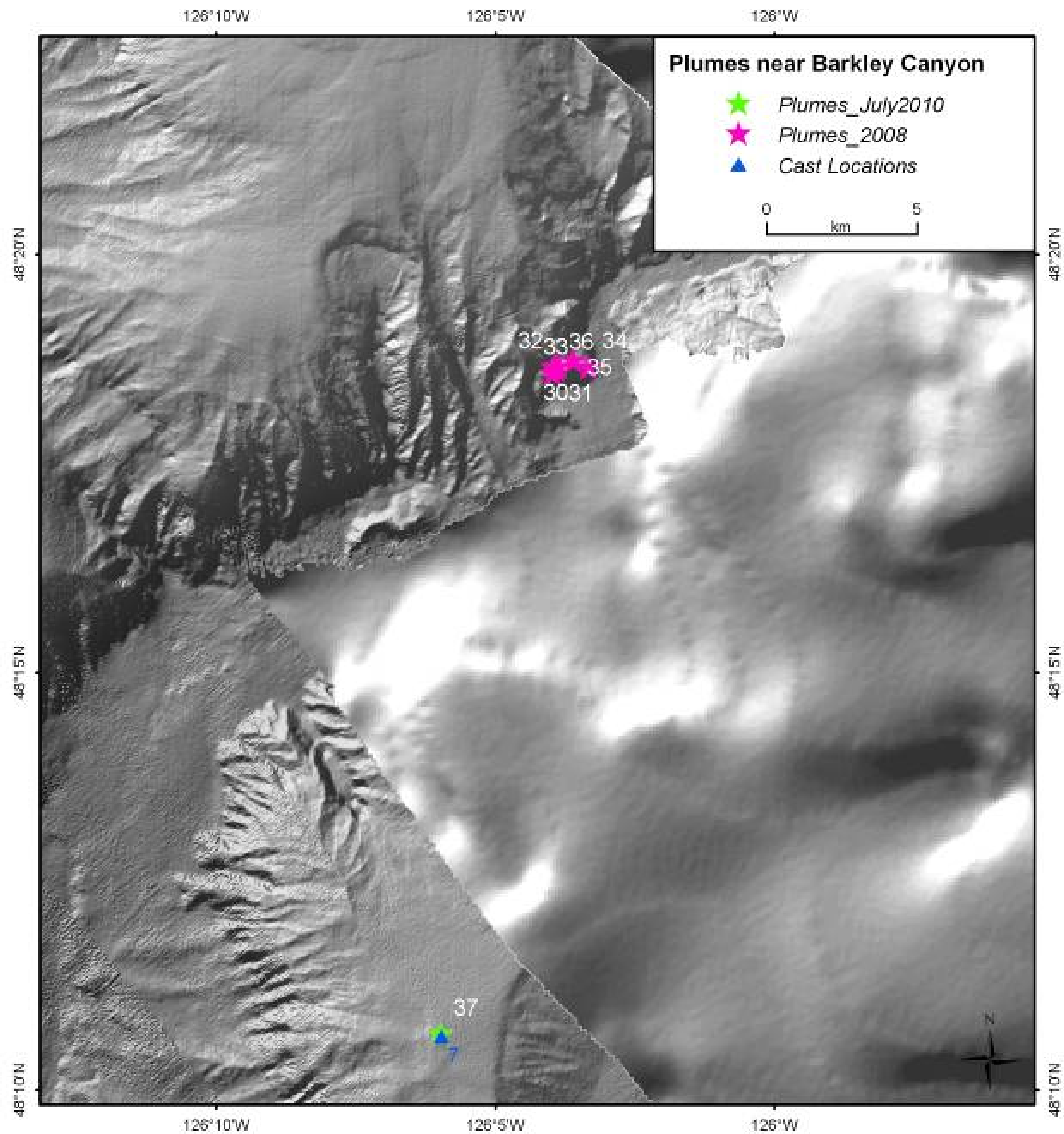


Figure 2
Map of vent-locations visited during the expedition 2010007
(d) Barkley Canyon

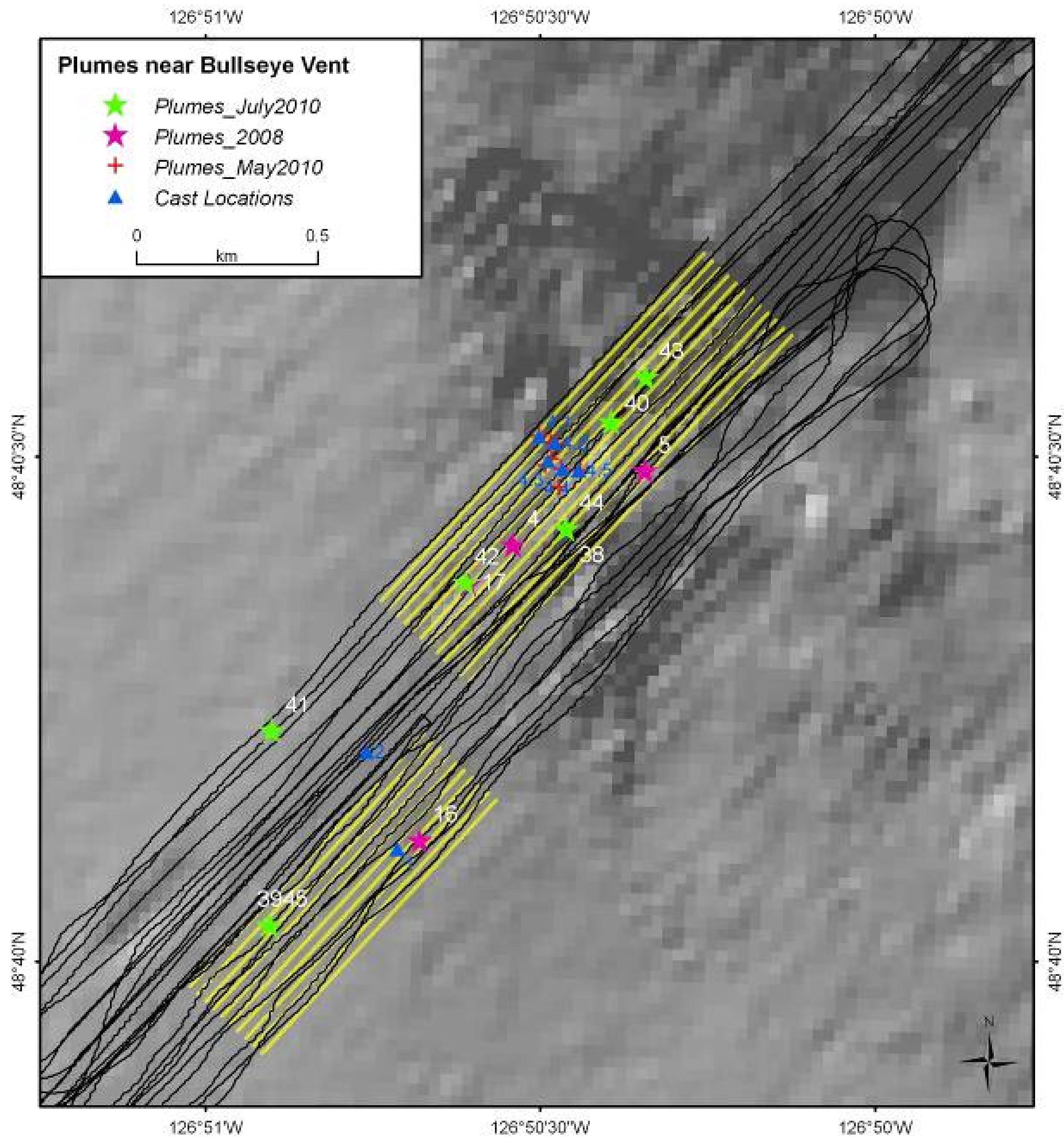


Figure 3
Acoustic lines acquired (black) and proposed (yellow) over Plume locations
(a) Bullseye Vent and Bubbly Gulch

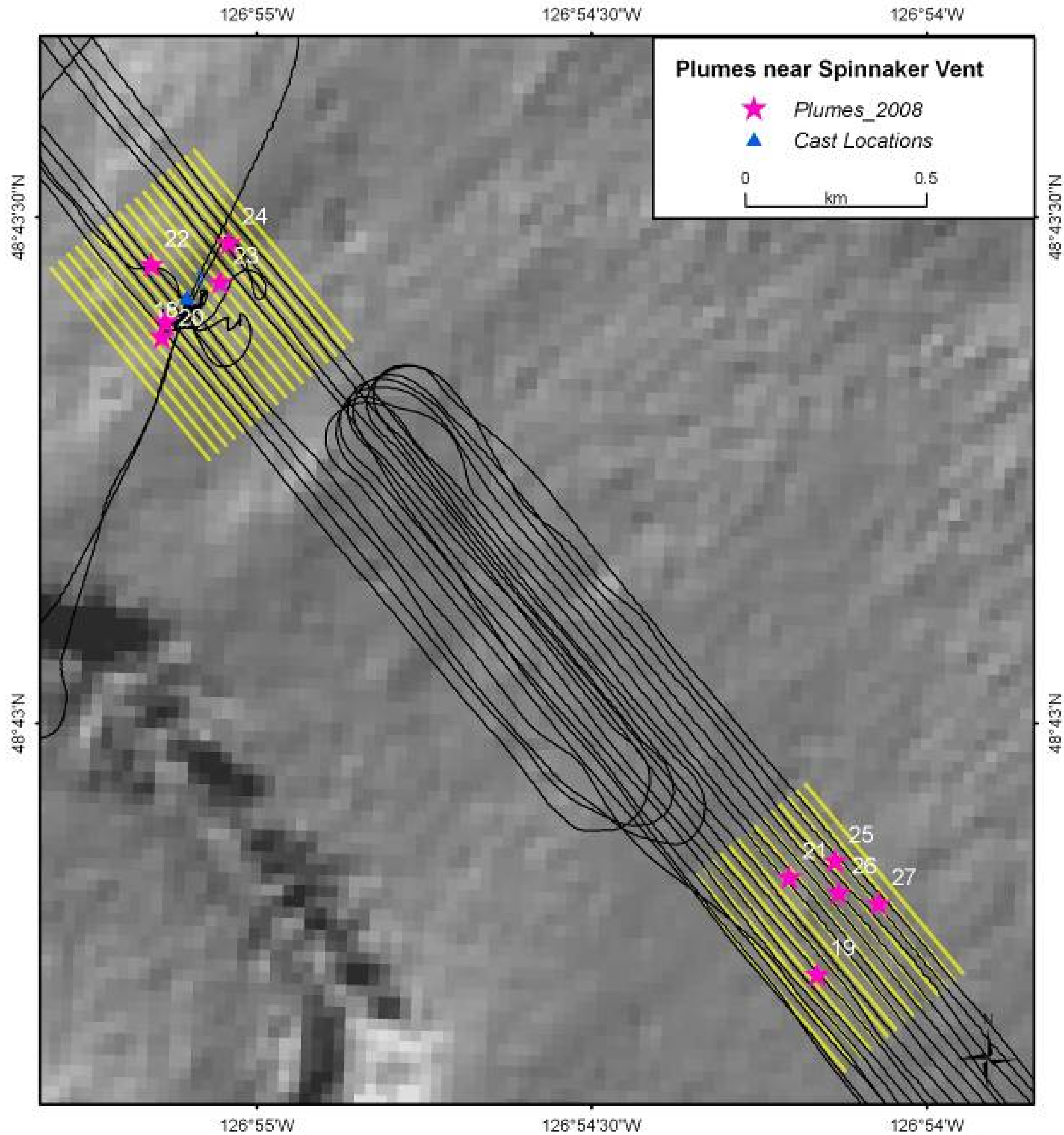


Figure 3
Acoustic lines acquired (black) and proposed (yellow) over Plume locations
(b) Spinnaker Vent

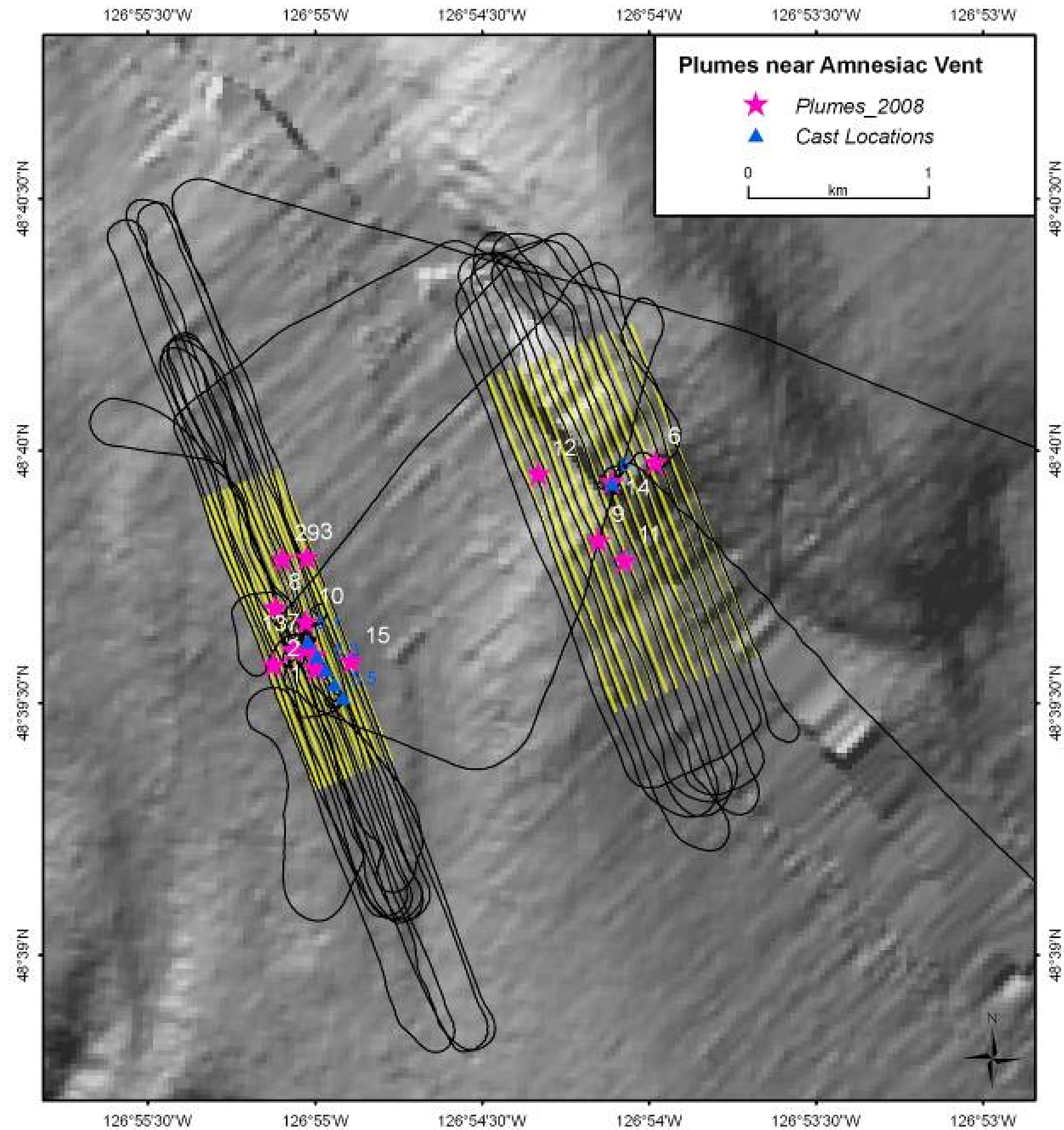


Figure 3
Acoustic lines acquired (black) and proposed (yellow) over Plume locations
(c) Amnesiac Vent

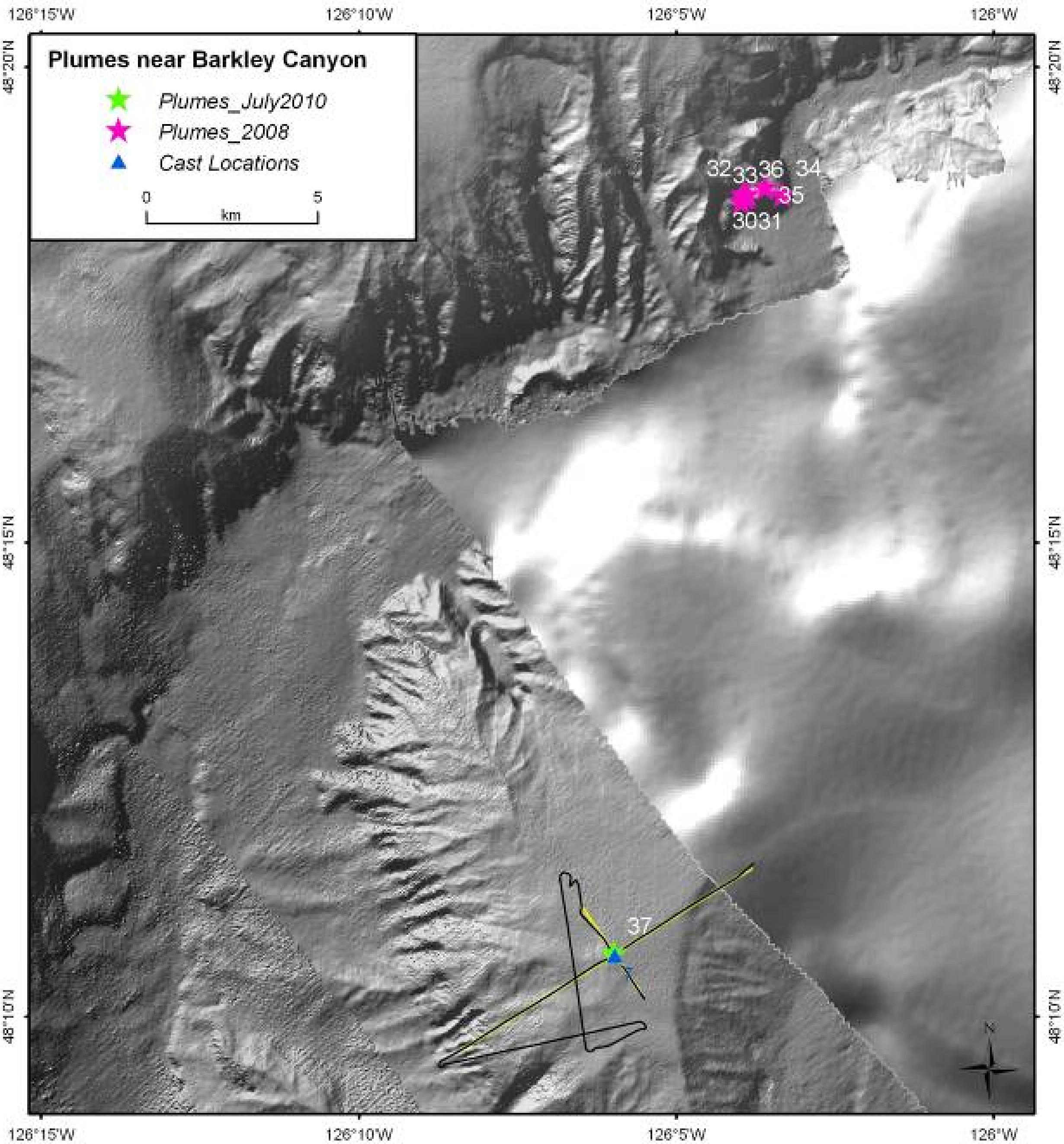


Figure 3
Acoustic lines acquired (black) and proposed (yellow) over Plume locations
(d) Barkley Canyon

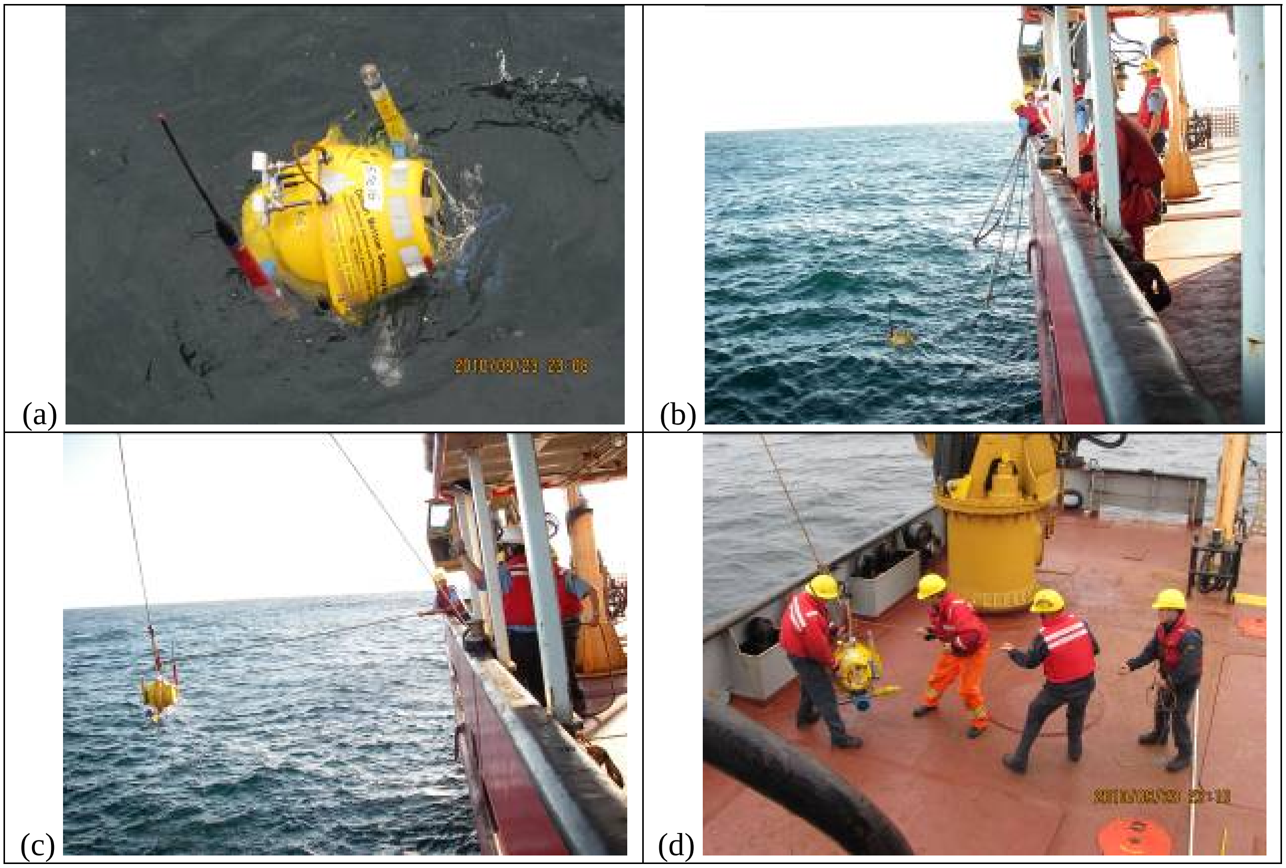


Figure 4

Examples of OBS recovery. (a) OBS floating in water, the radio beacon (red) and flash-light (yellow) are mounted at the sides of the floatation-sphere (main yellow body of OBS); (b) Quick-release hooks are attached to the main OBS-recovery-hook; (c) The quick-release-hook is then attached to the main crane and lifted out of the water; (d) OBS arrives on deck.

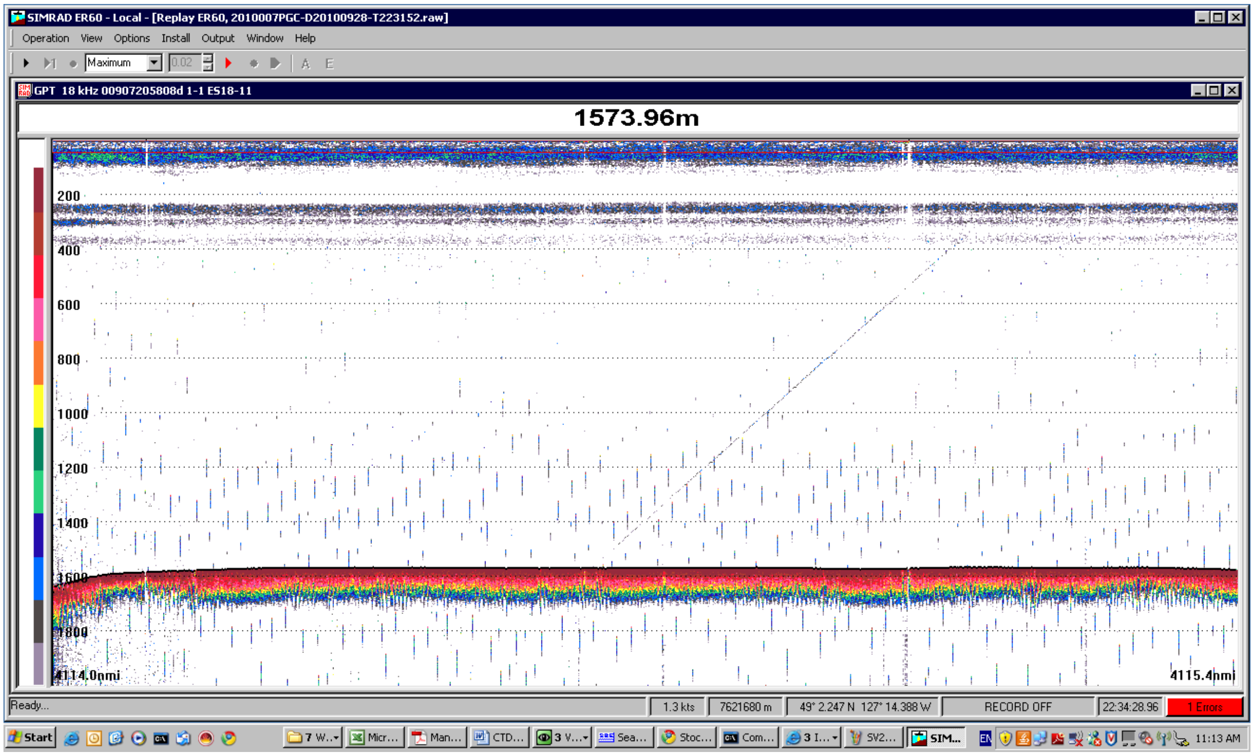
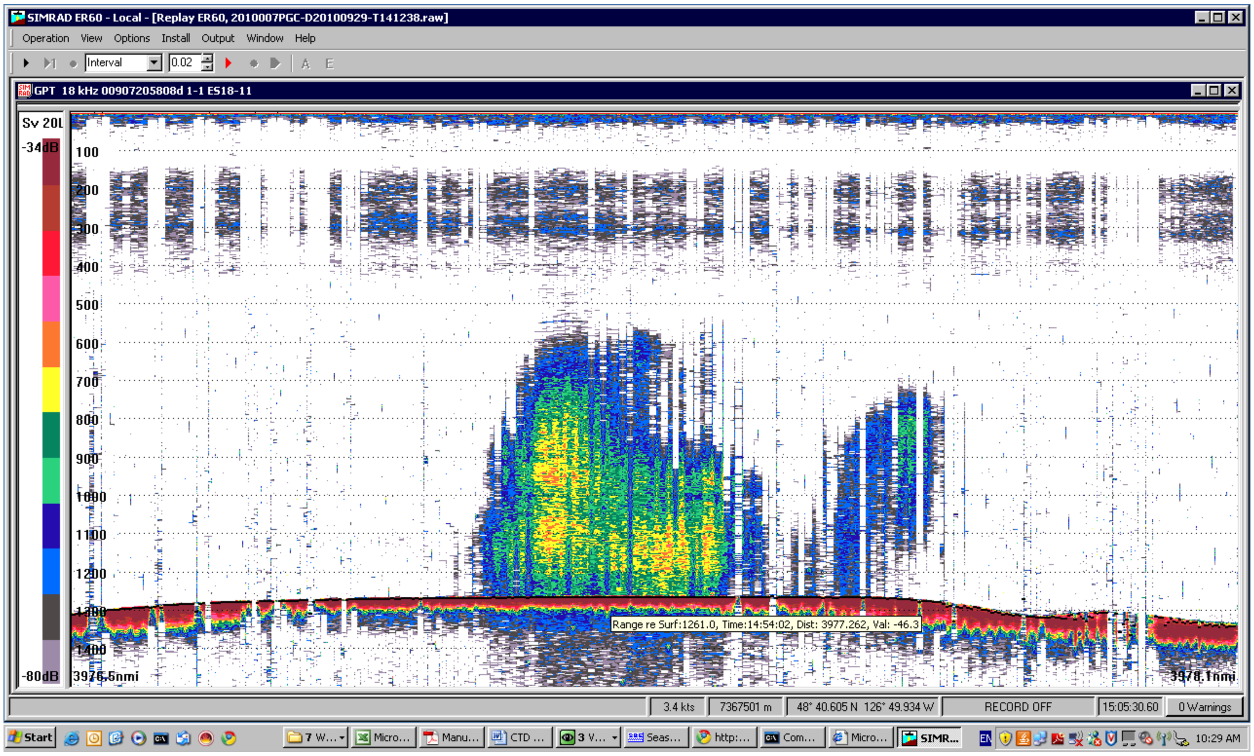


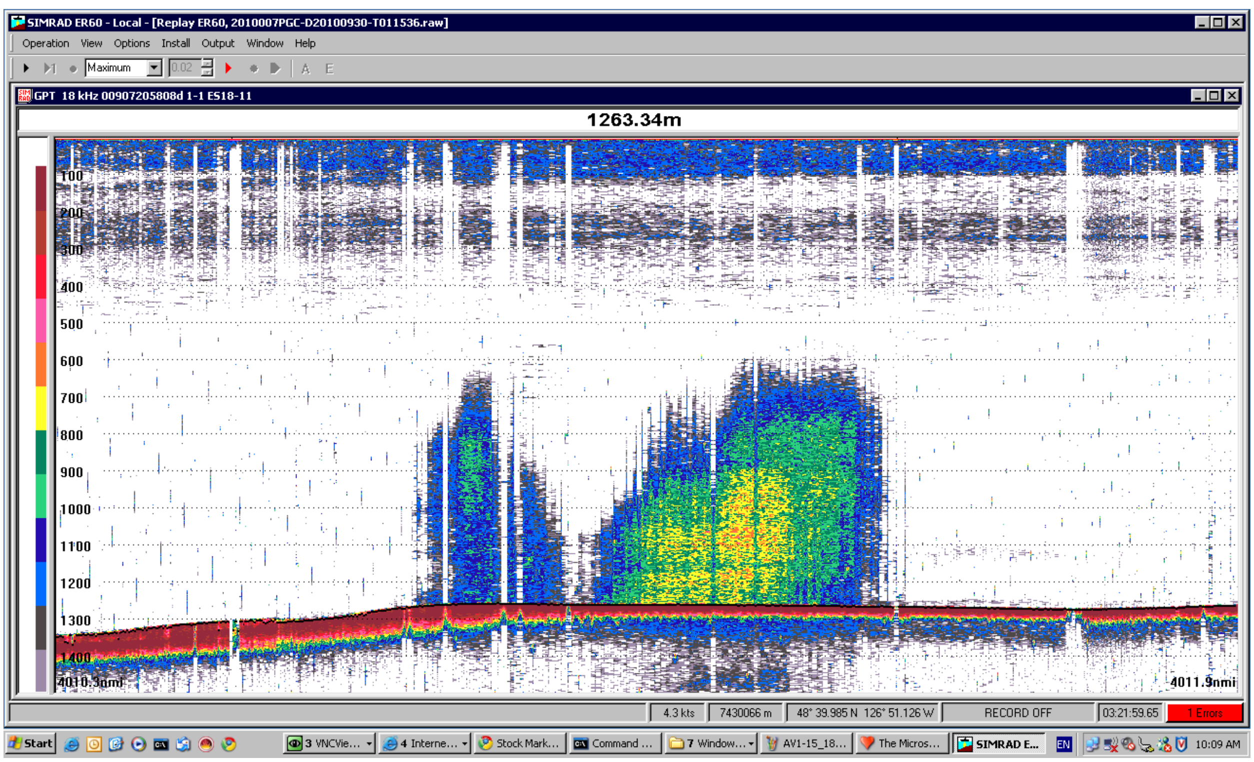
Figure 5

Example of the track of an OBS echo seen on the 18 kHz echosounder system. The OBS rises at a speed of 1 m/second (60 meter per minute). The records of the OBS ascent were possible only on the days after the storm was over and seas/wind had considerably calmed down.



<u>Figure 6</u>

(a) Example of acoustic plume at Bullseye Vent (Area 1).



<u>Figure 6</u>

(b) Example of acoustic plume at Bullseye Vent (Area 2).

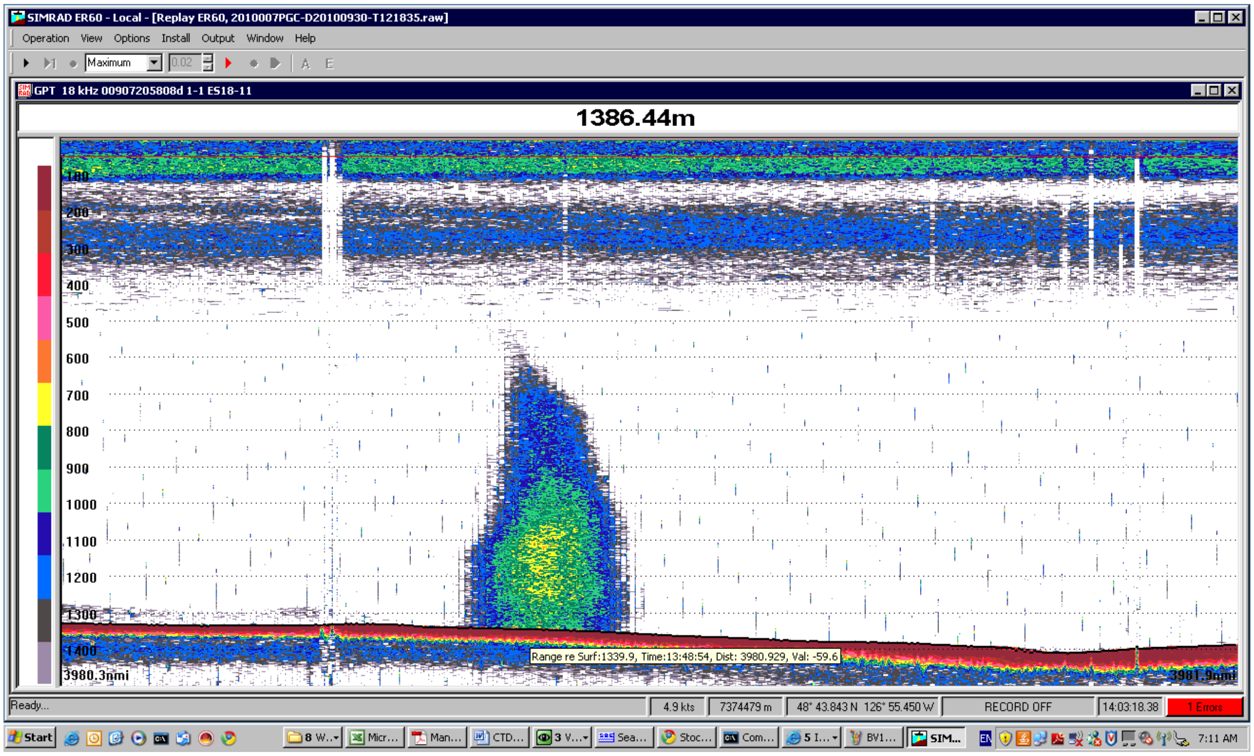


Figure 6
(c) Example of acoustic plume at Spinnaker Vent (Area 2).

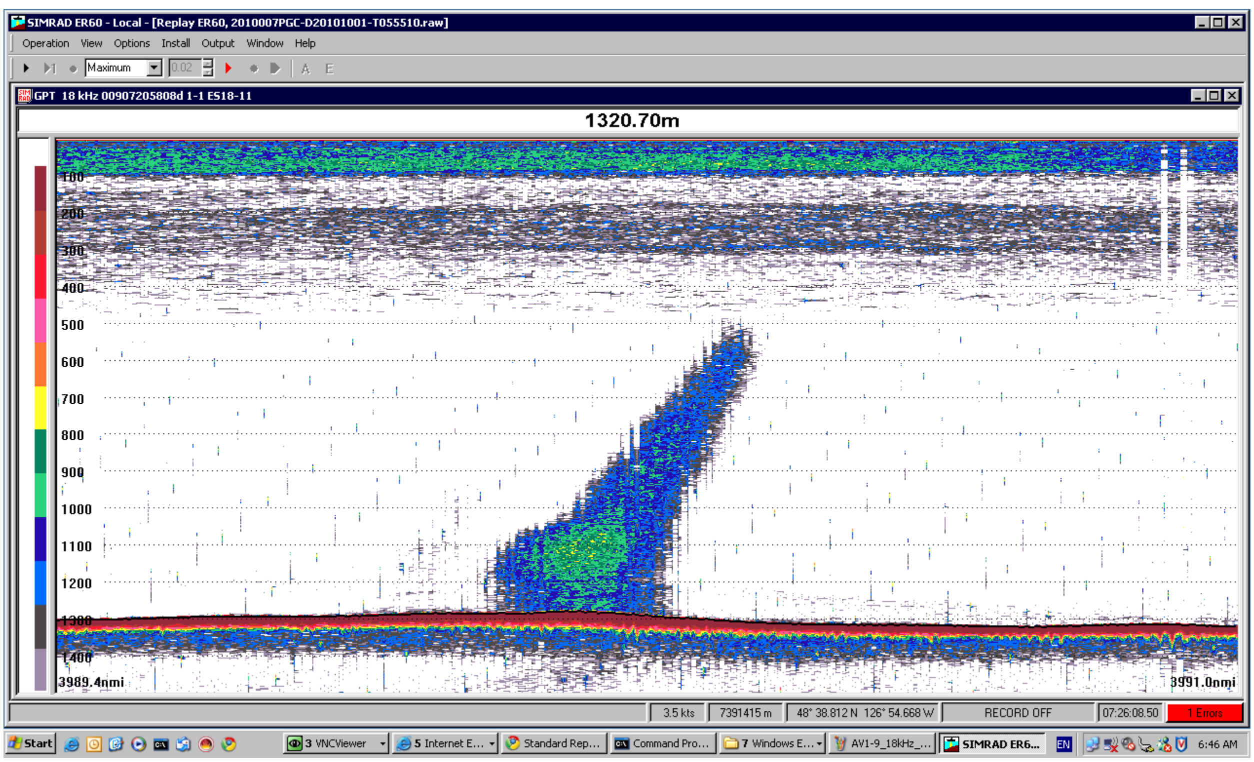


Figure 6
(d) Example of acoustic plume at Amnesiac Vent (Area 1).

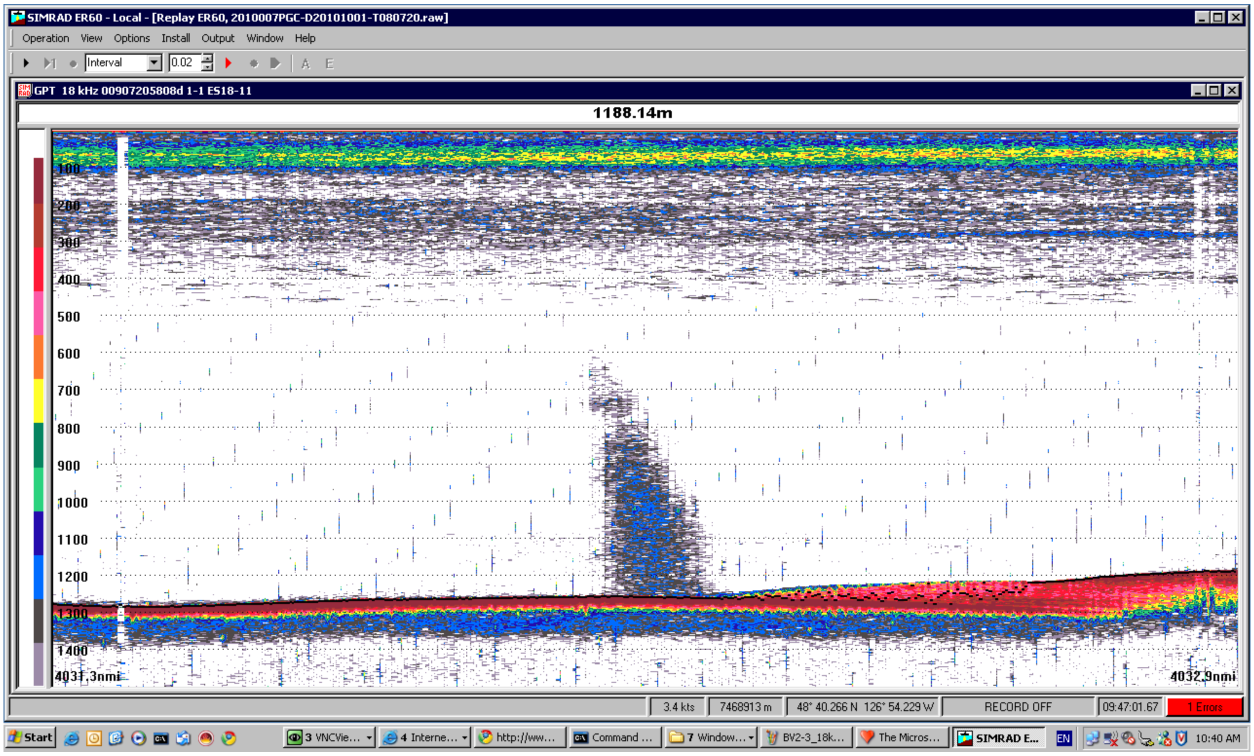


Figure 6

(e) Example of acoustic plume at Amnesiac Vent (Area 2).

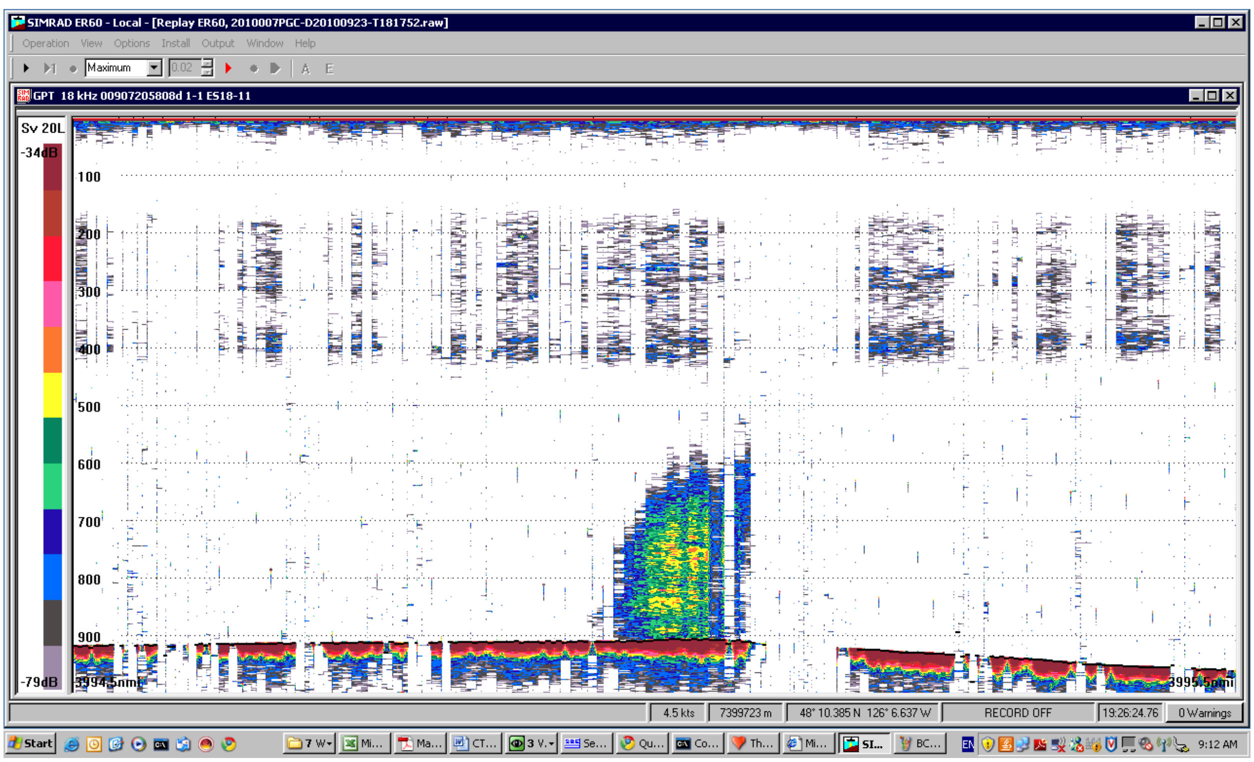


Figure 6

(f) Example of acoustic plume at Barkley Canyon.

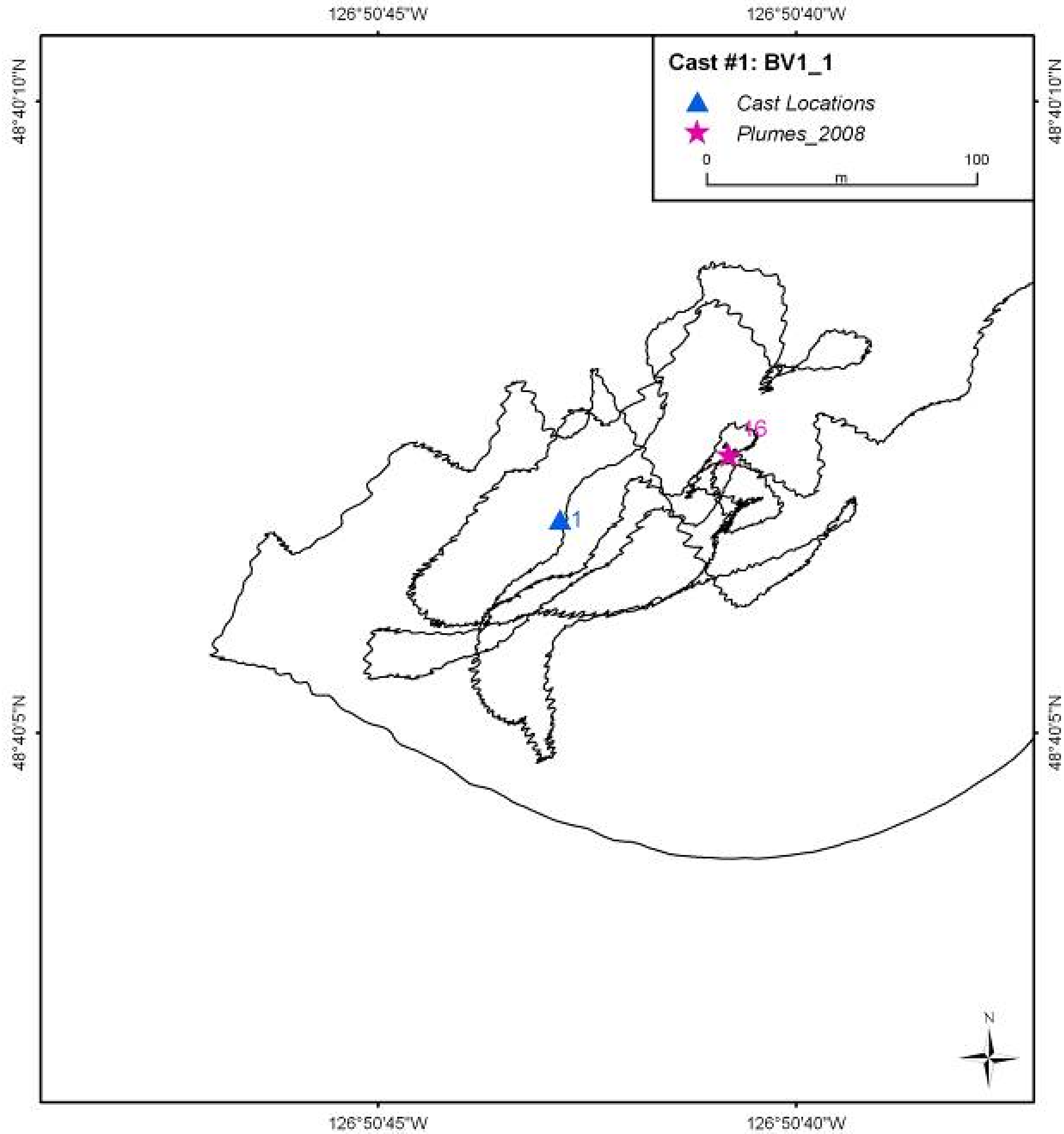


Figure 7
(a) Location of vessel on CTD cast 1 at Bullseye Vent Area 1 (BV1-1)

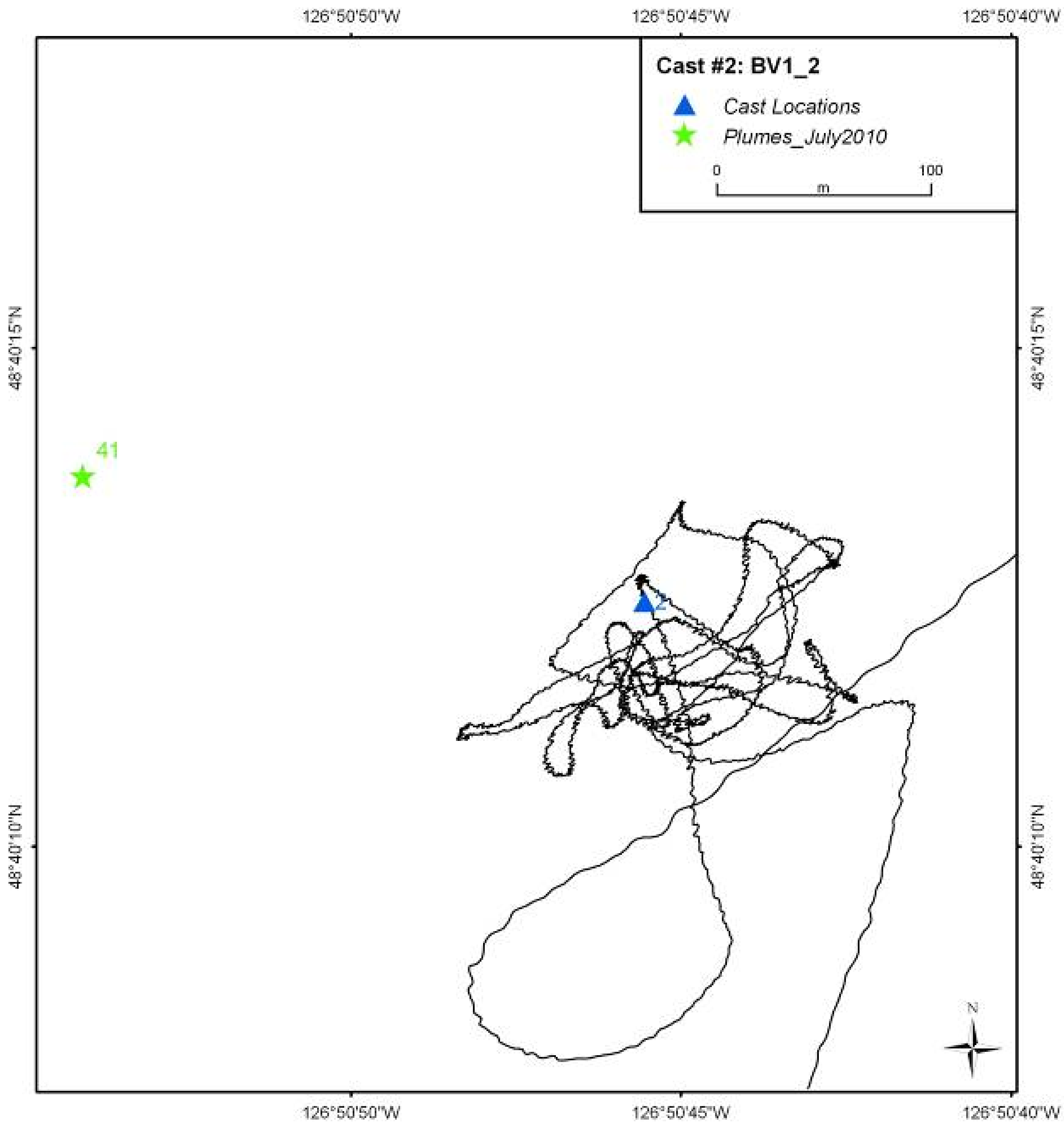


Figure 7
(b) Location of vessel on CTD cast 2 at Bullseye Vent Area 1 (BV1-2)

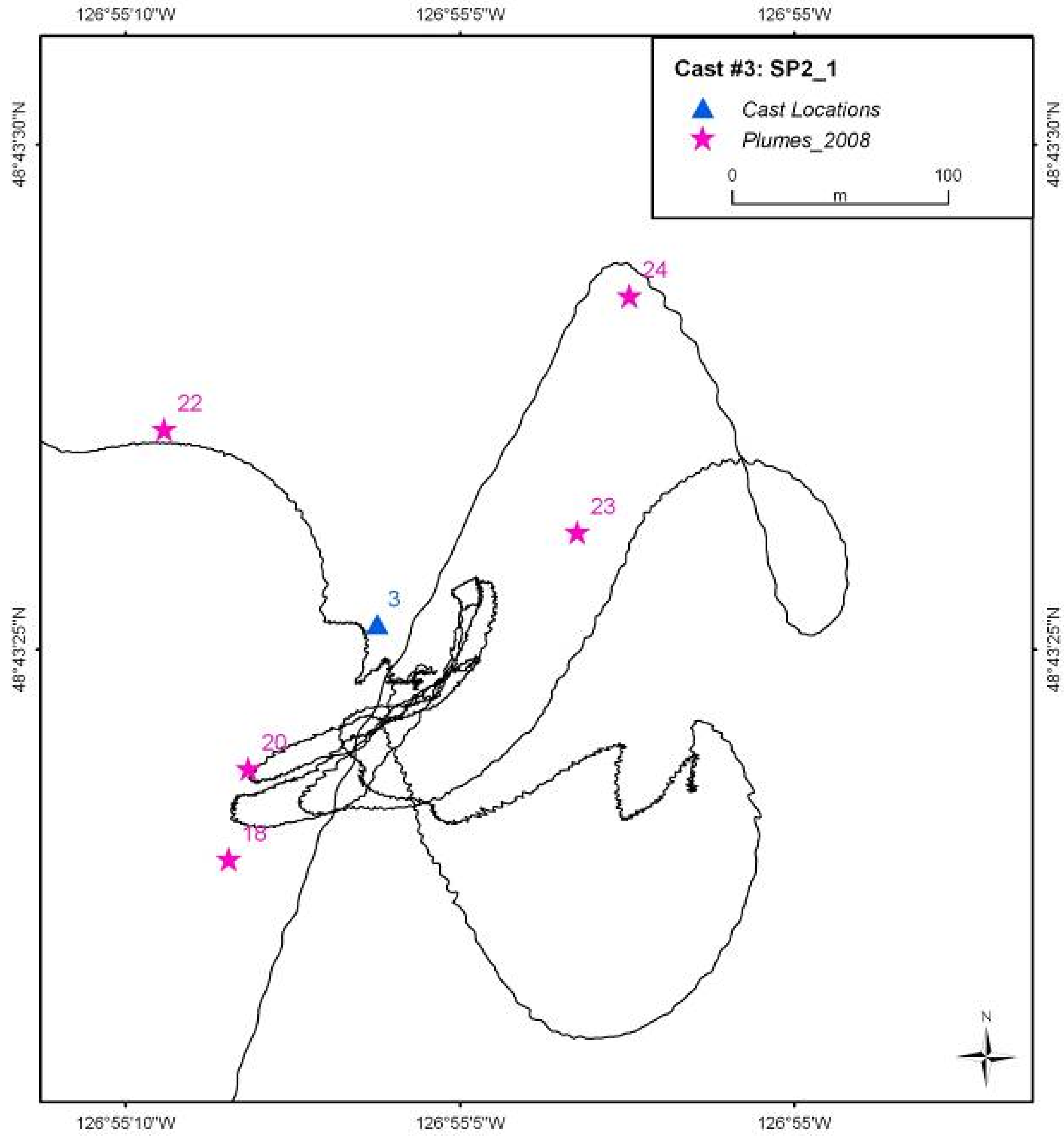


Figure 7
(c) Location of vessel on CTD cast 3 at Spinnaker Vent Area 2 (SV2-1)

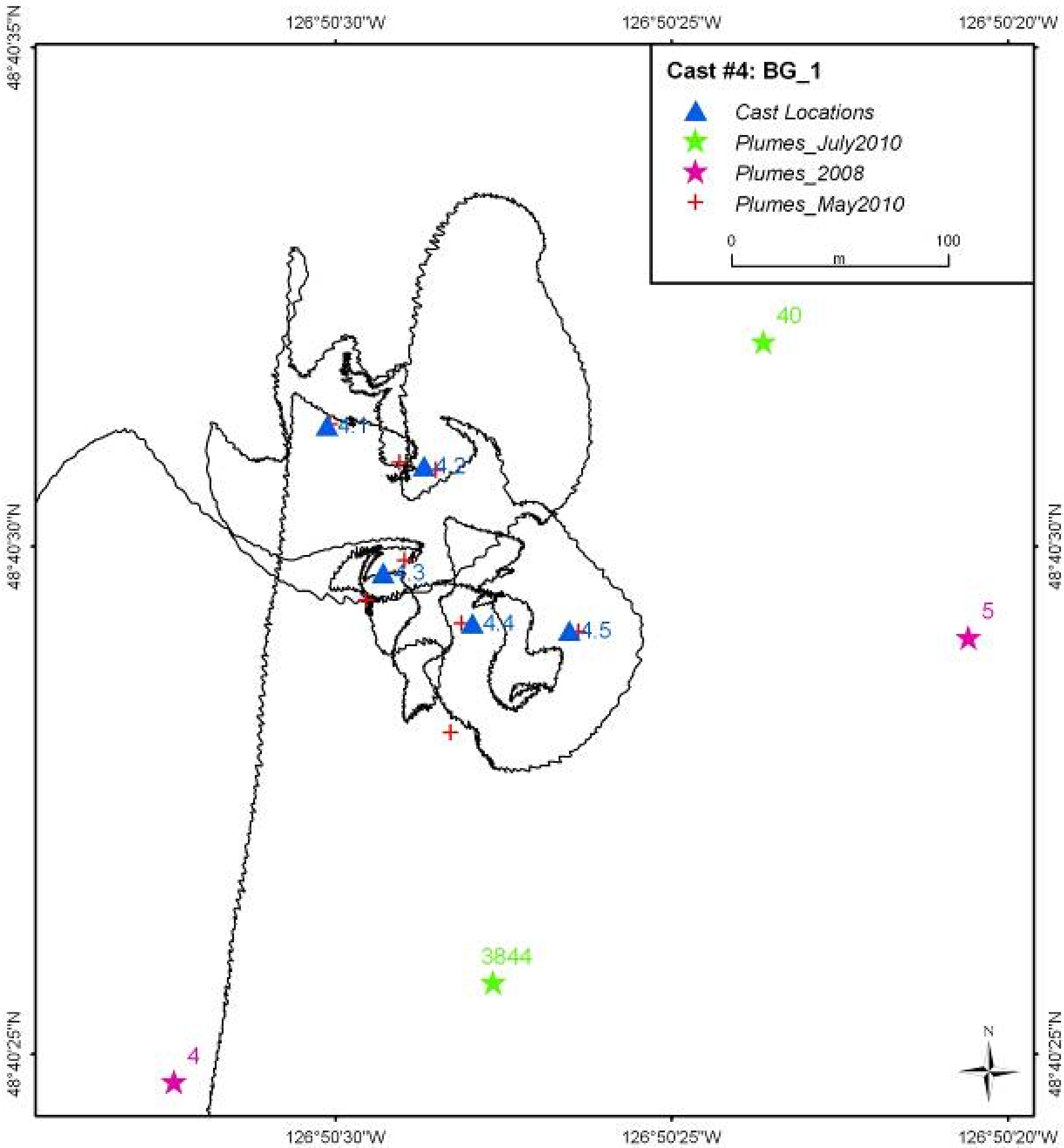


Figure 7
(d) Location of vessel on CTD cast 4 at Bubbly Gulch (BG-1)

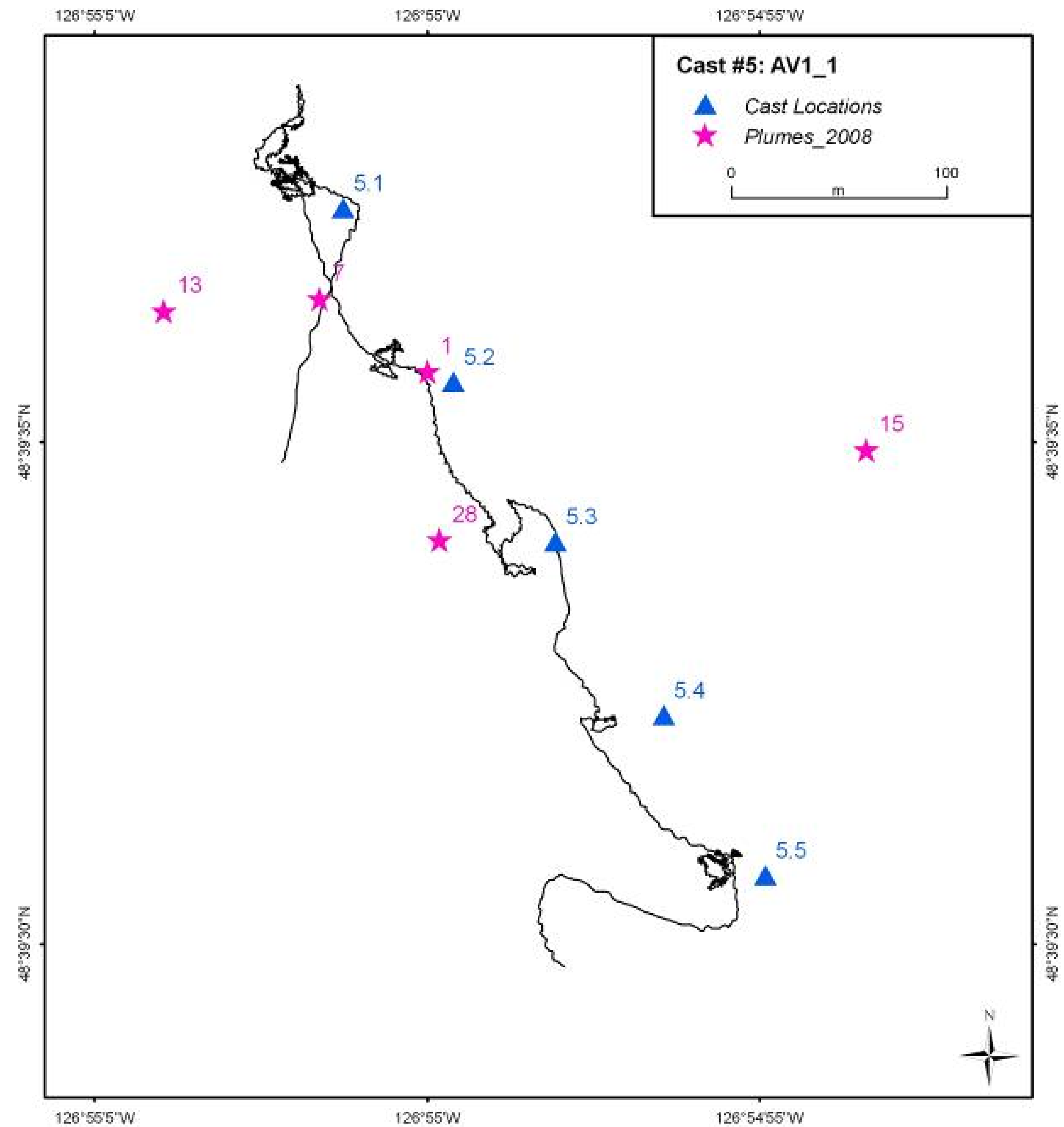


Figure 7
(e) Location of vessel on CTD cast 5 at Amnesiac Vent Area 1 (AV1-1)

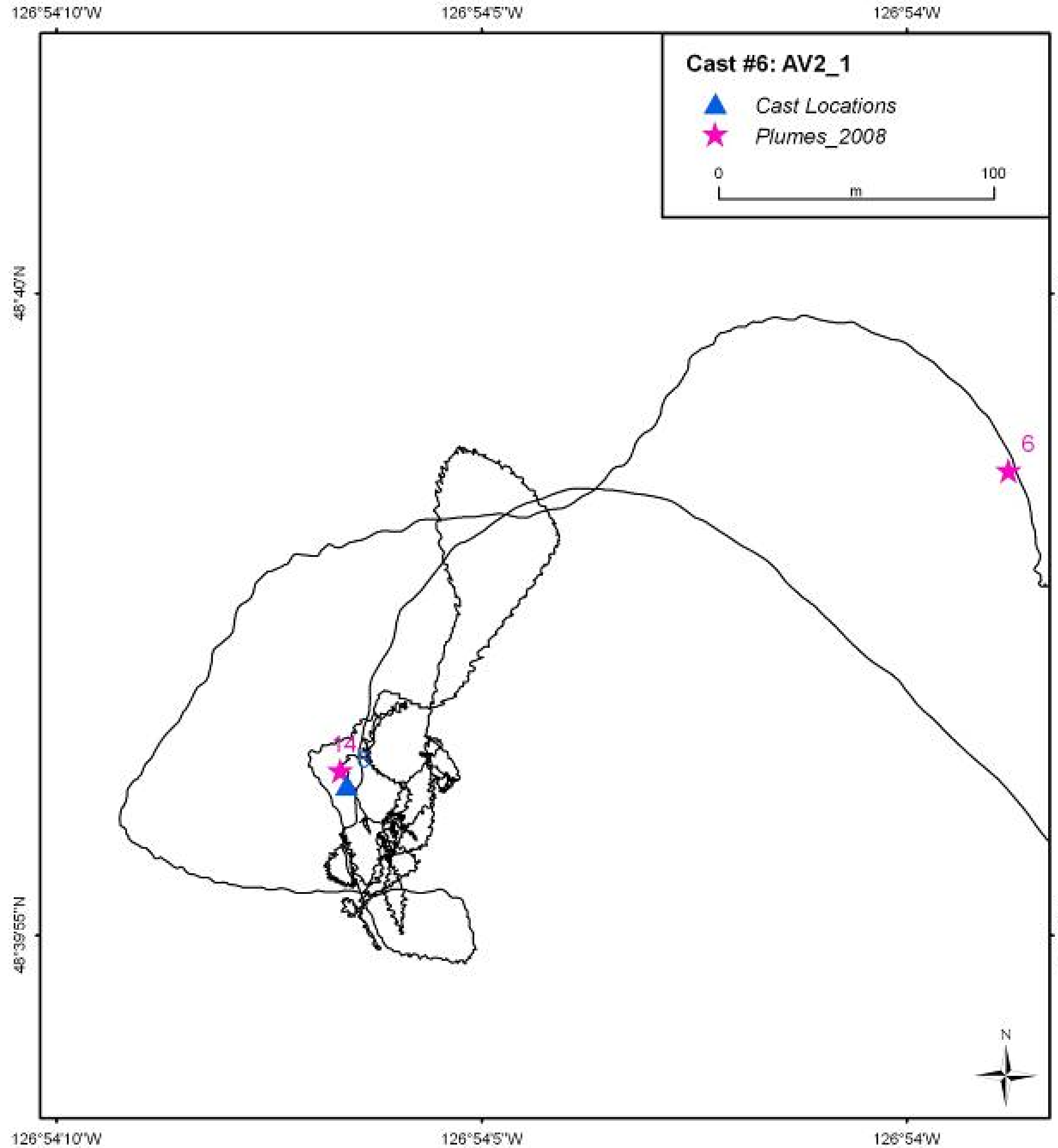


Figure 7
(f) Location of vessel on CTD cast 6 at Amnesiac Vent Area 2 (AV2-1).

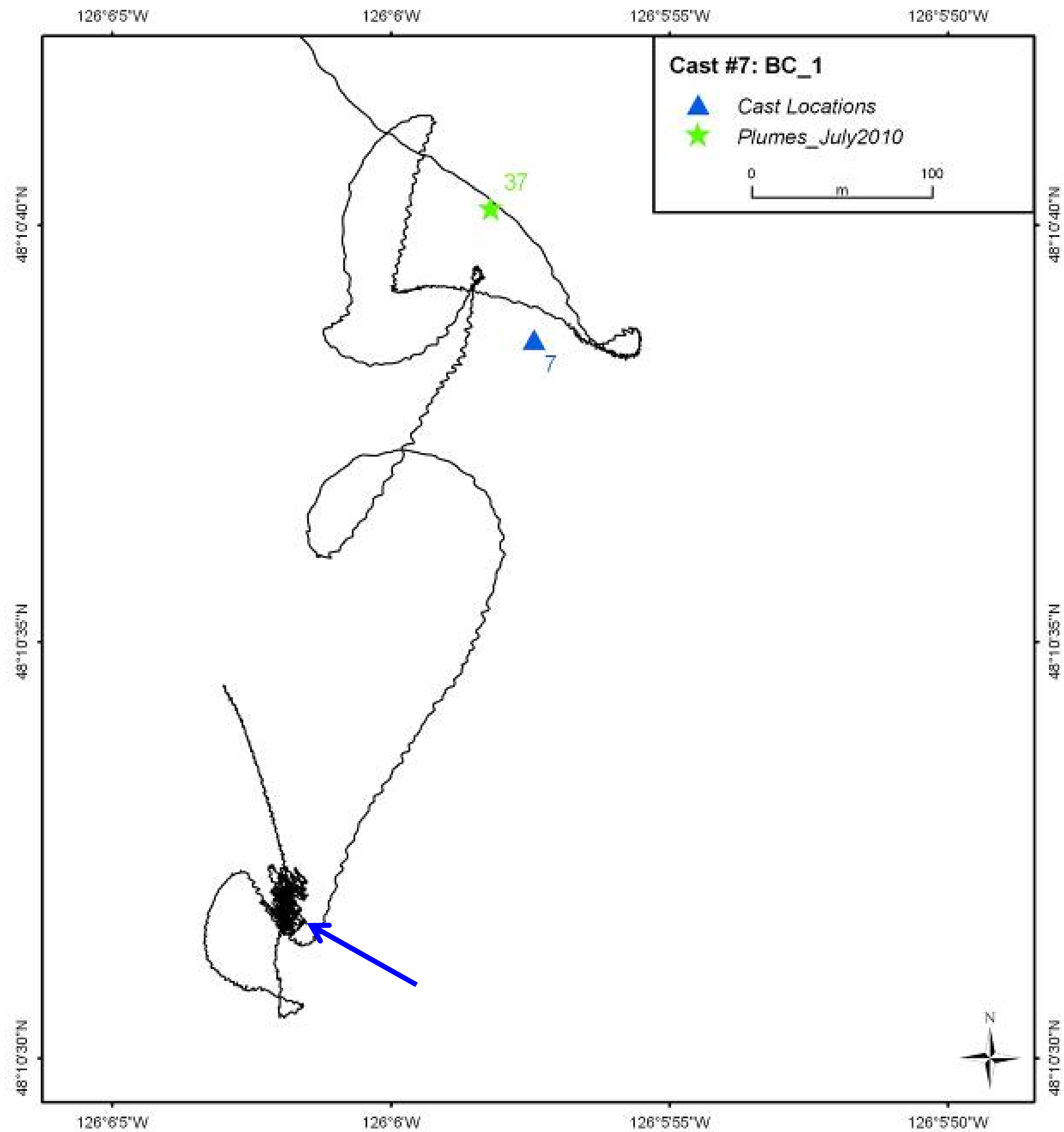


Figure 7

(g) Location of vessel on CTD cast 7 at Barkley Canyon (BC-1). Note that the intended Cast-location (#7) was chosen based on initial acoustic data from the two cross-lines over the plume-location (from July 2010 cruise). However, upon arrival on that location the plume was not as clear in the echo-sounder data as previously imaged. We started a drift around this location and picked up a much stronger signal of the plume towards the south (marked by blue arrow), upon which the CTD-cast was completed.

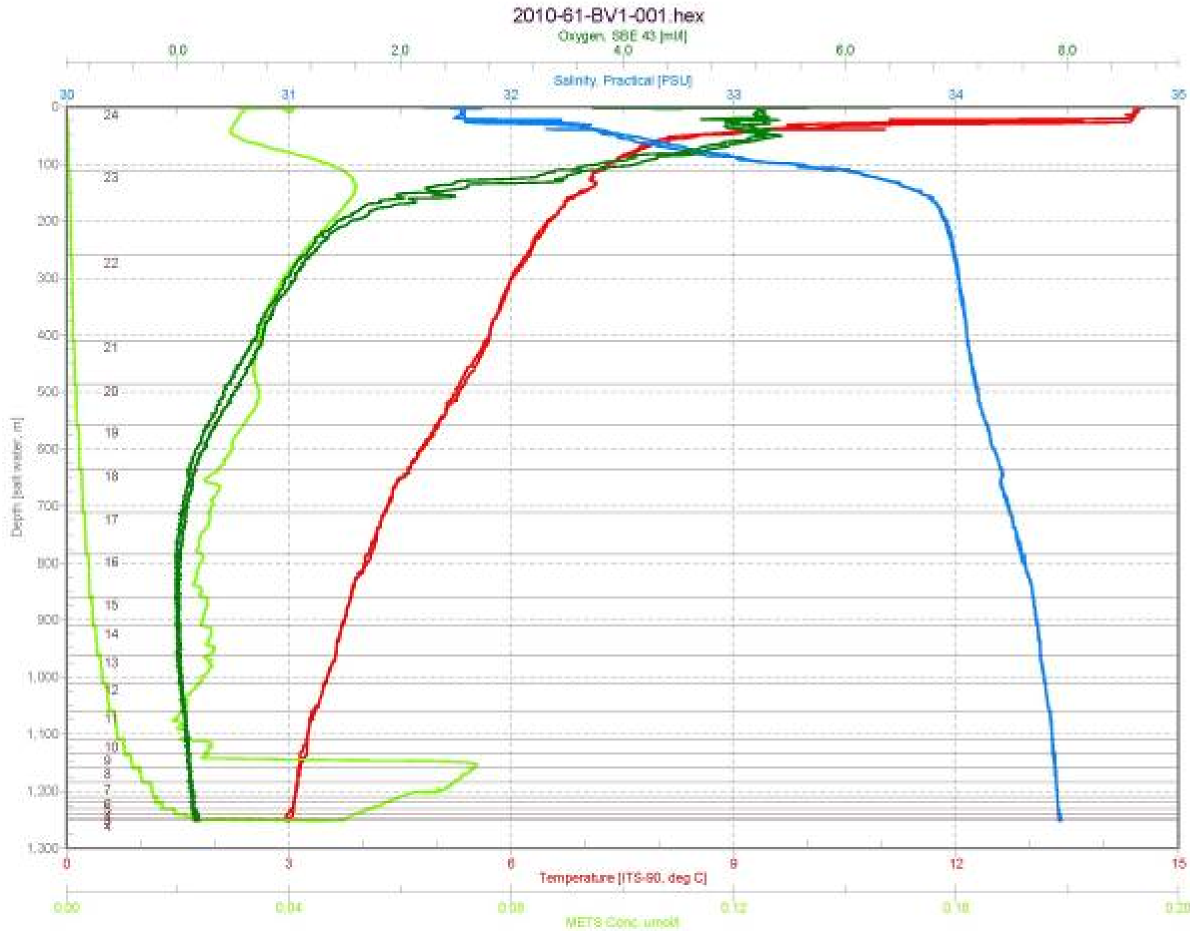


Figure 8
(a) CTD Cast-1 (BV1-1) at Bullseye Vent. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

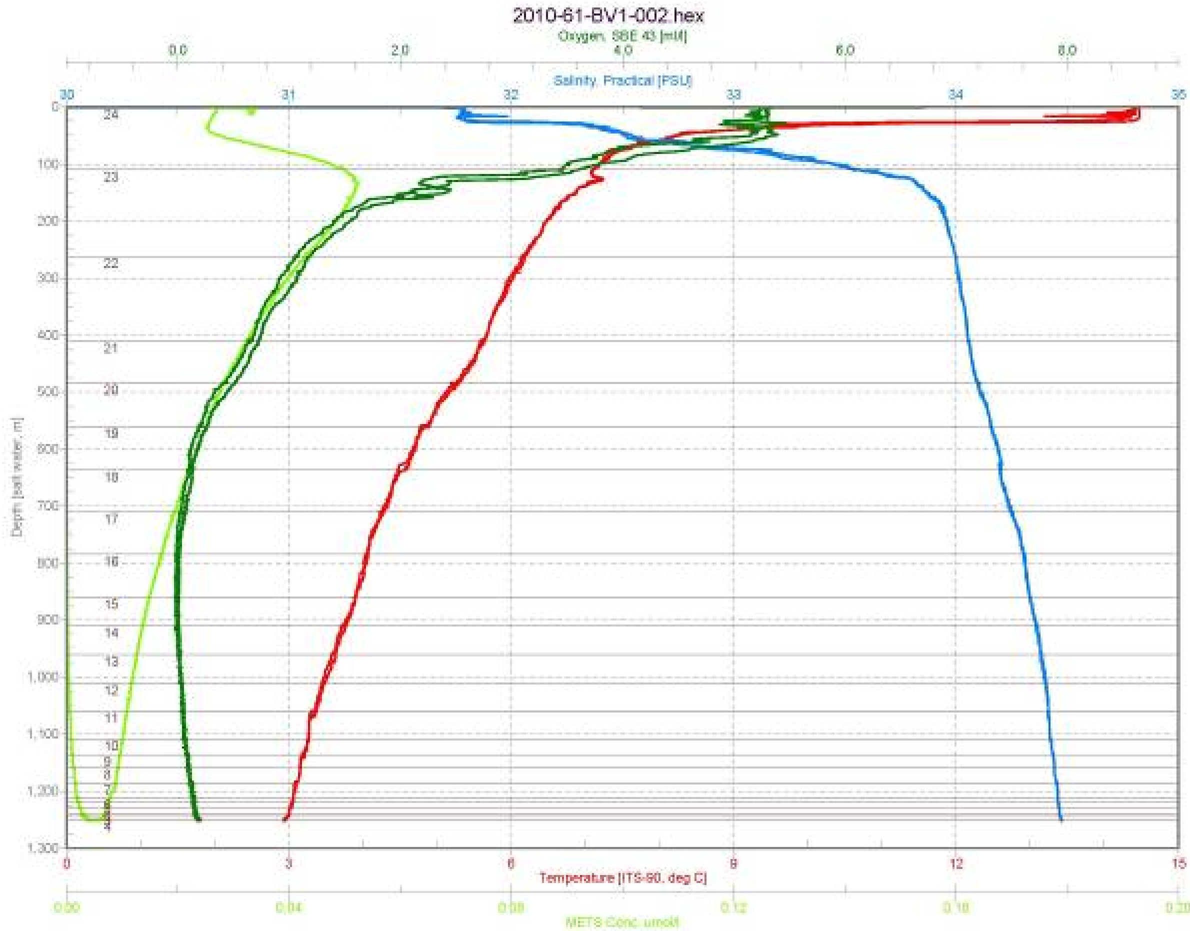


Figure 8
(b) CTD Cast-2 (BV1-2) at Bullseye Vent. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

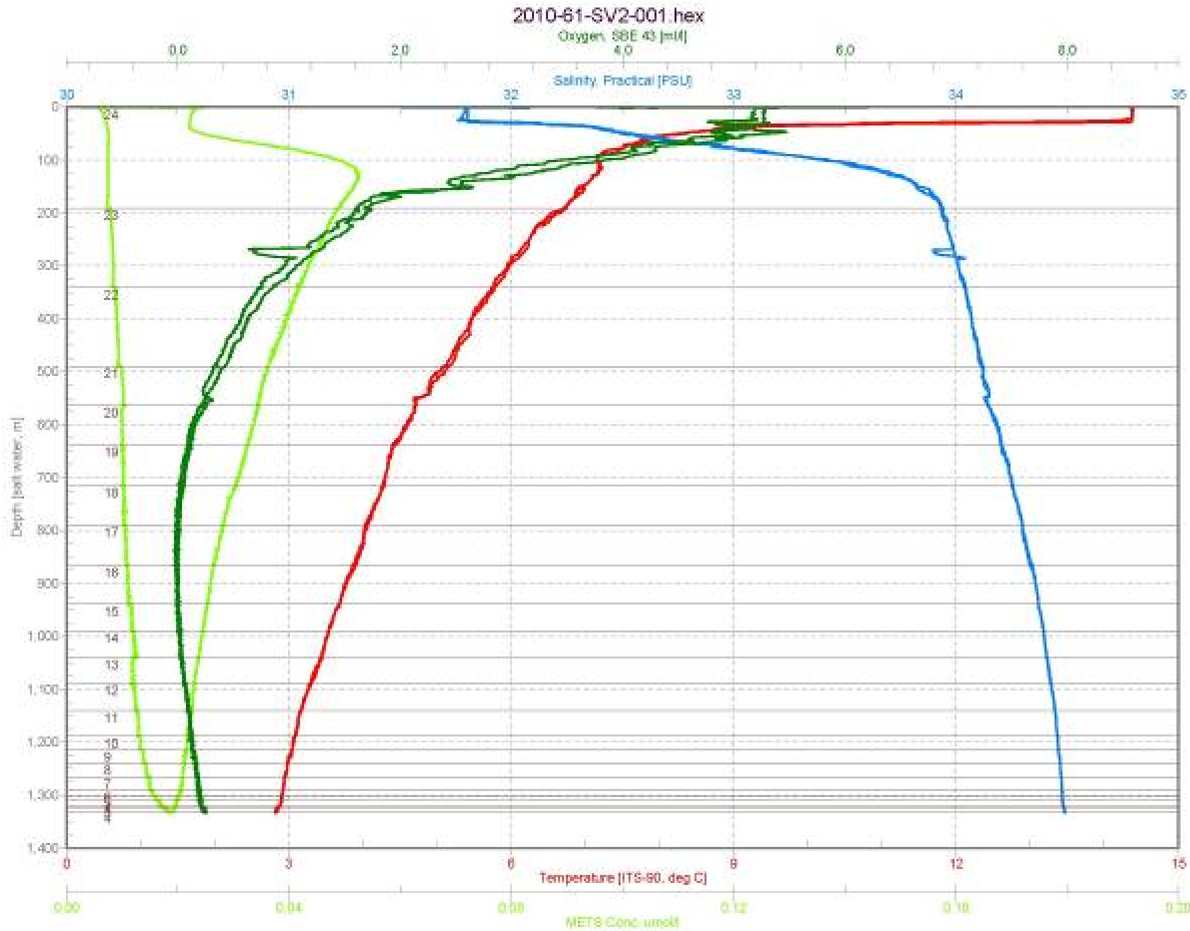


Figure 8
(c) CTD Cast-3 SV2-1 at Spinnaker Vent Area 2. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

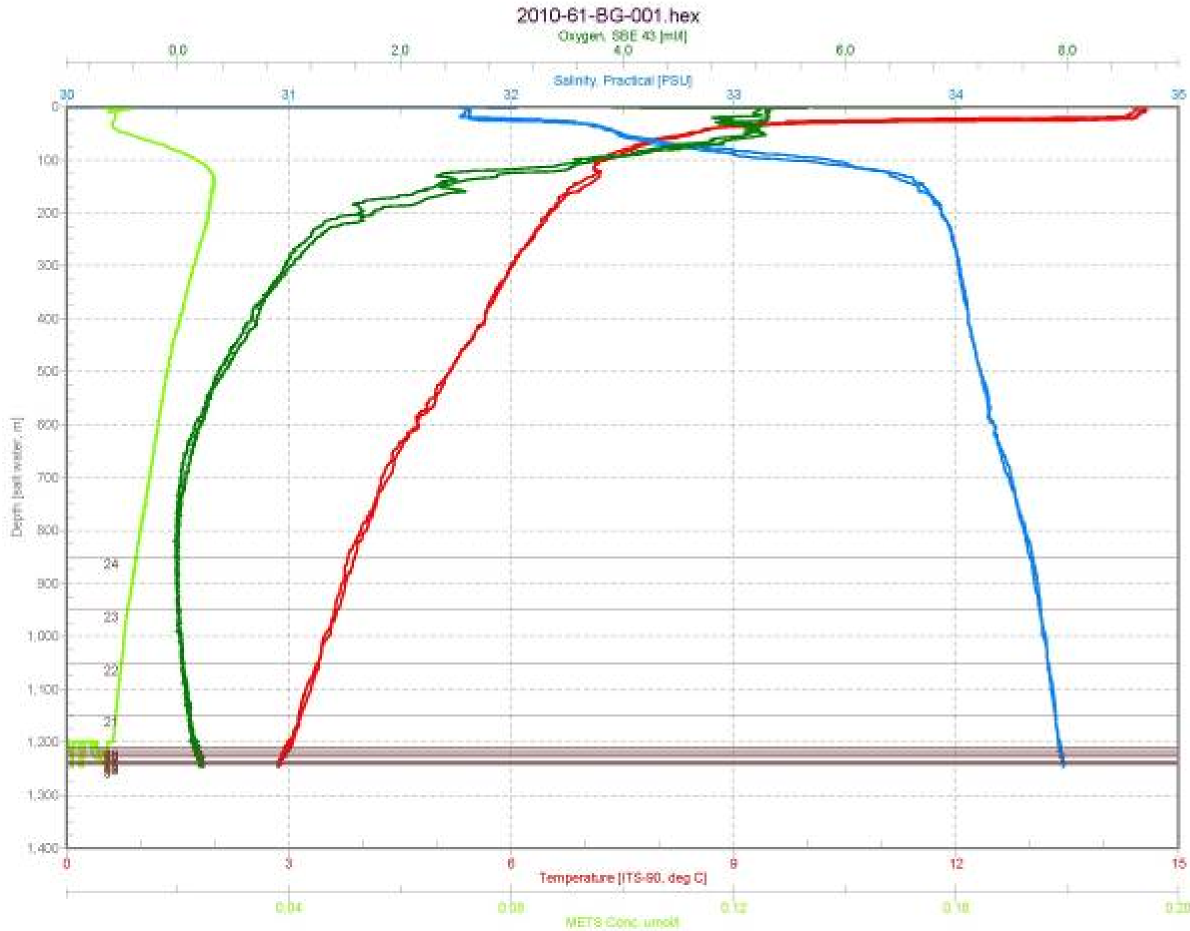


Figure 8
(d) CTD Cast-4 (BG-1) at Bubbly Gulch. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

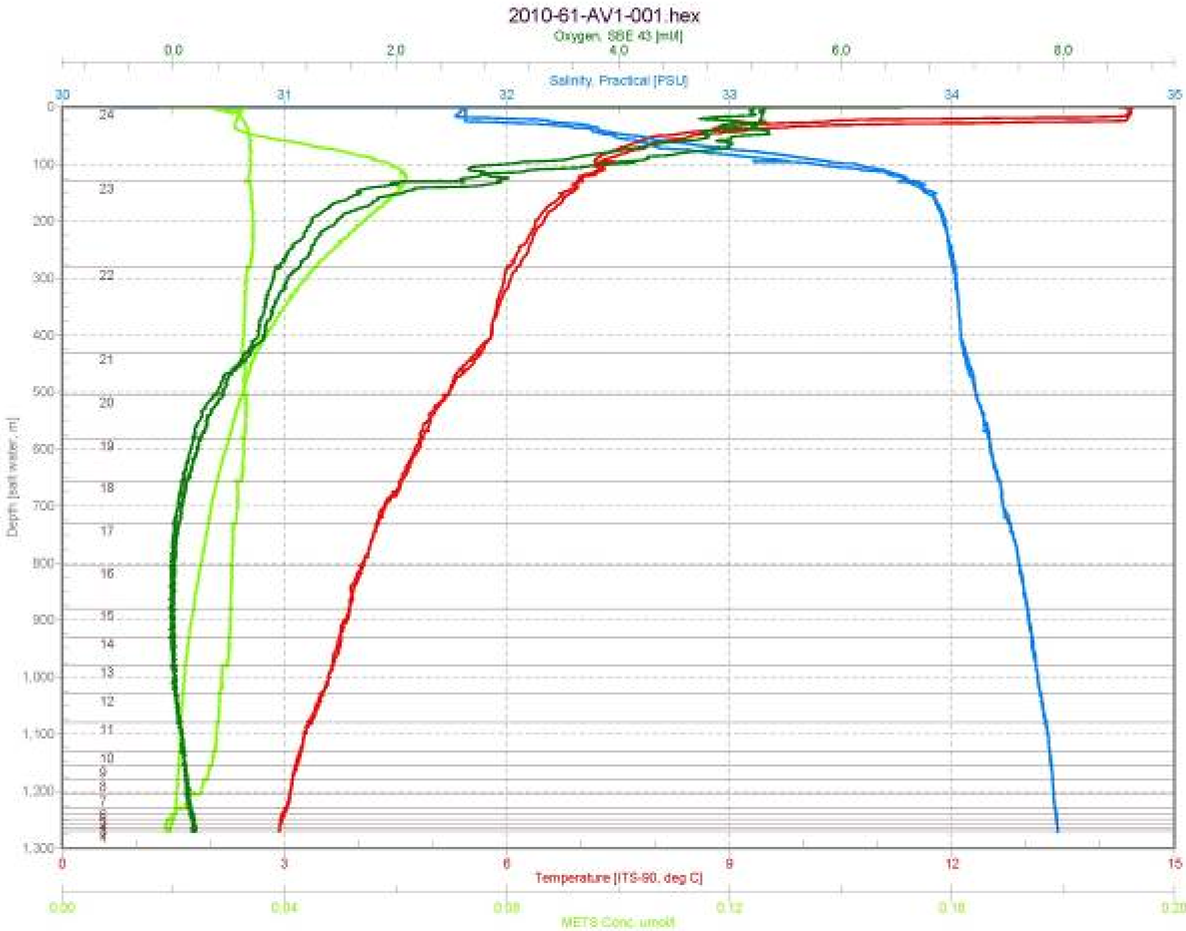


Figure 8
(e) CTD Cast-5 (AV1-1) at Amnesiac Vent Area 1. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

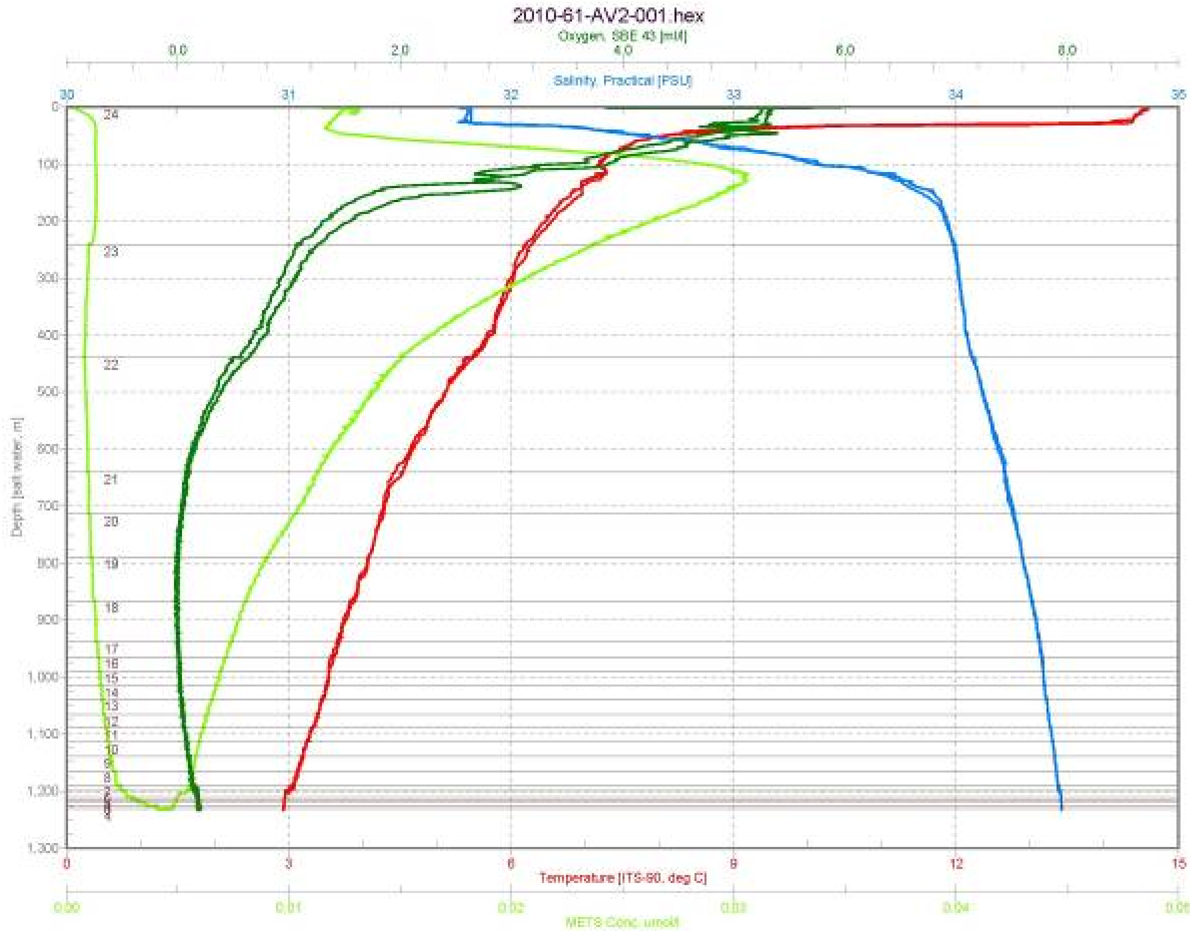


Figure 8
(f) CTD Cast-6 (AV2-1) at Amnesiac Vent Area 2. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

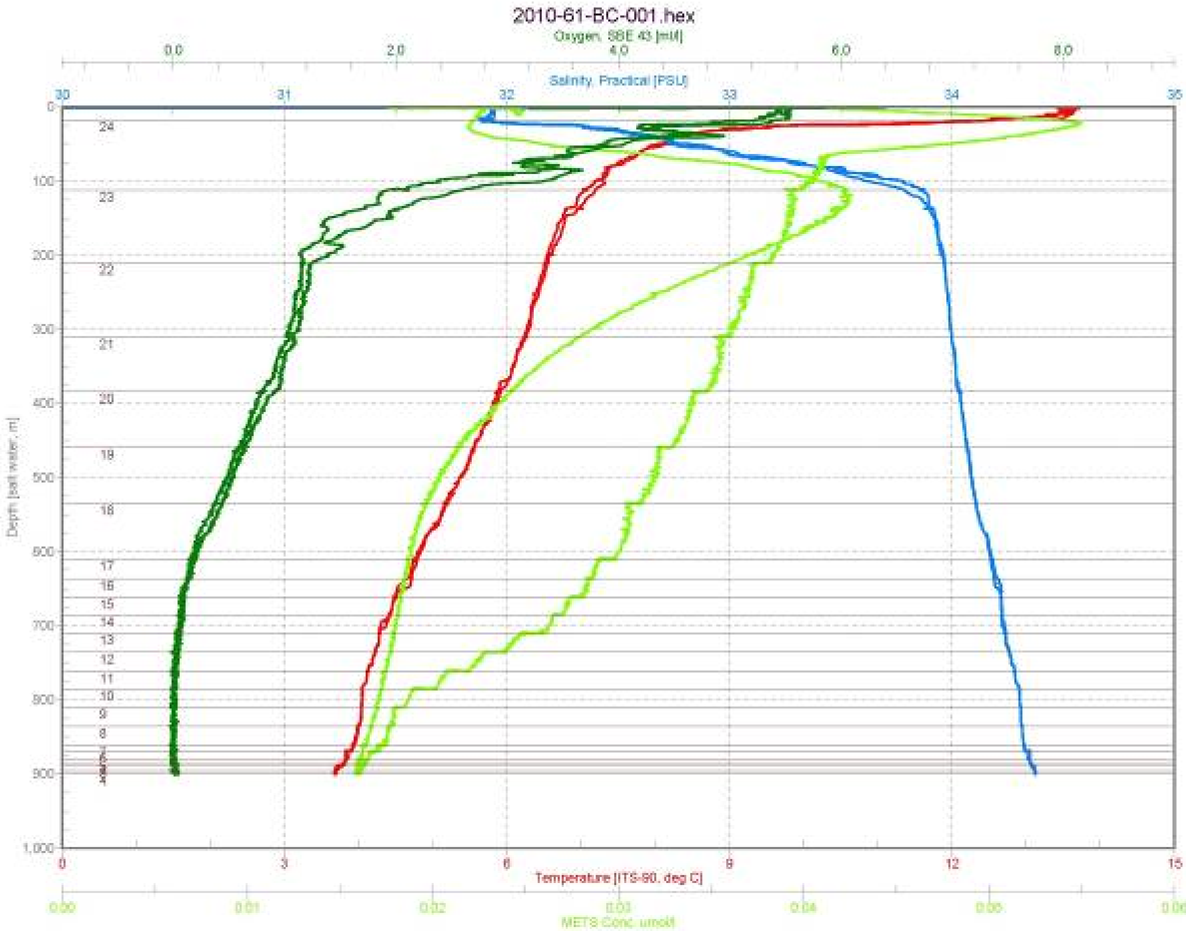


Figure 8
(g) CTD Cast-7 (BC-1) at Barkley Canyon. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

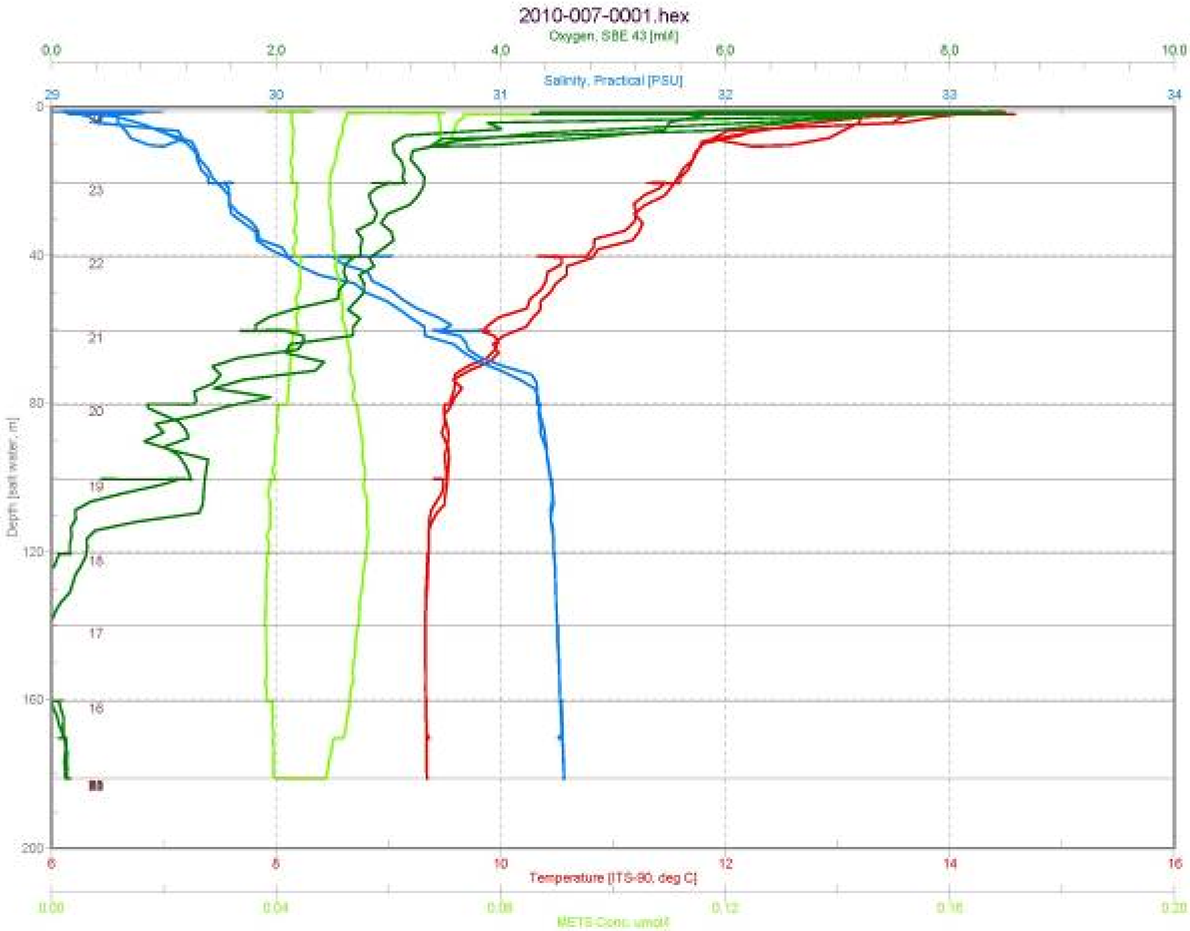


Figure 8
(h) Test CTD Cast in Saanich Inlet. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

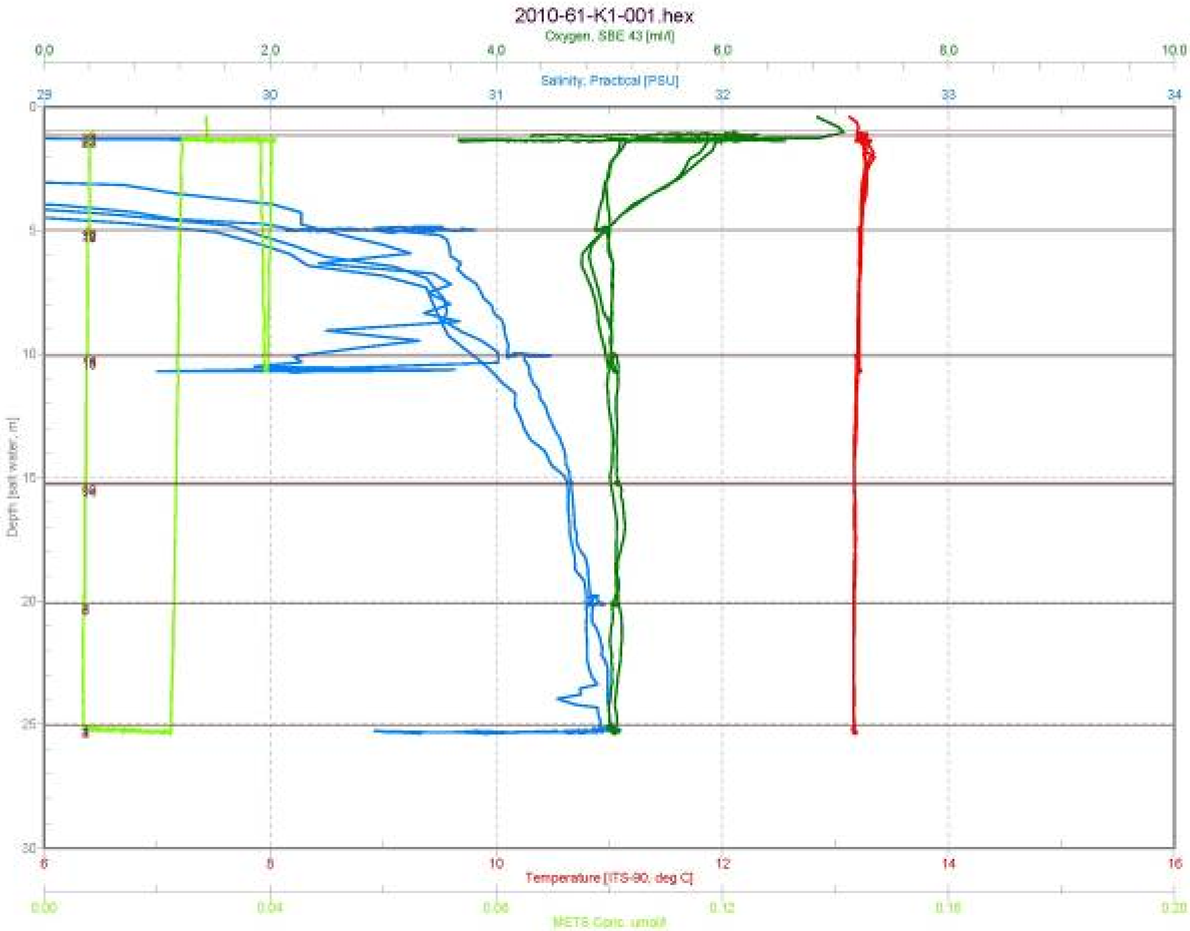


Figure 8
(i) Test CTD Cast in Kyuquot Inlet. Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

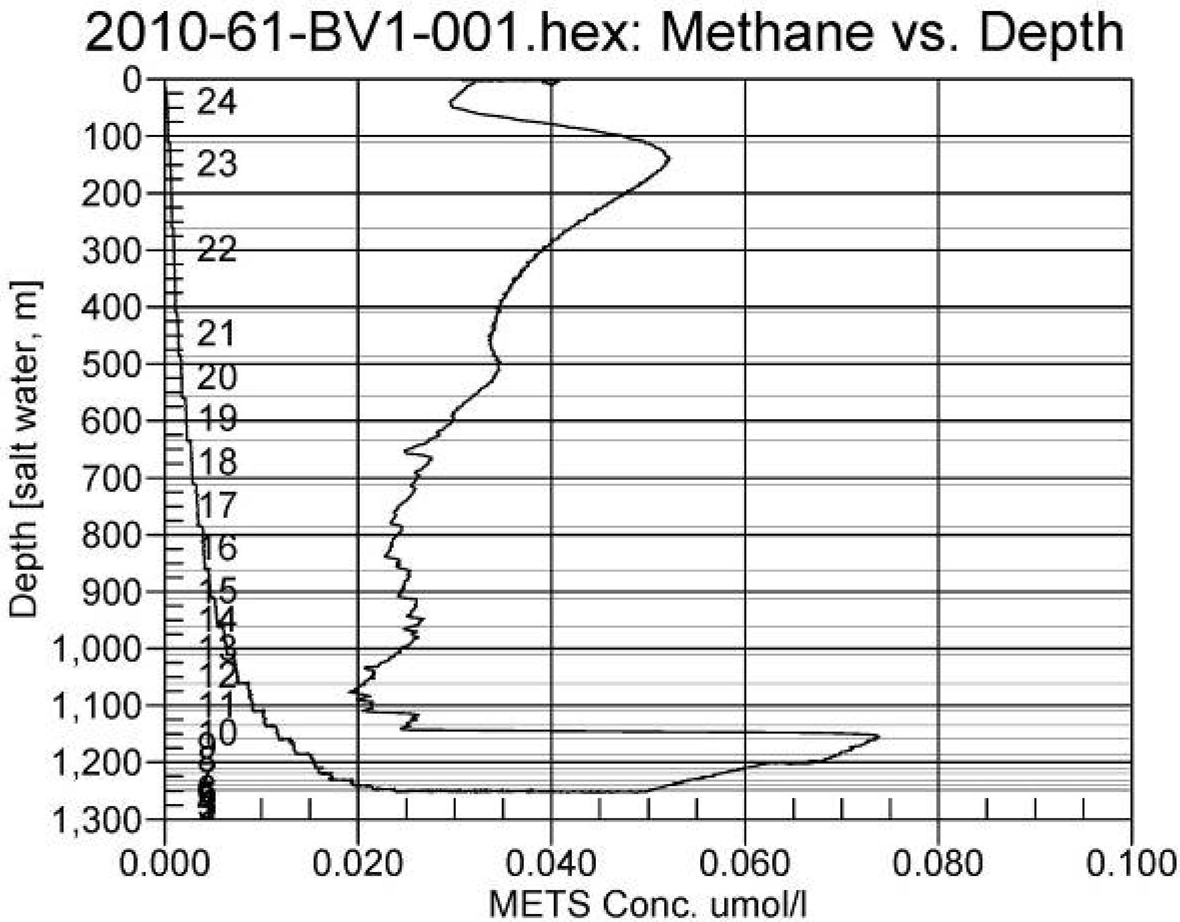


Figure 9
(a) Methane (METS) data from Cast 1 (BV1-1). Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

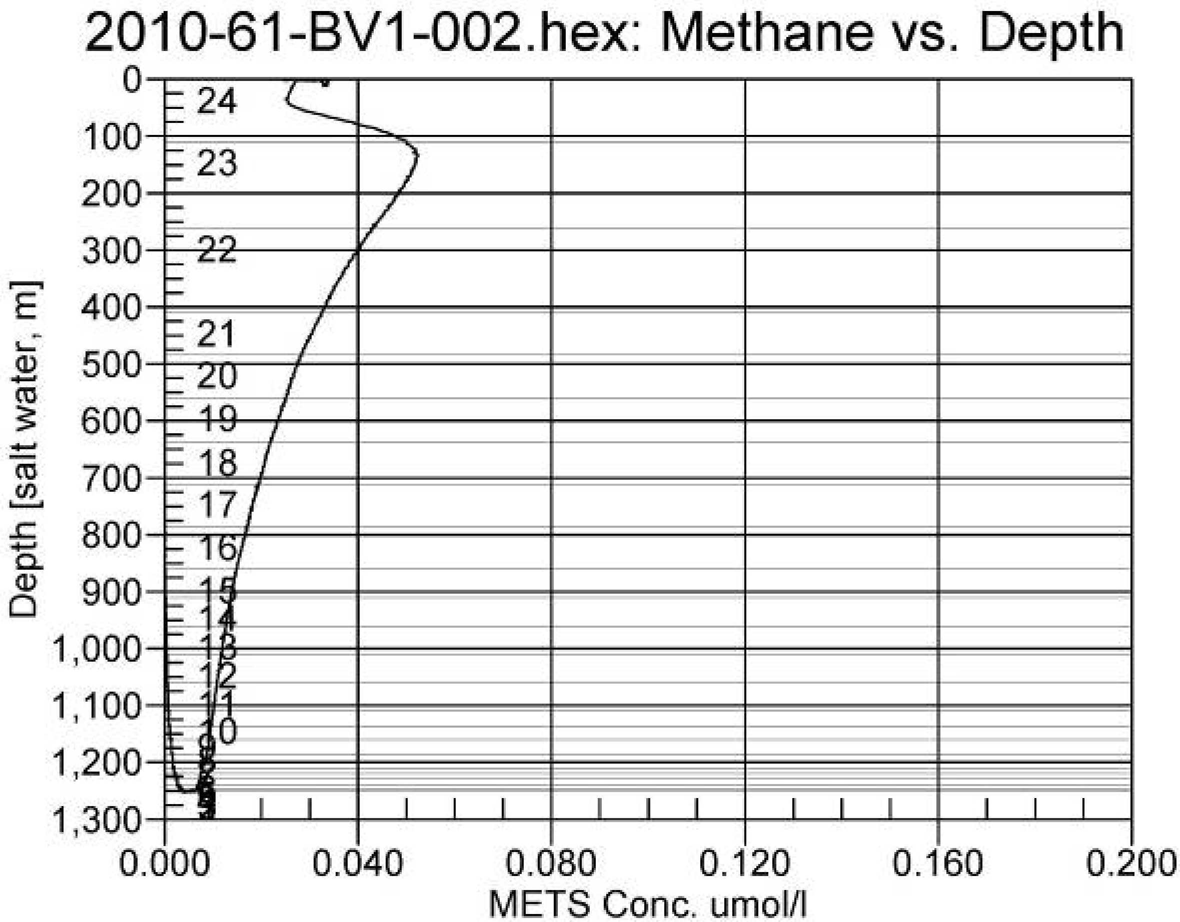


Figure 9
(b) Methane (METS) data from Cast 2 (BV1-2). Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

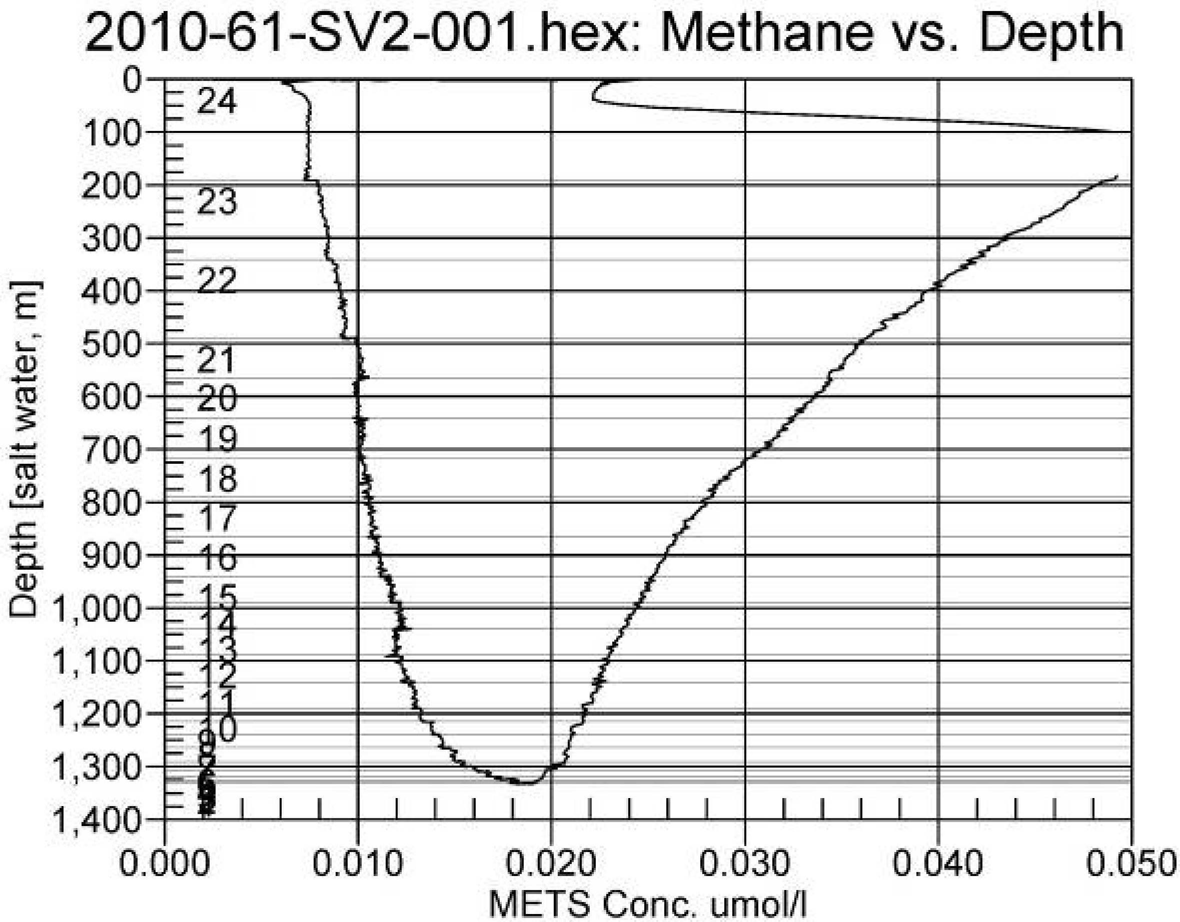


Figure 9
(c) Methane (METS) data from Cast 3 (SV2-1). Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

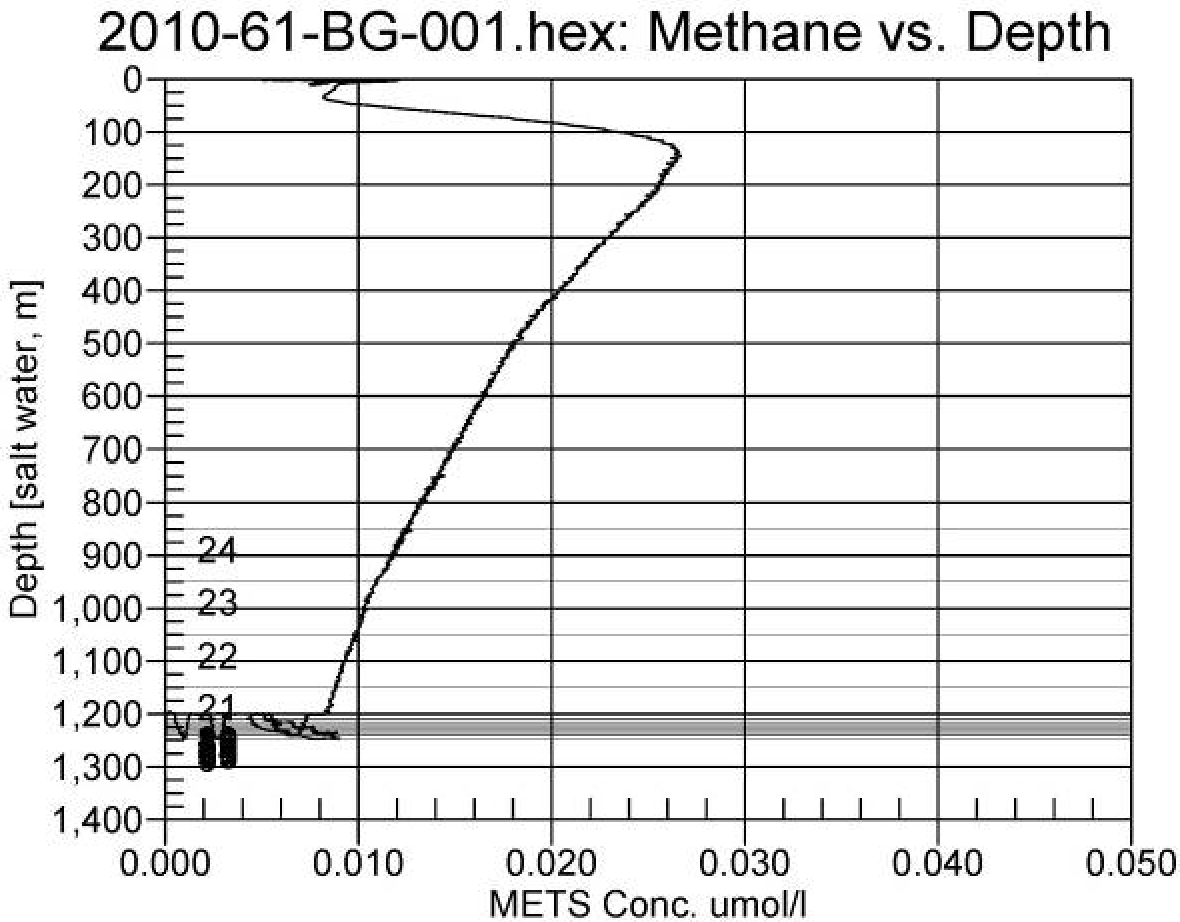


Figure 9
(d) Methane (METS) data from Cast 4 (BG-1). Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

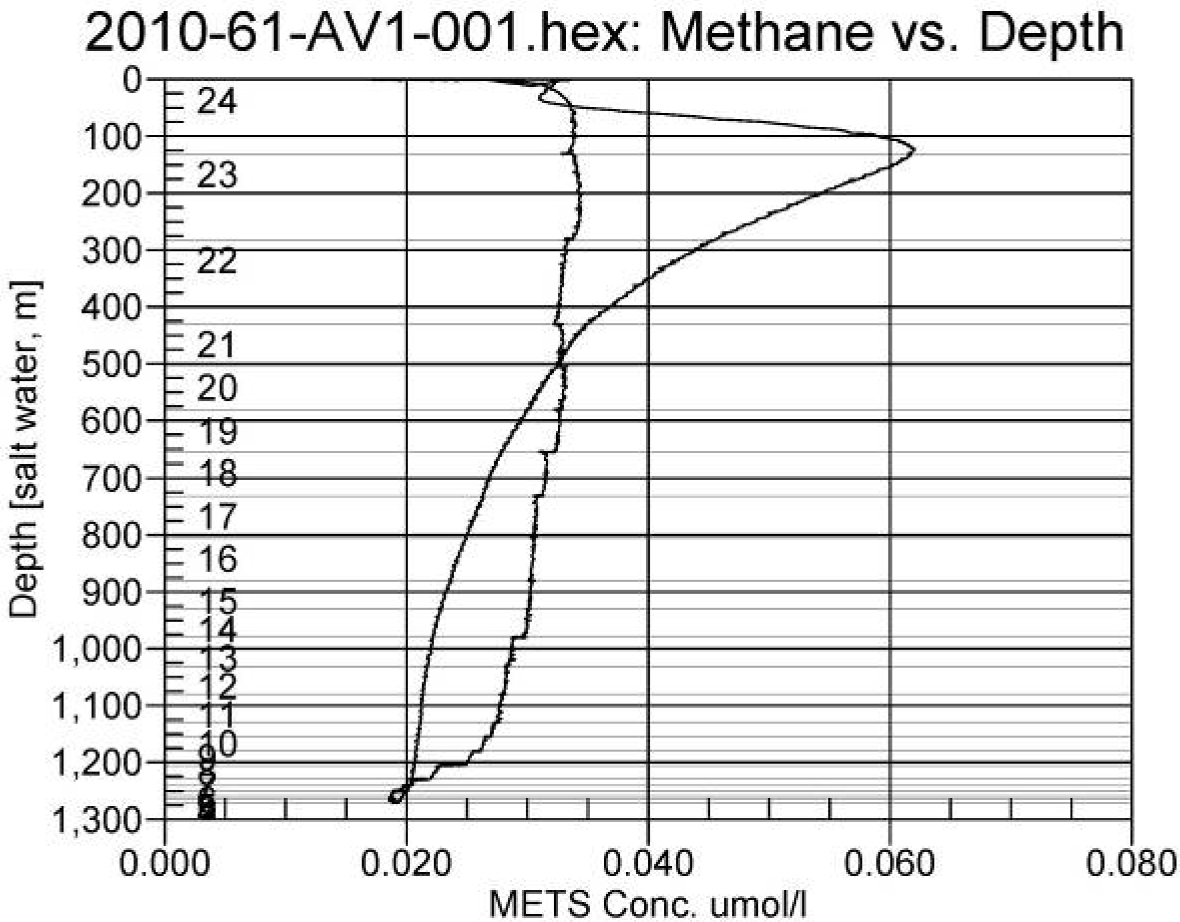


Figure 9
(e) Methane (METS) data from Cast 5 (AV1-1). Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

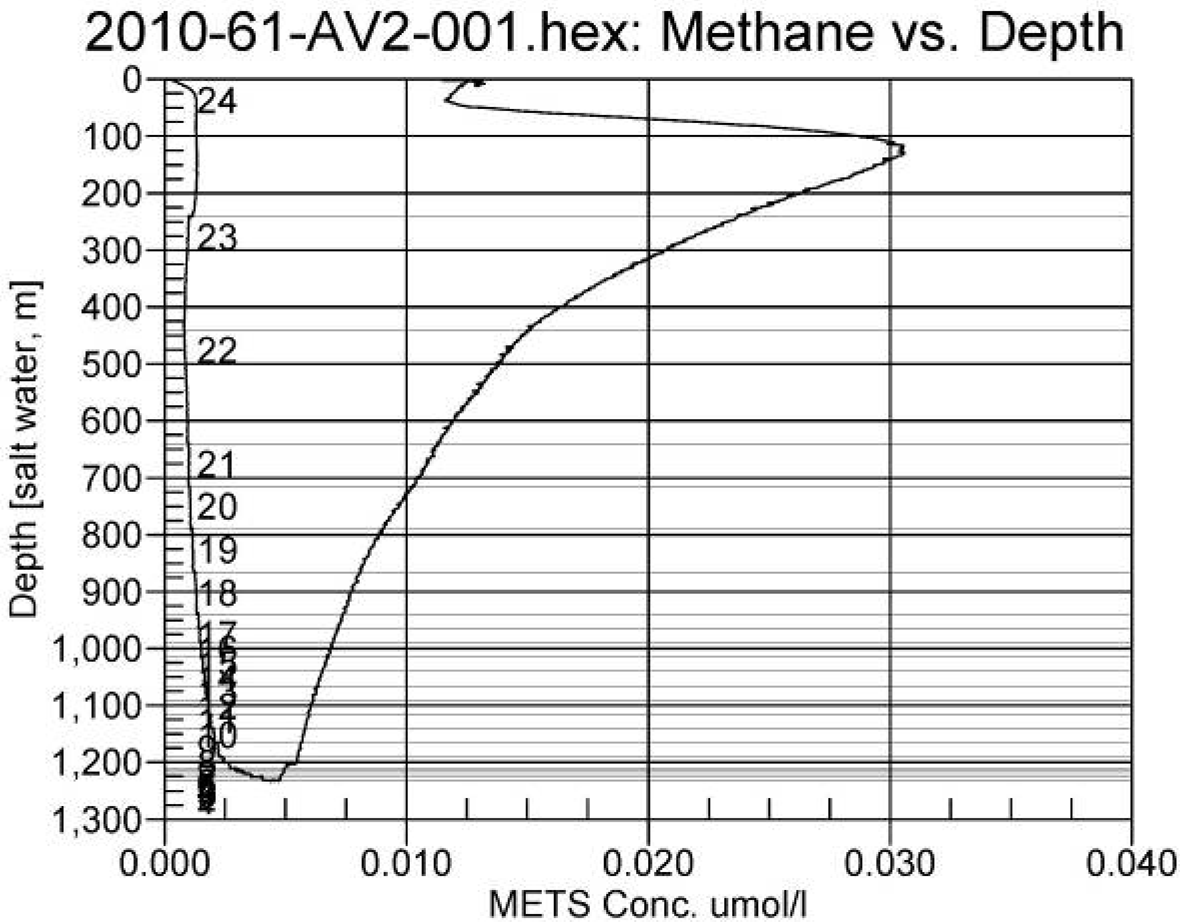


Figure 9
(f) Methane (METS) data from Cast 6 (AV2-1). Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

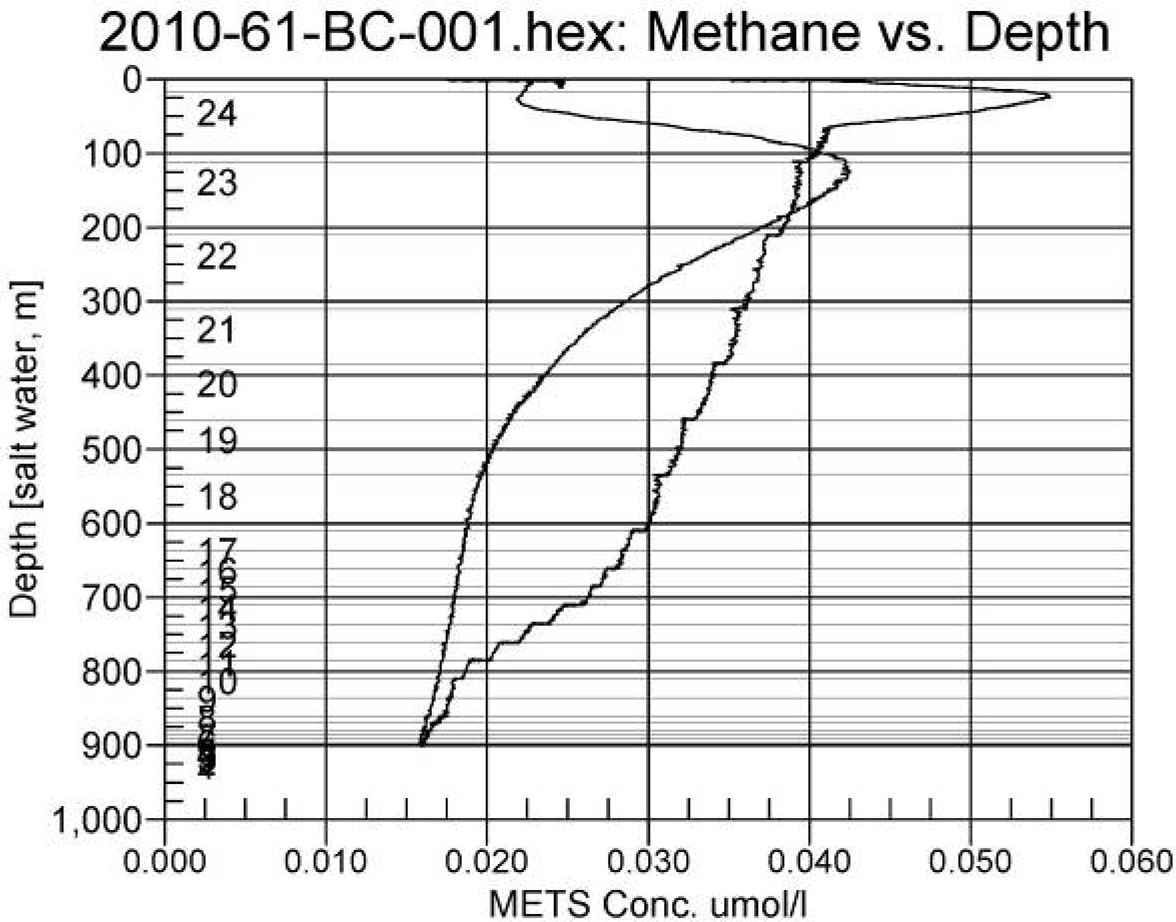


Figure 9
(g) Methane (METS) data from Cast 7 (BC-1). Sequential numbers (1-24) on left hand side indicate location depth when Niskin-bottle was fired.

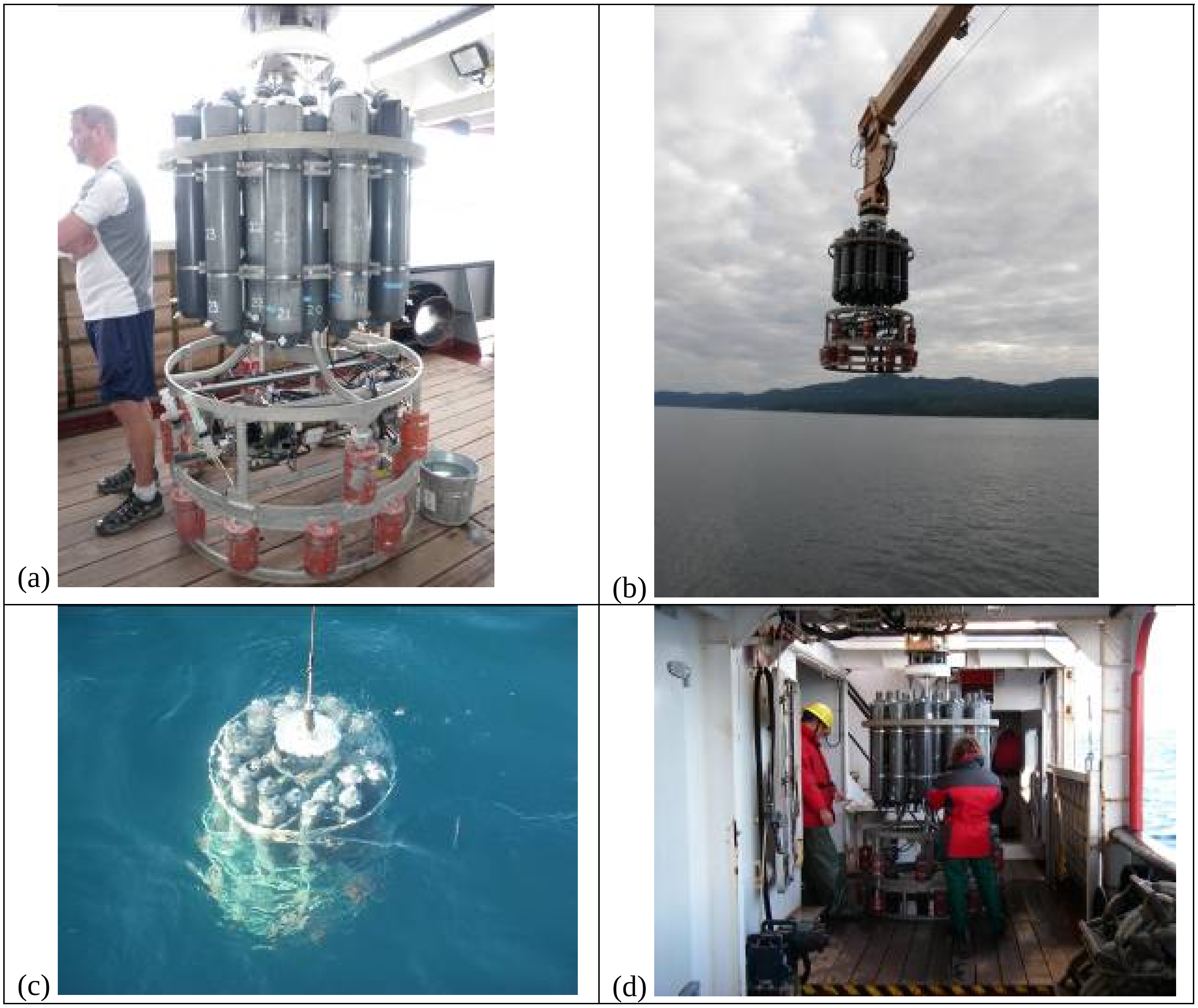


Figure 10

Examples of the CTD and water-sampling rosette. (a) On deck (with Scott rose for scale); (b) loaded on crane (starboard winch) and ready to be deployed; CTD just at surface; (d) sub-sampling of water from Niskin Bottles (P. Neelands, and M. Cote).

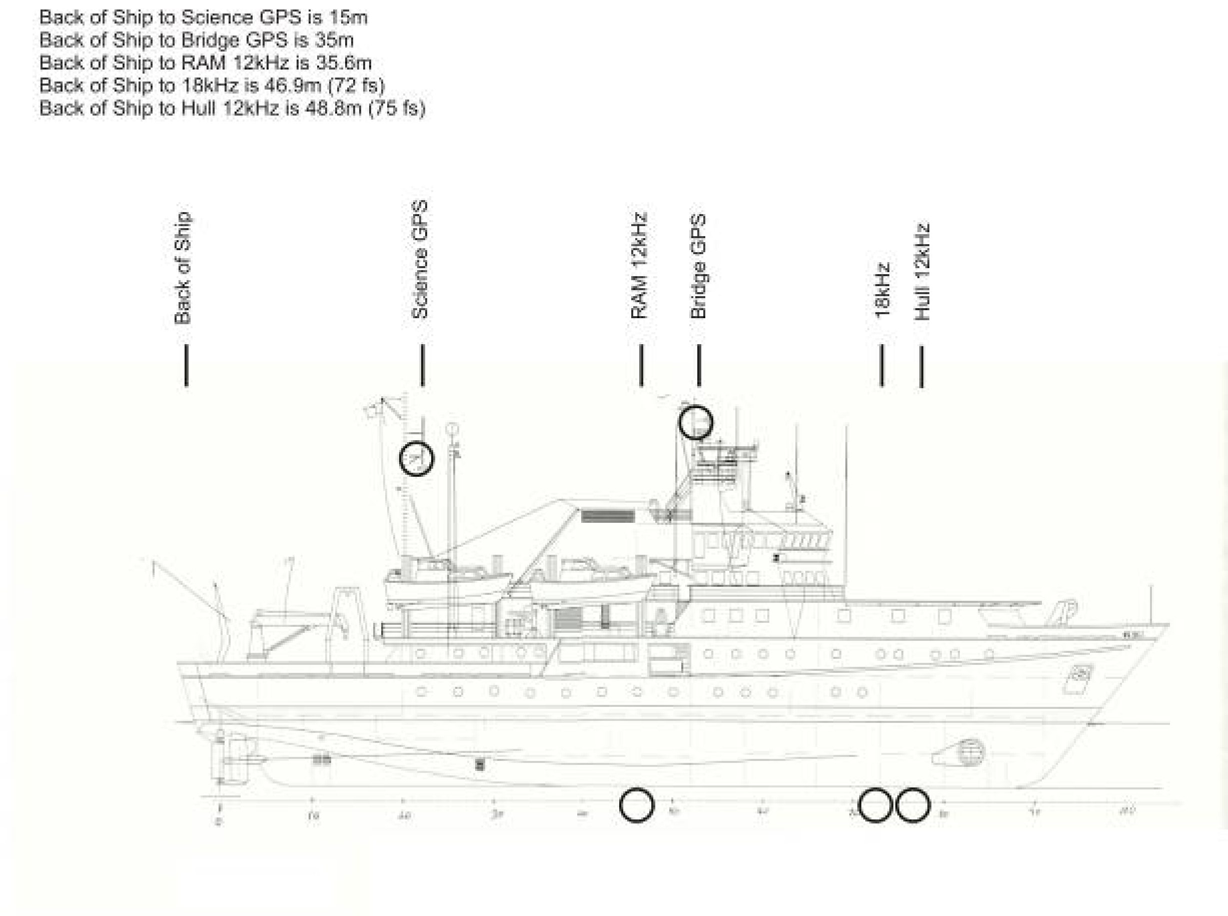


Figure 11
Schematic diagram of the CCGS *John P. Tully* and locations of echo-sounders and GPS antennae. The distances from the back of the vessel to individual units are indicated in the upper left hand corner.