MGLN06MV ABE Dive Engineering Summaries

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1 Introduction

This document summarizes the ABE dives on MGLN06MV from an engineering perspective. It shows basic vehicle performance, sensor performance, and shows the first-cut plume sensor and bathymetric maps.

2 Description of ABE

2.1 Overview

The Autonomous Benthic Explorer (ABE) is a fully autonomous underwater vehicle used for exploring the deep ocean up to depths of 4500 meters. ABE produces bathymetric and magnetic maps of the seafloor and has also been used for near-sebed oceanographic investigations, to quantify hydrothermal vent fluxes. Most recently, ABE has been used to locate, map, and photograph deep sea vent sites following preliminary work by towed and lowered instruments. ABE has taken digital bottom photographs in a variety of deep sea terrains, including the first autonomous surveys of an active hydrothermal vent site. By the end of MGLN06MV in Papua New Guinea, ABE has completed 199 dives in the deep ocean over 17 cruises, covering more than 3000 km of survey tracks at an average survey depth of deeper than 2000 meters.

2.2 Vehicle characteristics

ABE is a three body, open frame vehicle that utilizes glass balls as flotation in two free-flooded upper pods while the single, lower housing is host to the batteries that power the vehicle and all of its electronics. This separation of buoyancy and payload gives a large righting moment which simplifies control and allows the vertical and lateral thrust propellers to be located inside the protected space between the three, faired bodies. ABE has five thrusters allowing it to move in any direction. It can travel forward at a cruising speed of 0.6m/sec but one of ABEs most unique characteristics is that it can also hover and reverse characteristics that are particularly valuable in the hostile and rugged terrain routinely encountered when investigating the deep seafloor. The navigation system onboard ABE consists of two proven and complementary navigation systems. For general use, ABE uses long baseline transponders, identical to those used by the research submersible Alvin and ROV Jason, and these allow deep seafloor surveys over distances of ca.5 kilometers to be carried out. In addition, however, ABE also carries an acoustic doppler velocity log (DVL) which provides short-range, high-precision navigation. With these navigation systems, ABE has the ability to follow tracklines with a repeatability of order 10m line-spacing or better.

2.3 Standard Sensors on ABE

The sensors on board ABE consist of a number of vehicle attitude sensors such as depth, altitude, heading, pitch and roll. In addition, ABE carries a suite of dedicated science-specific sensors. These include:
a SIMRAD SM2000 200kHz multibeam sonar, rated to 3000m
Imagenex 675kHz scanning sonar, rated to 4500m
3-component Develco fluxgate magnetometer, rated to 4500m
SeaBird 9/11+ CTD systems, rated to 4500m
SeaPoint optical backscatter sensor (OBS) rated to 4500m
digital still camera imaging system, rated to 4500m

We usually carry an Eh sensor through an on-going collaboration between the ABE group and Dr Koichi Nakamura (Japan).

All data are stored on the vehicle and retrieved upon recovery.

2.4 ABE Operations

ABE operates autonomously from the support research vessel. It has no tether, and is controlled in real-time by onboard computers using its own rechargeable batteries for all power. Upon launch, ABE descends to the seafloor through the use of a descent weight which is released after safe arrival at the seafloor. Throughout any dive, ABE uses acoustic long- baseline transponder navigation together, when close enough to the seafloor, with bottom-lock acoustic doppler measurements to determine its position and velocity over the seabed. ABE descends at 15-20m/minute following a controlled spiral trajectory to ensure that it reaches the desired starting point while consuming minimal energy. After reaching the seafloor and performing a series of checks, ABE releases its descent weight to become neutrally buoyant and begins its pre-programmed survey. A dive can consist of any mix of water column investigations (e.g. hydrothermal plume surveys) at constant water depths, seafloor geophysical investigations at fixed heights above the seafloor (anywhere from 50-200m off depending on the application: e.g.magnetics, high-resolution bathymetric mapping) and digital photography at a height of just 5 meters above the seafloor. ABE usually surveys until either it reaches the end of its programmed survey or its batteries are depleted (typically between 20-30km along track and 15-30 hours of survey time, depending on sensor payload, survey type, and terrain). At the end of its dive or in the case of a serious fault, ABE releases two ascent weights to become positively buoyant and return to the surface at 15-20m/minute. Optionally, ABE can anchor itself to the seafloor when battery voltages reach a critical level or when a fault condition occurs. An acoustic command can be issued from the vessel to recall the vehicle.

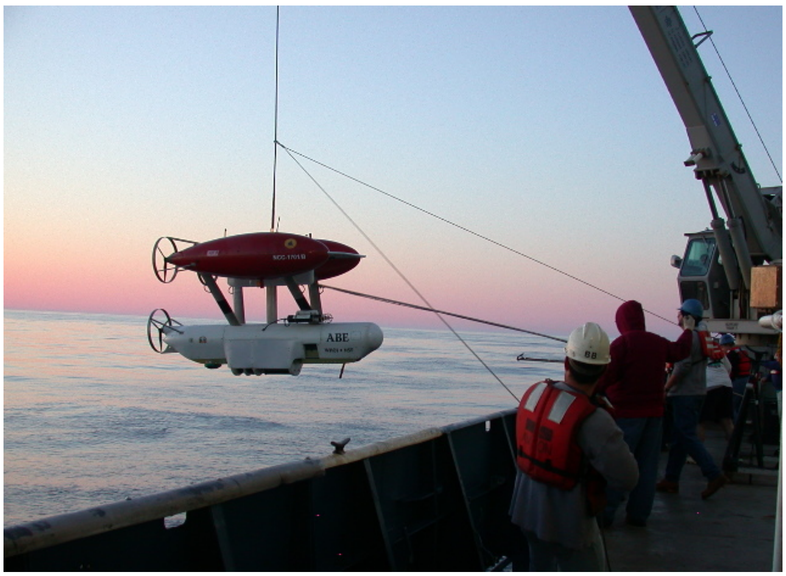

Figure 1: This photo shows ABE being recovered after a plume mapping dive

3 Overview of Dives

For this cruise, ABE covered 348km of bottom tracks over 176 hours of bottom time. For each dive, ABE carried one or two CT pairs, a three-axis magnetometer, an optical backscatter sensor, an eH probe, and a multibeam bathymetric sonar. ABE made 18 dives, 3 of which was shortened by an engineering problems, 2 of which failed before any survey data was acquired.

Dive	Date	location	survey km	survey hrs	ave. depth	area
182	2006/07/23	3.1S, 150.2E	28.3	13.5	2419	Vienna Woods
183	2006/07/24	3.1S, 150.2E	24.0	11.4	2350	Vienna Woods
184	2006/07/26	3.1S, 150.2E	0.0	0.0	2509	Vienna Woods
185	2006/07/26	3.1S, 150.2E	26.1	13.7	2490	Vienna Woods
186	2006/07/28	3.1S, 150.2E	27.1	12.7	2459	Vienna Woods
187	2006/07/30	3.1S, 150.2E	27.1	13.0	2449	Vienna Woods
188	2006/08/01	3.7S, 151.6E	27.0	13.1	1619	Pacmanus
189	2006/08/03	3.7S, 152.1E	25.2	13.9	1513	Suzette
190	2006/08/05	3.7S, 152.1E	30.5	14.6	1621	Pacmanus
191	2006/08/07	3.7S, 151.6E	10.6	5.2	1621	Pacmanus
192	2006/08/10	3.7S, 151.6E	32.4	15.0	1824	NE Pual
193	2006/08/12	3.7S, 151.6E	4.8	2.4	1851	NE Pual
194	2006/08/14	3.7S, 152.1E	23.2	14.2	1299	SuSu
195	2006/08/16	3.7S, 152.1E	26.1	14.5	1530	SuSu
196	2006/08/18	3.7S, 152.1E	0.0	0.0	1550	SuSu
197	2006/08/22	3.7S, 152.1E	0.0	0.0	1488	SuSu
198	2006/08/22	3.7S, 152.1E	25.7	13.4	1427	SuSu
199	2006/08/24	3.7S, 151.9E	9.8	5.6	1963	Umbo
totals			347.9	176.2	1888	

Failed or shortened dives

Dive	Date	location	comments
184	2006/07/26	Vienna Woods	failed, could not release descent mooring
191	2006/08/07	Pacmanus	shortened, nav problem
193	2006/08/12	NE Pual	shortened, depth bug
196	2006/08/18	SuSu	shortened, thruster shorted
197	2006/08/22	SuSu	failed, thruster stopped comms on descent

Dives were conducted in 5 areas: Vienna Woods, Pacmanus, NE Pual, Susu, and Umbo. Figure 2 shows the dives in the Vienna Woods area, figure 3 shows dives in Pacmanus, figure 4 shows the dives in NE Pual, and figure 5 shows the dives on Suzette and Susu.

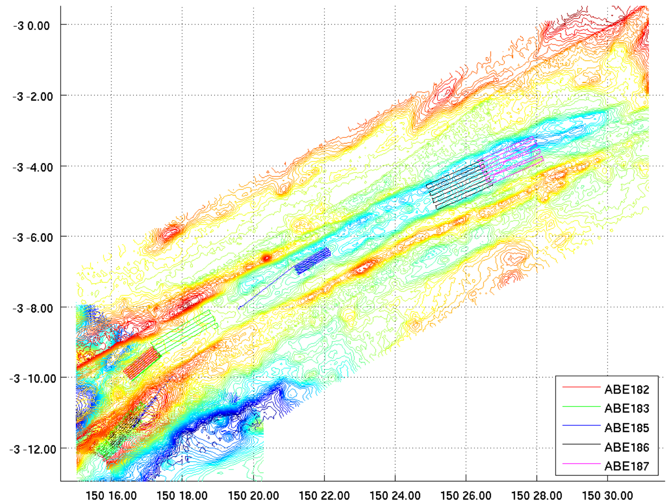

Figure 2: This plot shows the tracklines forthe ABE dives at Vienna Woods

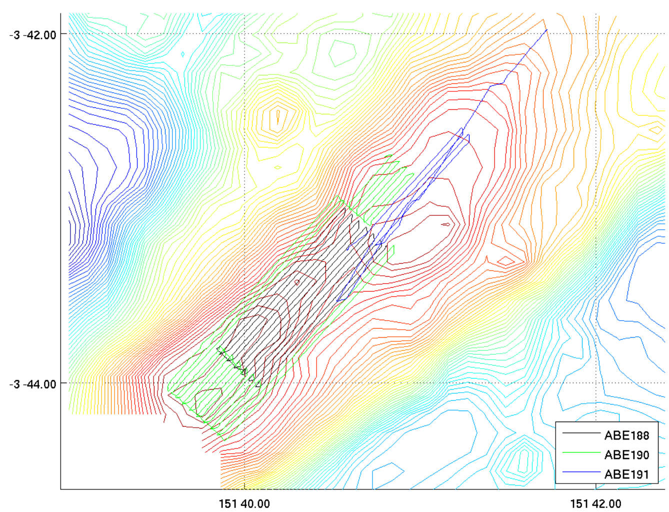

Figure 3: Tracklines for ABE dives in the Pacmanus area

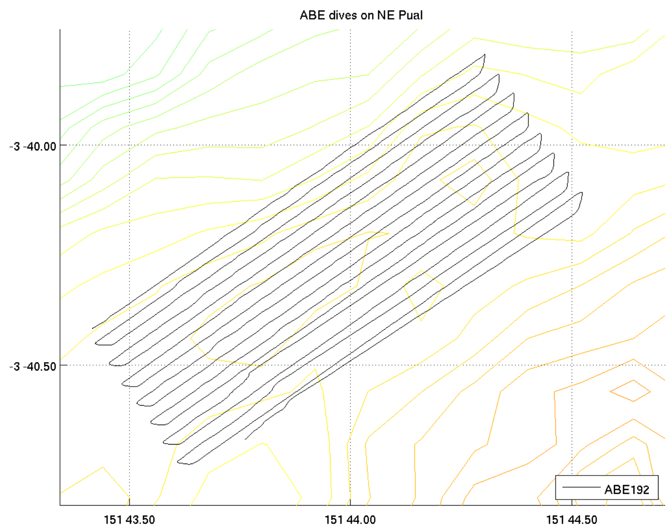

Figure 4: Tracklines for the ABE dive in NE Pual

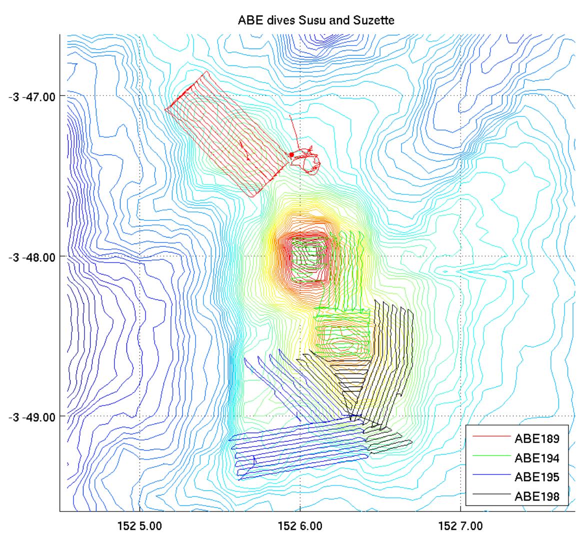

Figure 5: Tracklines for ABE dives at Suzette and Susu

4 ABE 182

On this dive, the vehicle flew a rectangular grid for multibeam, magnetics, and plume mapping. Lines were 2km long and spaced 50 meters apart. The vehicle flew 50 +-5 meters above the seafloor.

Overall, this survey met our expectations for bathymetry, magnetics, and water column mapping results. All science sensors (magnetometer, both CT pairs, optical backscatter, eH) performed as expected. Plume signals were registered strongly over the known site (Site 1) and weakly over another.

The transponder net consisted of two primary transponders, a third (C) was in range during the eastern portions of the survey. In hindsight, it would have been better to have ignored the third transponder, as survey errors were multiplied by poor geometry. This caused some jumps (order 10 meters) between real-time fixes in the eastern part of the survey. This problem was reduced by postprocessing the data with transponder C turned off. Reception of acoustic returns at the vehicle was solid, with only one 600 meter section with transponder B not heard, and the vehicle dead-reckoned through that stretch with only a few meters error. I (DY) did a compass calibration after the dive, but based on the DR performance I decided not to enter the changes into the run-time program. The postprocessed navigation track and kalman smoother output is shown in figure 6.

On this dive, ABE data confirmed the location of the Vienna Woods field and defined its boundaries. Also, the data shows at least on other probably venting site and another possible site. Figure 9 shows the temperature and eH vs time. The large hits, seen in both records, correspond to the Vienna Woods site, as seen in figure 7. Also, the small temperature anomaly seen earlier in the record, at 16:45, represents another likely vent site. Figure 10 shows the temperature data (T1) over the possible site, with the temperature rescaled. Figure 11 shows the temperature anomaly and the corresponding eH data. While the eH signal does not change much (a few millivolts), the transient is negative.

The bathymetry was processed normally using first-cut and reprocessed navigation. The assembled map, using the postprocessed navigation, is shown in figure 12. The processing of the magnetics data will be covered in the main cruise report.

Summary: abe182
Start time: 2006/07/23 08:17:48
Survey start: 2006/07/23 10:39:01
Survey end: 2006/07/24 00:10:59
Surface time: 2006/07/24 02:59:43
Recovery time: 2006/07/24 03:33:47
Launch: 03 9.902'S 150 16.727'E
Recovery 03 9.713'S 150 17.381'E
Origin 03 13.000'S 150 15.000'E
descent: 0.29 kwhr over 2.35 hrs, ave pwr: 123.0 w
survey: 4.21 kwhr over 13.53 hrs, ave pwr: 311.1 w over 28.3km 2419 m depth
ascent: 0.15 kwhr over 4.01 hrs, ave pwr: 38.1 w
surface: 0.03 kwhr over 0.57 hrs, ave pwr: 60.1 w
Total energy use: 4.68 kwhr
energy from pack 1: 1.545 2: 1.563 3: 1.543 kwhrs

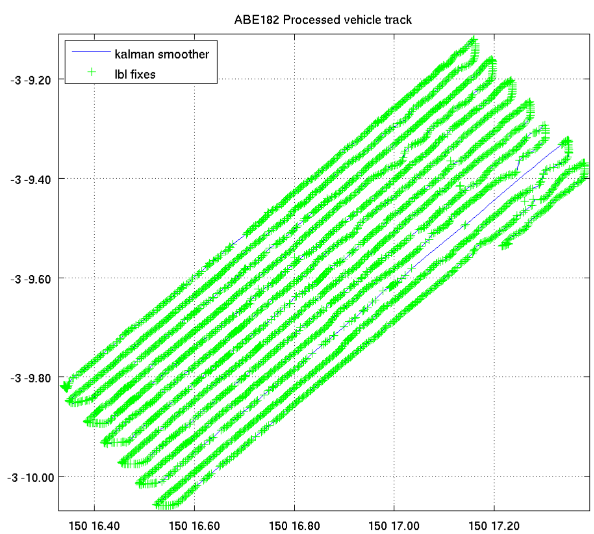

Figure 6: ABE182: This plot shows the post-processed LBL fixes and the final track from the Kalman smoother, which combines LBL fixes with data from the doppler velocity log (DVL) and compass

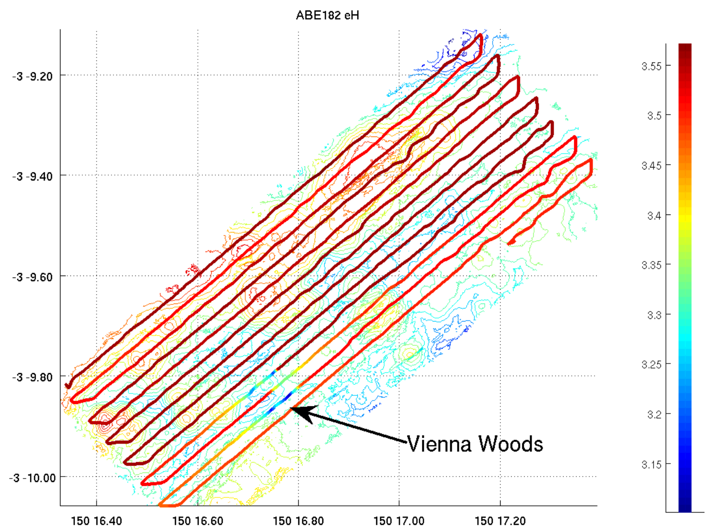

Figure 7: ABE182: This plot shows the eH signal as a funtion of position. The underlay is bathymetry from both ABE182 and ABE183. The area with the strong eH signals is Vienna Woods

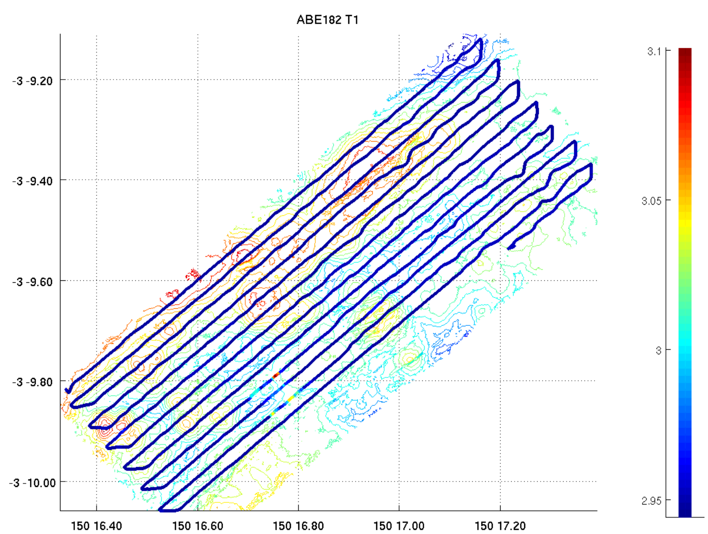

Figure 8: ABE182: This plot shows the temperature (T1) overlaid on the bathymetry. As for the eH plot, the location of Vienna Woods is clear

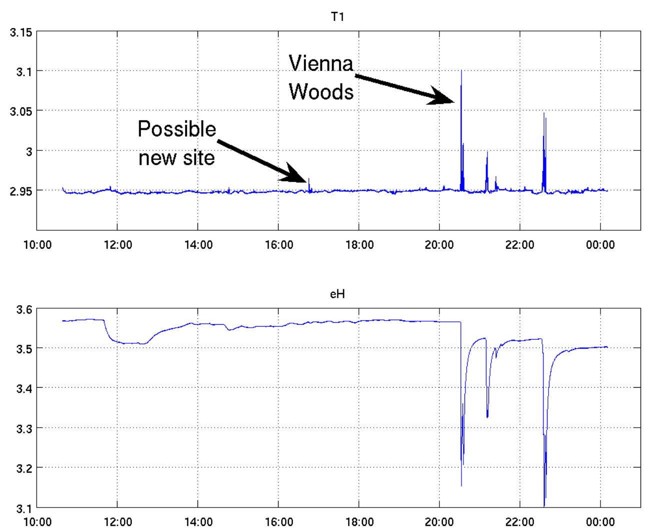

Figure 9: ABE182: This plot shows both temperature (T1) and eH as functions of time. In addition to the Vienna Woods anomalies, a small temperture anomaly can be seen earlier in the record at 16:45

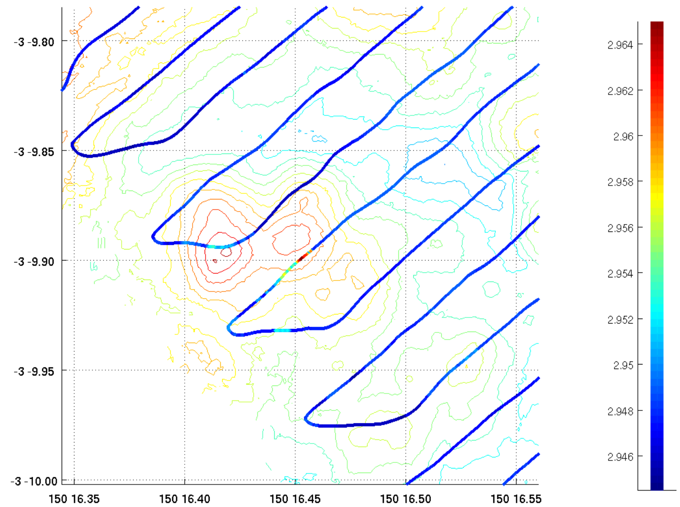

Figure 10: ABE182: This plot shows the small anomaly seen at 16:45 in the temperature record. The temperature anomalies are smaller than for Vienna Woods but were seen on multiple tracks. A very small eH anomaly was seen, no signal was observerd in the optical backscatter record.

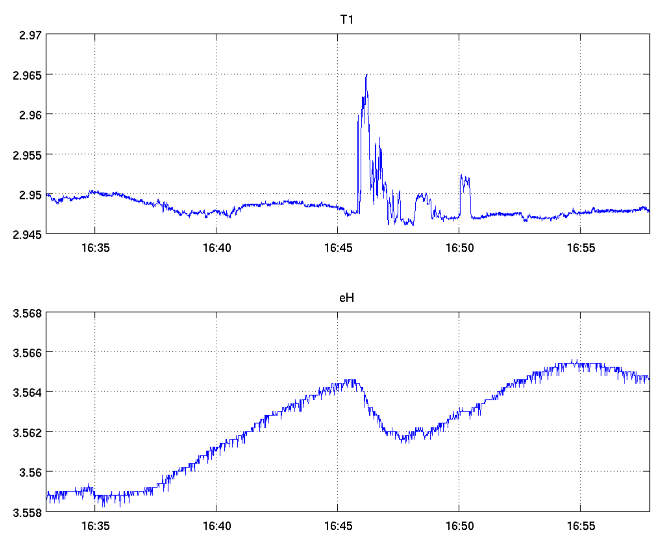

Figure 11: ABE182: This plot shows a close up of the temperature anomaly along with the eH trace. A very small eH negative transient can be seen

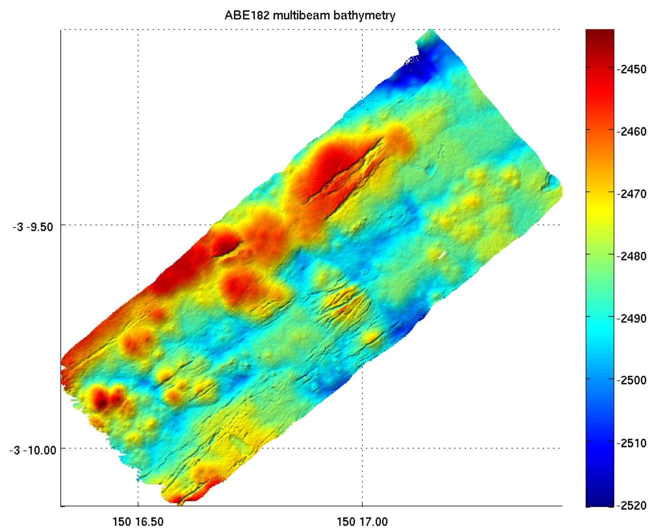

Figure 12: ABE182: This plot shows the bathymetry after the navigation was postprocessed.

5 ABE183

ABE183 extended the survey of Vienna Woods. The vehicle completed two survey lines extending the bathy/maggy survey of abe182 at 50 m height, then surveyed a block to the east at 150 m height. ABE was launched with Jason in the water, the launch position was about 1 km to the west of the survey start position.

The post-processed nav track is shown in figure 13. All fixes were computed from two transponders only (A and B to the west, B and C for the eastern block, both in real-time and in post-processing). The northernmost track on the eastern block had a period with no C direct replies received, however the dead-reckoning performance was very good.

Figure 14 shows the eH data superimposed on the tracklines. Three probable venting areas are indicated on the plot. As seen in figure 15 and 16, the eH transients corresponded to small or neglible temperature changes. No significant signals in optical backscatter were seen.

Figure 17 shows the bathymetry from the eastern segment collected at 150 meters height. The additional two lines that extended the ABE182 survey are shown in the ABE82 bathymetry (figure12)

Summary: abe183
Start time: 2006/07/24 21:10:24
Survey start: 2006/07/24 23:38:15
Survey end: 2006/07/25 11:03:39
Surface time: 2006/07/25 13:44:06
Recovery time: 2006/07/25 14:01:08
Launch: 03 9.485'S 150 16.987'E
Recovery 03 8.490'S 150 18.752'E
Origin 03 13.000'S 150 15.000'E
descent: 0.35 kwhr over 2.46 hrs, ave pwr: 143.9 w
survey: 3.12 kwhr over 11.41 hrs, ave pwr: 273.8 w over 24.0km 2350 m depth
ascent: 0.16 kwhr over 3.20 hrs, ave pwr: 48.7 w
surface: 0.02 kwhr over 0.28 hrs, ave pwr: 77.2 w
Total energy use: 3.64 kwhr
energy from pack 1: 1.210 2: 1.222 3: 1.203 kwhrs

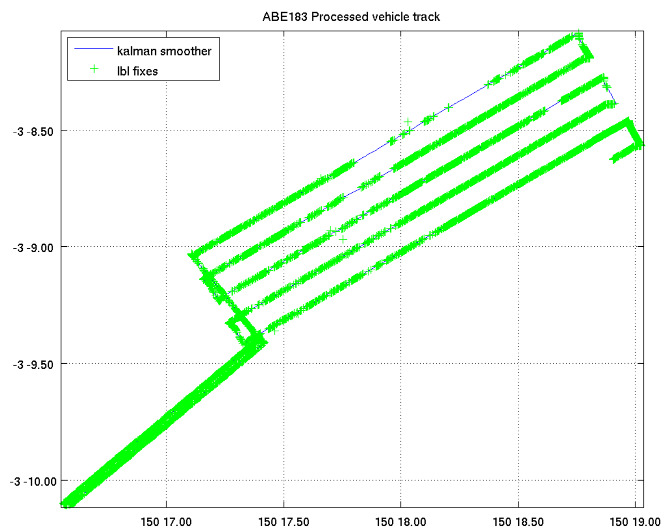

Figure 13: ABE183: This plot shows the post-processed LBL transponder fixes and the track derived by post-processing the LBL, doppler velocity log (DVL) and compass using a kalman smoother. The first lines extended the ABE182 survey

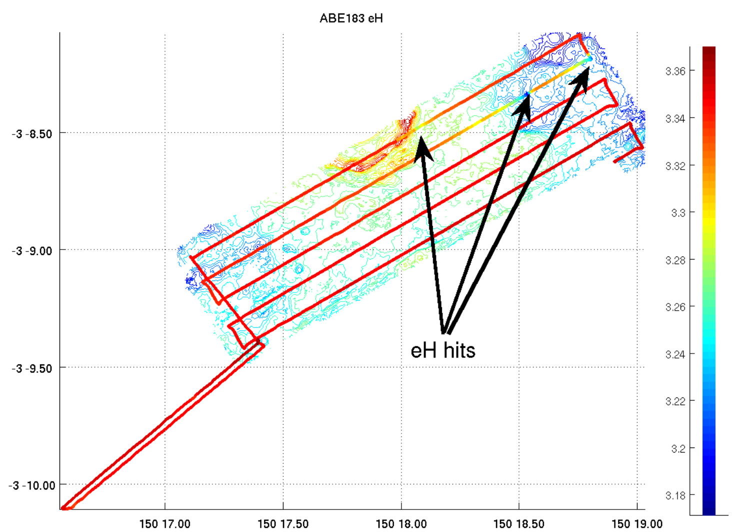

Figure 14: ABE183: This plot shows the eH data superimposed on the tracklines. Several probable venting sites can be seen at the spots where the eH voltage decreases rapidly

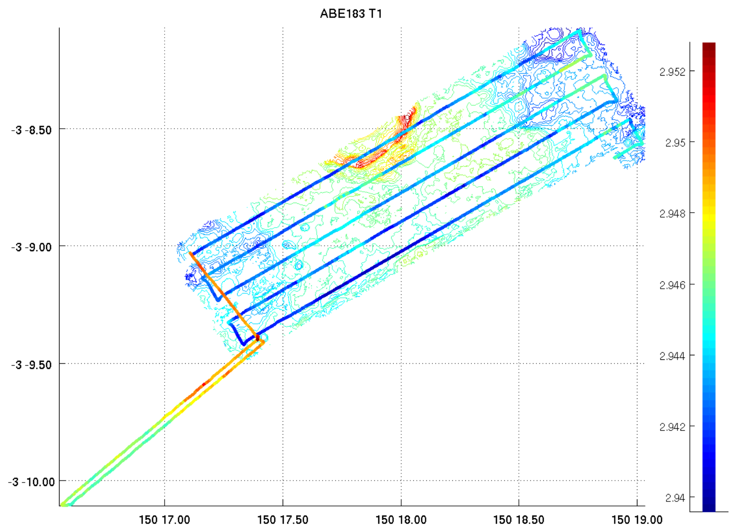

Figure 15: ABE183: The plot shows the temperature (T1) superimposed on the tracklines. The dominant change corresponds to the depth change when the survey height changed from 50 meters to 150 meters. The temperature at the shallower depth is lower, however.

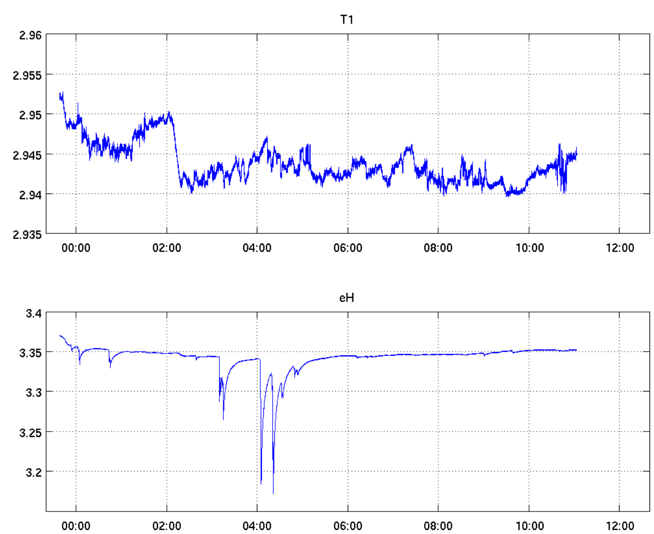

Figure 16: ABE183: This plot shows the T1 and eH signals vs time. The largest eH transients correlate with small temperature changes

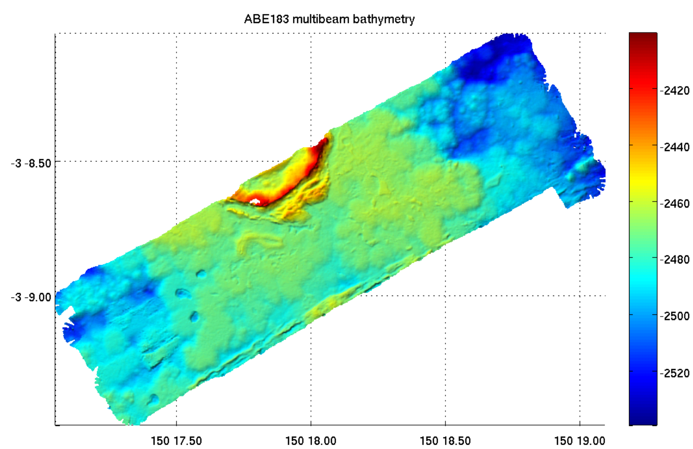

Figure 17: ABE183: This figure shows the bathymetry from the segment of ABE183 run at 150 meters height.

6 ABE184

ABE184 failed. ABE was launched normally, Jason was not in the water. The vehicle was programmed to deploy the anchor if an abort occurred after the first trackline started. But the vehicle aborted after reaching the seafloor when it was unable to detach from the descent mooring. It did not anchor since the command to enable anchoring had not been reached in the program. Either both descent weight burn wires did not release in the allotted time (20 minutes, they normally go in 5 minutes) or the mooring line hung up in some way. The vertical thurster rpm data confirms that both verticals were providing thrust, so the vehicle was pulling up against the descent mooring.

The standard thrust sequence executed during each abort (included under the assumption that the vehicle ended up trapped) freed the vehicle, and it ascended normally. We have no obvious explanation why the descent mooring did not release normally. The vehicle landed on a steep slope, but the anchor did not seem to slip after landing (based on vehicle depth). All sonars (Robertson forward-looker, dvl beams, and SM2000) indicate that the bottom was sloping 45 degrees but showed the vehicle unobstructed. We thoroughly inspected the area around the ascent weight release and saw nothing unusual. Either the descent mooring hung up in some way, or one of the two slow burn wires released coincidently with the abort sequence.

We lengthened the timeout on the weight release process to 40 minutes.

Summary: abe184
Start time: 2006/07/26 12:50:12
Survey start: 2006/07/26 14:53:43
Survey end: 2006/07/26 15:23:13
Surface time: 2006/07/26 17:54:13
Recovery time: 2006/07/26 18:20:16
Launch: 03 6.855'S 150 21.148'E
Recovery 03 6.766'S 150 20.036'E
Origin 03 13.000'S 150 15.000'E
descent: 0.25 kwhr over 2.05 hrs, ave pwr: 123.6 w
survey: 0.10 kwhr over 0.48 hrs, ave pwr: 211.6 w over 0.2km 2509 m depth
ascent: 0.16 kwhr over 3.18 hrs, ave pwr: 51.4 w
surface: 0.03 kwhr over 0.43 hrs, ave pwr: 62.7 w
Total energy use: 0.52 kwhr
energy from pack 1: 0.175 2: 0.173 3: 0.174 kwhrs

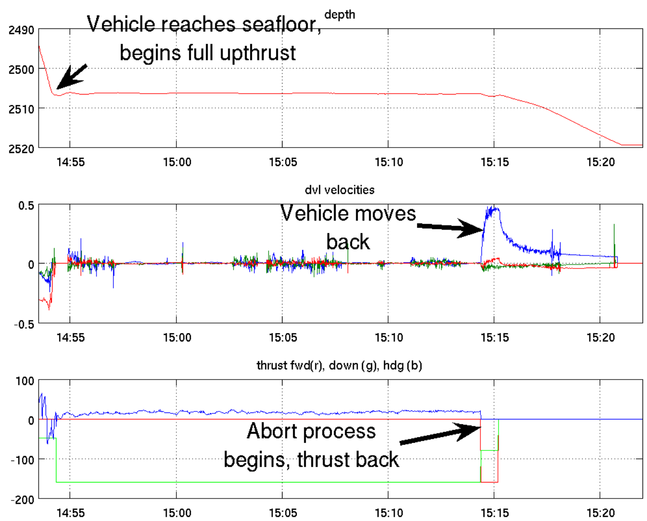

Figure 18: ABE184: These plots show the vehicle's failure to release as expected, then releasing after the abort command was given. The DVL velocity shows the vehicle backing up at about 0.5 m/sec for nearly 1/2 minute without descending, indicating that the descent mooring was no longer attached

7 ABE185

ABE185 extended our coverage of Vienna Woods. ABE was launched with Jason in the water, about 6 km to the west of the start of the survey. ABE covered about 2 km of that distance on descent, then drove a 4 km connector (at 150 m height) to the survey start point. ABE then descended to 50 m survey height. The dive ended when the vehicle reached the end of the last trackline and anchored. We observed the end of the dive, saw ABE change its LBL cycle to 20 seconds as it began anchoring, then remain stationary. We commanded ABE to return to the surface about 30 minutes after is anchored.

ABE started its descent on the BCD transponders, then switched to CD after starting the connector leg. The D transponder gave somewhat erratic performance, showing many returns that were slightly long (on the order 50 msec or so), which were not always filtered out in real time. So the tracking was a bit rough, although some of this could be cleaned up in post processing. The bad returns were hand-editted out. Figure 19 shows the post-processed LBL fixes and the postprocessed, filtered track.

ABE spotted an area of active venting, as noted on both the eH and T1. Figure 20 shows the eH voltage superimposed on position, eH hits can be seen in 4 consecutive tracklines. Likewise, figure 21 shows temperature anomalies in the same area. These correlations are confirmed in the time plot showing both temperature and eH (figure 22).

Figure 23 shows the gridded bathymetry (2 meter grid cells). The processing required no special filtering.

Summary: abe185
Start time: 2006/07/26 22:26:46
Survey start: 2006/07/27 01:54:20
Survey end: 2006/07/27 15:37:10
Surface time: 2006/07/27 18:13:23
Recovery time: 2006/07/27 18:25:25
Launch: 03 13.000'S 150 15.000'E
Recovery 03 6.077'S 150 21.637'E
Origin 03 13.000'S 150 15.000'E
descent: 0.46 kwhr over 2.69 hrs, ave pwr: 172.8 w
survey: 3.84 kwhr over 13.71 hrs, ave pwr: 280.4 w over 26.1km 2490 m depth
ascent: 0.15 kwhr over 3.00 hrs, ave pwr: 49.2 w
surface: 0.02 kwhr over 0.20 hrs, ave pwr: 77.9 w
Total energy use: 4.46 kwhr
energy from pack 1: 1.479 2: 1.498 3: 1.480 kwhrs

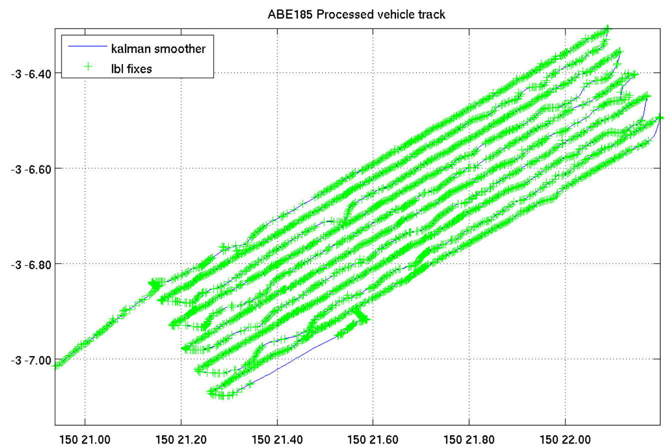

Figure 19: ABE185: This plot shows the post-processed LBL fixes and the post-processed, filtered track. The tracklines were a bit rough due to noise on returns from transponder D.

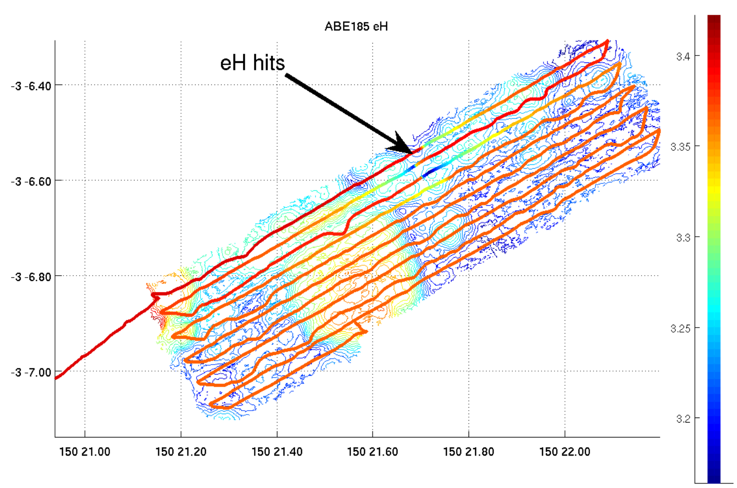

Figure 20: ABE185: the eH plot shows an area of probable venting

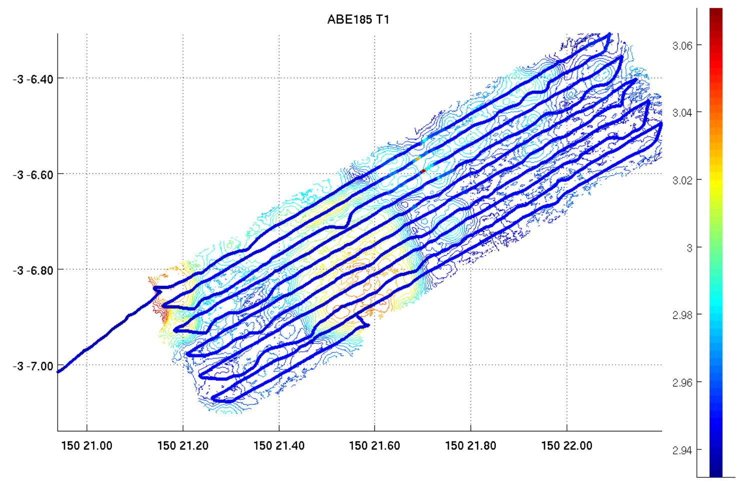

Figure 21: ABE185: temperature anomalies correspond to the locations of the eH signals shown in figure 20

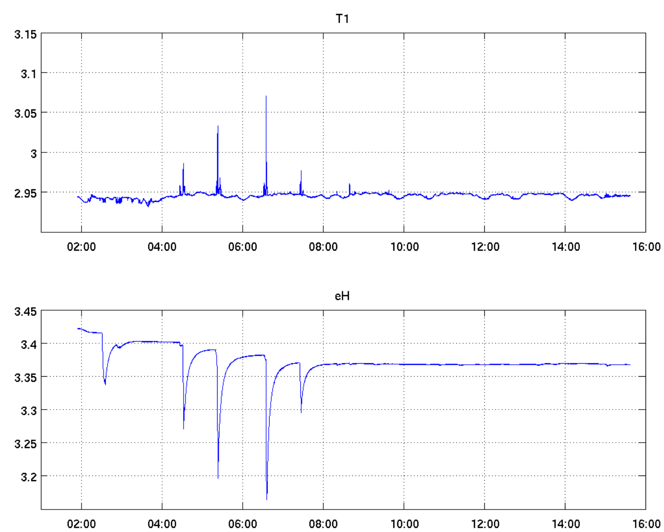

Figure 22: ABE185: these time plots confirm the coregistration of the eH and temperature signals

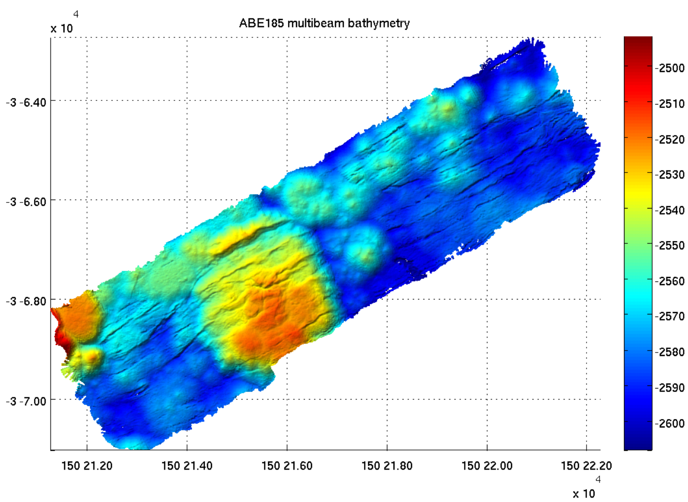

Figure 23: ABE185: bathymetry gridded at 2 meter intervals.

8 ABE186

ABE186 extended our coverage of Vienna Woods. ABE was launched conventionally with Jason on deck. The vehicle anchored for about 7 hours at the end of the run while Jason was recovered.

The vehicle navigation track, shown in figure 24, was extremely clean. We used a two element net. The A transponder (8.5 khz) showed substantial random noise, but that was filtered in real time, with more good ranges recovered in postprocessing.

No obvious plume activity was noted in either the eH or temperature plots. Figure 25 shows the time plots of both temperature and eH. The eH transients are very small (on the order of 2 millivolts) are not especially sharp, and do not correlate with temperature fluctuations.

Figure 26 shows the bathymetry gridded at 5 meters (the tracklines were flown at 150 meter height). This result required substantial filtering of the range data, as interference from the DVL introduced substantial noise correlated over several pings. This noise was removed with a cross-track median filter.

Summary: abe186
Start time: 2006/07/28 16:35:31
Survey start: 2006/07/28 18:54:30
Survey end: 2006/07/29 07:37:59
Surface time: 2006/07/29 17:17:04
Recovery time: 2006/07/29 17:34:35
Launch: 03 4.550'S 150 26.750'E
Recovery 03 3.291'S 150 26.334'E
Origin 03 13.000'S 150 15.000'E
descent: 0.28 kwhr over 2.30 hrs, ave pwr: 123.2 w
survey: 3.63 kwhr over 12.71 hrs, ave pwr: 285.6 w over 27.1km 2459 m depth
ascent: 0.38 kwhr over 10.12 hrs, ave pwr: 37.7 w
surface: 0.02 kwhr over 0.29 hrs, ave pwr: 71.6 w
Total energy use: 4.30 kwhr
energy from pack 1: 1.427 2: 1.445 3: 1.430 kwhrs

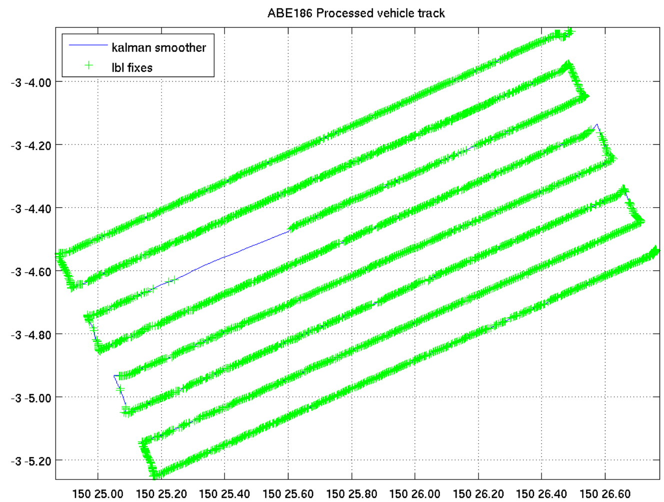

Figure 24: ABE186: the postprocessed LBL and filtered trackline

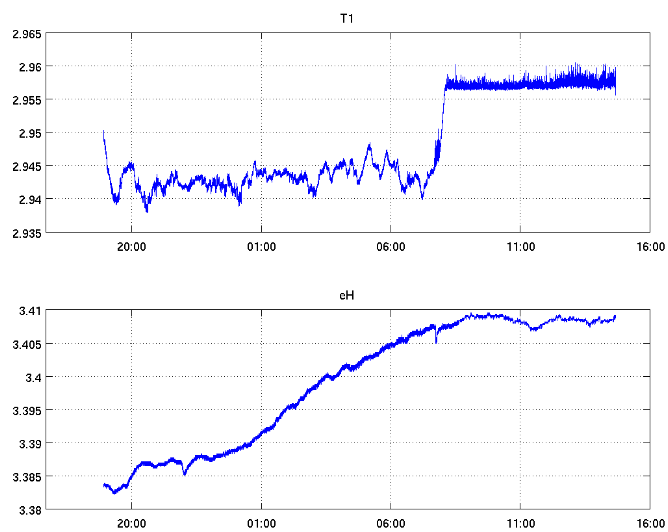

Figure 25: ABE186: the eH and temperature data showed no obvious signs of plume activity. The eH fluctuations are very small and not especially fast and do not correlate with and changes in temperature.

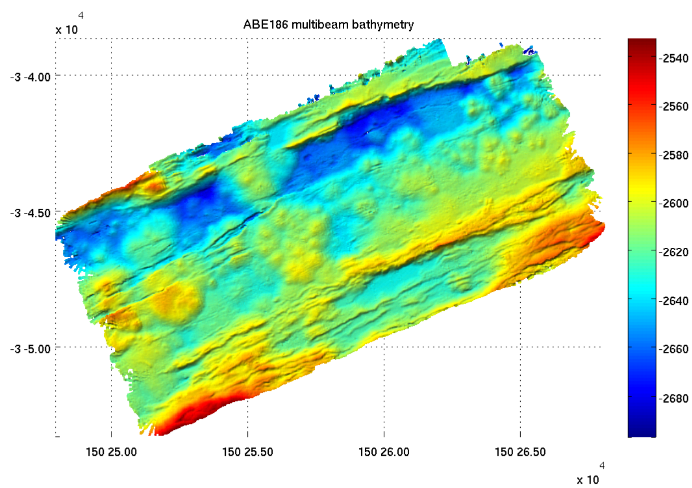

Figure 26: ABE186: This figure shows the bathymetry gridded at 5 meters. The geolocated ping positions were filtered with a cross-track median filter which removed most of the bad hits

9 ABE187

ABE187 extended our coverage of Vienna Woods. ABE was launched with Jason in the water and ABE anchored for about 14 hours at the end of the dive while we were working off site. ABE returned to the surface when we issued an acoustic command.

We noted no plume activity on the eH, temperature, or optical backscatter sensors.

LBL navigation had a problem on two lines, as can be seen in figure 27. No direct returns were received on the 9.5 channel on two of the westbound legs, so no fixes were computed for about an hour. This resulted in a large DR error. Apparently, the compass calibration is poor on the westbound heading, I (DY) had not changed to calibration as the vehicle had DR'ed extremely well, although the only gaps previously in LBL were in the eastbound direction. So the compass cal was unverified for westbound tracks. Fortunately, coverage did not suffer badly, as the tracklines were spaced at 200 meters with a survey height of 140 meters. Some mismatch can be seen in the processed bathymetry however.

While no interesting transients in temperature or eH were seen during the survey, the vehicle saw some interesting changes while anchored (16 meters off the seafloor) at the end of the survey, as shown in figure 28. So perhaps there is some venting in the area, but we were not fortunate enough to intercept a plume at 140 meters height with 200 m line spacing.

The bathymetric data also required some serious editting due to crosstalk between the 300 khz DVL and the 200 khz SM2000. The editting was done with a cross-track median filter. The final grid show some sign of mismatch associated with the DR tracklines and there are some small gaps.

Summary: abe187
Start time: 2006/07/30 08:15:48
Survey start: 2006/07/30 10:42:10
Survey end: 2006/07/30 23:44:59
Surface time: 2006/07/31 17:17:10
Recovery time: 2006/07/31 17:33:11
Launch: 03 4.301'S 150 26.455'E
Recovery 03 3.831'S 150 26.213'E
Origin 03 13.000'S 150 15.000'E
descent: 0.32 kwhr over 2.44 hrs, ave pwr: 133.1 w
survey: 3.80 kwhr over 13.04 hrs, ave pwr: 291.1 w over 27.1km 2449 m depth
ascent: 0.63 kwhr over 17.97 hrs, ave pwr: 35.1 w
surface: 0.01 kwhr over 0.27 hrs, ave pwr: 49.7 w
Total energy use: 4.76 kwhr
energy from pack 1: 1.573 2: 1.597 3: 1.586 kwhrs

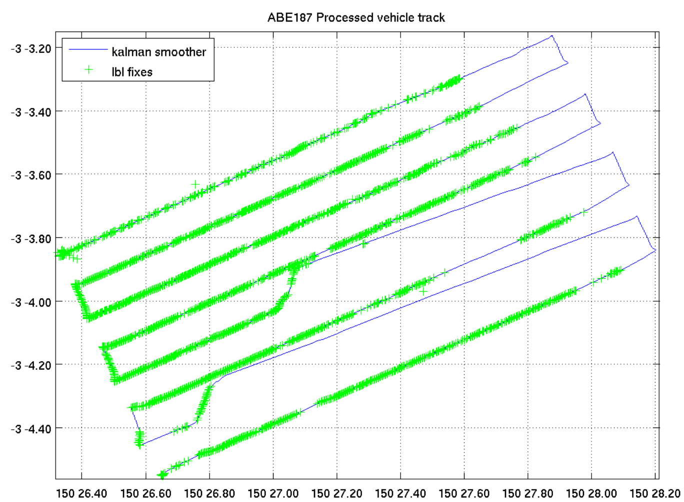

Figure 27: ABE187: The LBL nav had some large gaps on the two southern tracks heading west. The vehicle did not hear the direct reply from transponder A during these legs. Also, the vehicle had a large compass error on this heading, most offset due to current would have been compensated for by the DVL measurement.

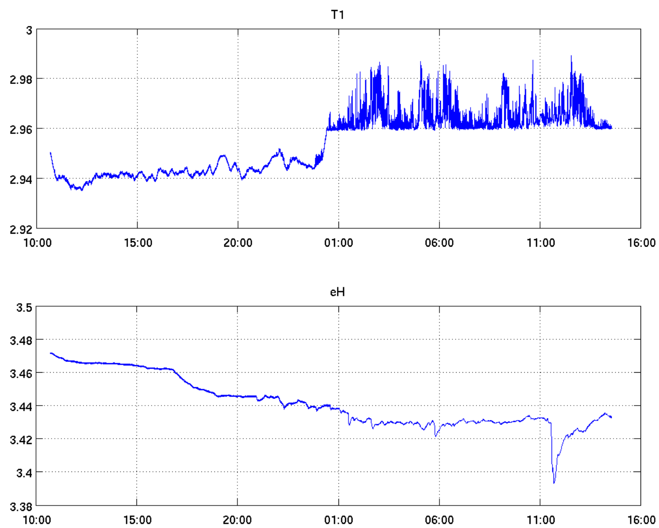

Figure 28: ABE187: These plots show the temperature (T1) and the eH as functions of time. No substantial activity was seen until the vehicle anchored 16 meters off the seafloor.

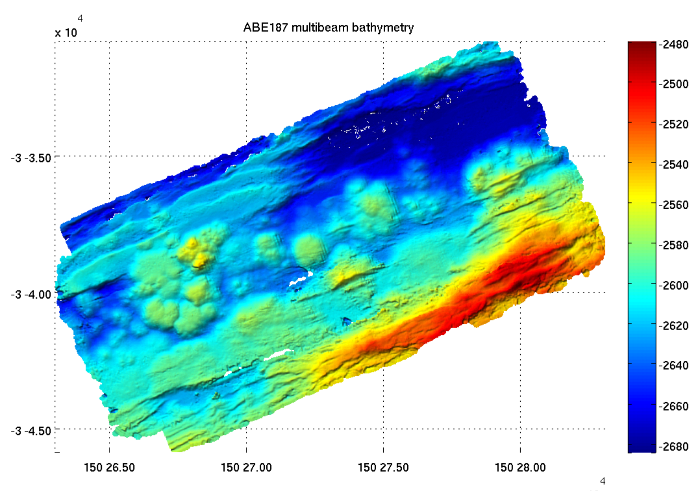

Figure 29: ABE187: the bathymetry is shown here gridded at 5 meters.

10 ABE188

ABE188 was our first dive in the Pacmanus area. The vehicle was launched conventionally and did not anchor at the end. The program called for the vehicle to anchor during the tracklines, as we left the site to set and survey transponders at Susu and for CTD work. But the program disabled anchoring after the last trackline, as we anticipated arriving back at the site before the last trackline. However we were delayed and the vehicle reached the surface as we approached, the RDF signal was received at 1011 local when the ship was several km from the final pickup point. In hindsight, it would have been safer to have the vehicle anchor regardless whether the tracklines were finished or not, as we are often delayed in our off-site work.

The LBL fixes were very solid. Most fixes used all three transponder ranges and the error was on the order of 1 meter. I had concerns that the B transponder, which was off the axis and a bit low, would not give us direct returns but it worked fine The nav data was post-processed with the async kalman smoother.

The plume data shows multiple hits on all water column sensors in at least three areas. Figure 31, 32 and 33 show the eH, optical backscatter, and temperature along the tracklines. At least three distinct areas can be seen. Figure 34 shows the three quantities plotted as functions of time. Good correlation can be seen between eH and optical backscatter, temperature is not correlated as consistently except fo r the biggest hits. Figure 35 shows the same data but with the optical backscatter and temperature scales expanded to clearly show the smaller magnitude signals. Figure 36 shows the vehicle depth and the temperature as functions of time. The vehicle depth can be seen decreasing as the vehicle is trying to follow descending depth setpoints. This is most likely caused by rising plume fluids pushing the vehicle up.

Figure 37 shows the bathymetry gridded at 2 meters. No editting was done on the this data, as the SM2000 data collected at 50 meters height is very clean.

Summary: abe188
Start time: 2006/08/01 17:38:25
Survey start: 2006/08/01 19:10:13
Survey end: 2006/08/02 08:17:10
Surface time: 2006/08/02 09:57:03
Recovery time: 2006/08/02 10:55:09
Launch: 03 43.949'S 151 39.993'E
Recovery 03 42.592'S 151 40.447'E
Origin 03 45.000'S 151 39.000'E
descent: 0.18 kwhr over 1.53 hrs, ave pwr: 120.7 w
survey: 3.83 kwhr over 13.11 hrs, ave pwr: 292.2 w over 27.0km 1619 m depth
ascent: 0.14 kwhr over 2.79 hrs, ave pwr: 50.2 w
surface: 0.05 kwhr over 0.97 hrs, ave pwr: 55.5 w
Total energy use: 4.16 kwhr
energy from pack 1: 1.380 2: 1.396 3: 1.381 kwhrs

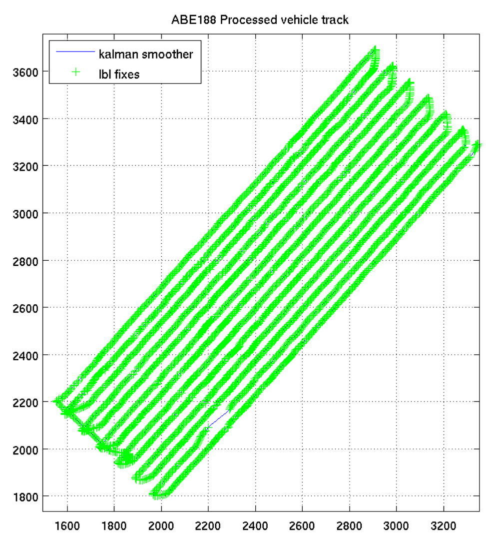

Figure 30: ABE188: the LBL nav for this dive was very solid, most fixes used three transponders and the errors were low 1 meter even before and net adjustments were made

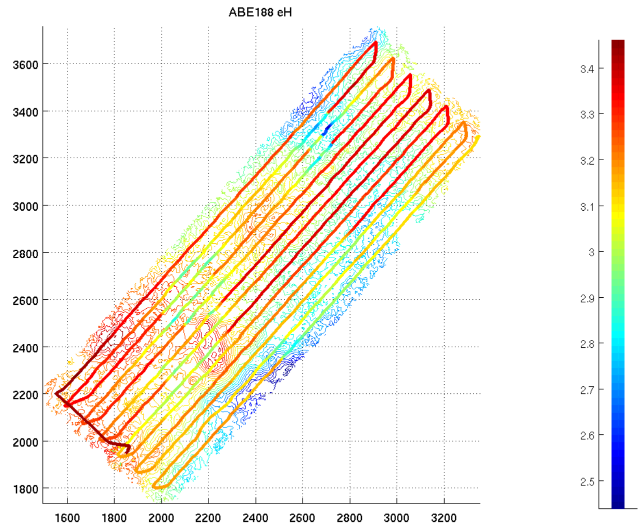

Figure 31: ABE188: the eH track shows hits in several locations

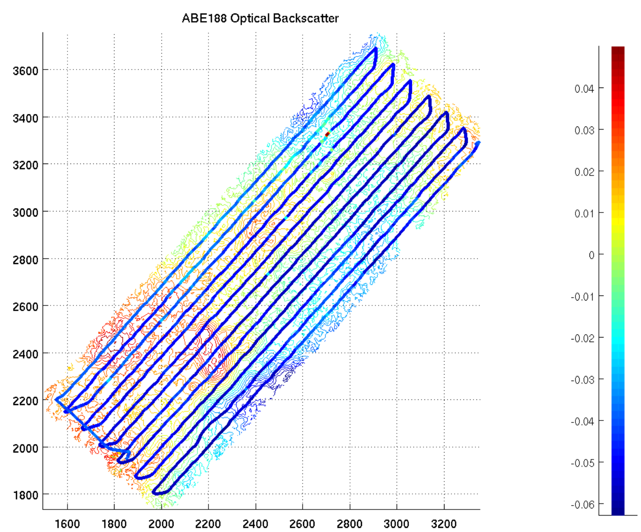

Figure 32: ABE188: the optical backscatter voltage (filtered) as a function of position

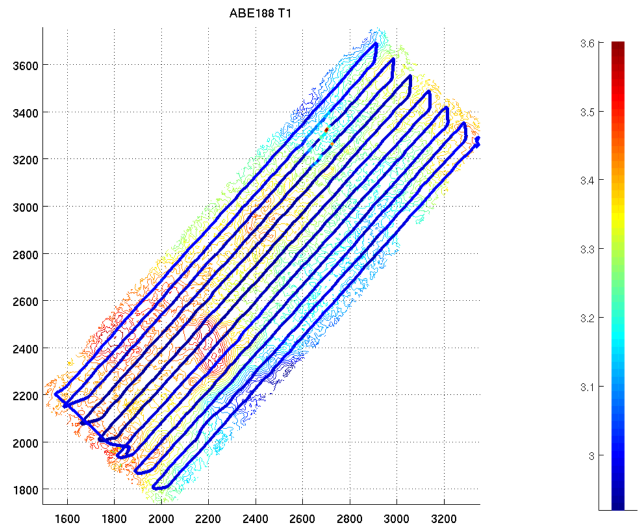

Figure 33: ABE188: temperature (T1) as a function of position

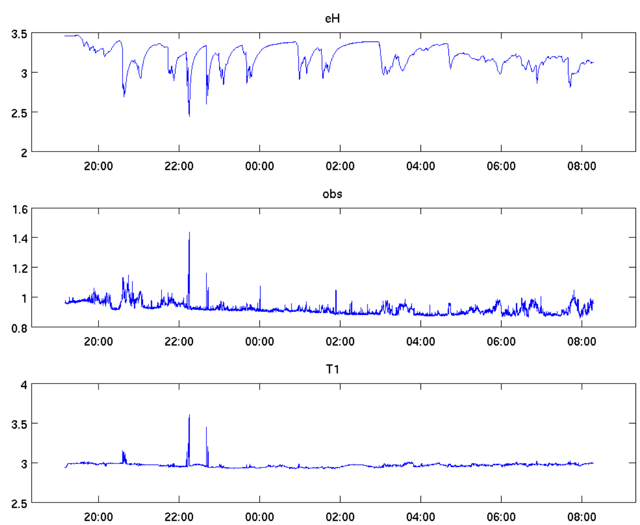

Figure 34: ABE188: these panels show, from the btop, eH, optical backscatter, and temperature. The correlation between eH and optical backscatter is very strong, the correlation with temperature is not as consistent

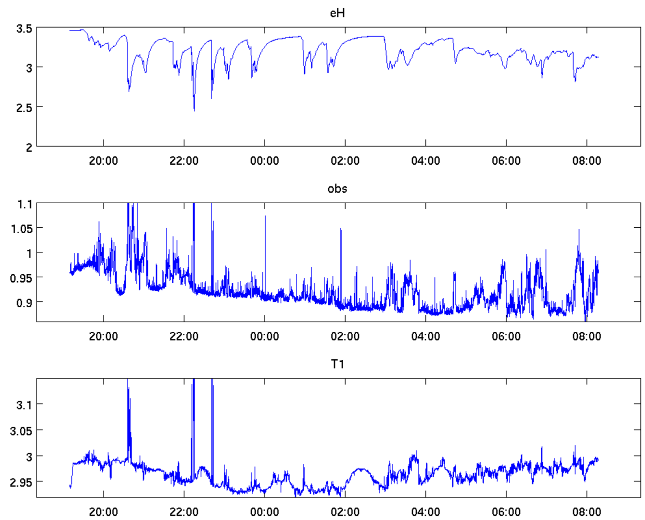

Figure 35: ABE188: this plot shows the same data as figure 34 but with the vertical scales of optical backscatter and temperature expanded to show the lower magnitude transients.

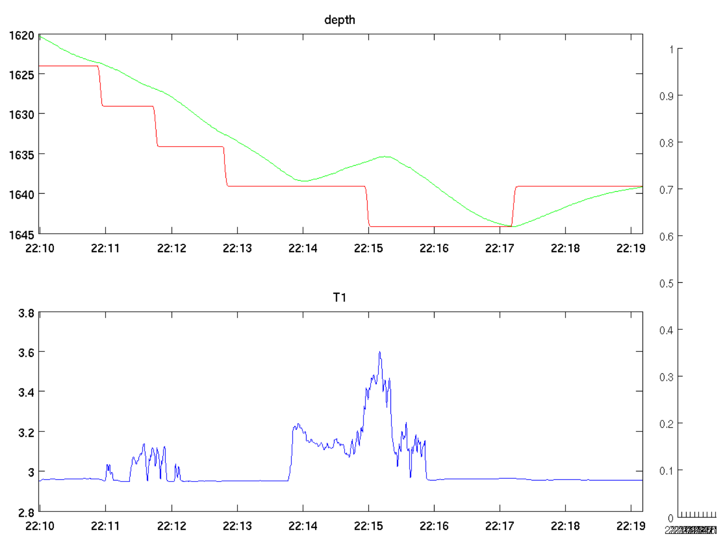

Figure 36: ABE188: These plots show the vehicle commanded and measured depth in the upper panel and temperature in the lower panel

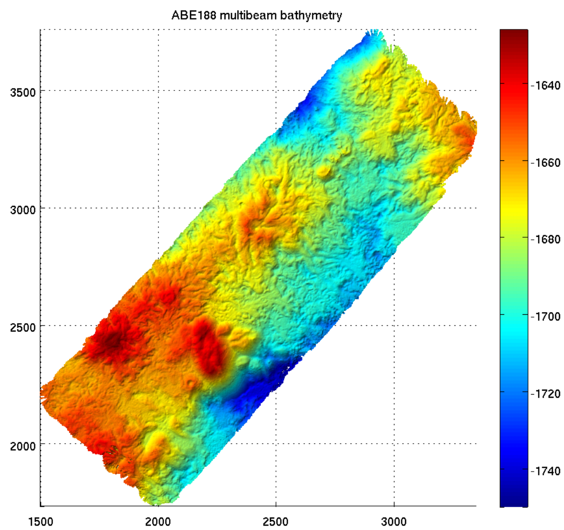

Figure 37: ABE188: the bathymetry was gridded at 2 meters and required no editting.

11 ABE189

ABE189 made a survey of the Suzette field. This dive was launched conventionally, and ABE anchored at the end for 8.2 hours. After seeing that ABE was off to a good start, the ship transitted back to the Pacmanus site (40 km away) for a Jason dive. After Jason was recovered, we transitted back to the site. We got a fix on ABE, then gave the release command.

The anchoring system did not behave normally on this dive. On abort, the command to release the ball and anchor was given successfully, but the ball and anchor didn't appear to release in the usual 5-10 minute time frame. The vehicle settled slowly to the seafloor, then popped up to the anchor mooring height about 35 minutes after the release command was issued. Another example of slow burn wires?

The tracklines were not programmed in a standard grid. Instead, the tracks spiralled out from the middle. So all tracklines on the northeastern side are heading southeast, and all tracklines on the southwestern side are heading northwest.

The LBL navigation was satisfactory, as seen in figure 38. An area on the western side shows that transponder D was shadowed. Also, the returns from transponder D showed some slightly long (10 meter) returns, which lead to a noisy track. This required hand editting.

The plume survey showed several strong venting sites based on eH, optical backscatter, and temperature. Figure 39 shows the temperature (T1), eH, and optical backscatter as functions of time. The correlation between these measurements can be seen. Figure 40 shows the eH data, which shows spatial correlation with the temperature data in figure 42 and the optical backscatter data in figure 41.

The multibeam bathymetry is shown in figure 43. The sonar data showed some noise, as the backscatter levels were pretty low (probably a sedimented bottom). Areas of low backscatter often have gaps in the received beams, which permits crosstalk from the DVL to be falsely detected. The hand-editted lbl navigation fixes improved the map quality considerably.

Summary: abe189
Start time: 2006/08/03 14:23:10
Survey start: 2006/08/03 15:51:17
Survey end: 2006/08/04 05:47:59
Surface time: 2006/08/04 15:45:45
Recovery time: 2006/08/04 16:21:49
Launch: 03 47.326'S 152 5.637'E
Recovery 03 47.139'S 152 5.906'E
Origin 03 50.000'S 152 4.000'E
descent: 0.19 kwhr over 1.46 hrs, ave pwr: 129.3 w
survey: 4.25 kwhr over 13.94 hrs, ave pwr: 304.6 w over 25.2km 1513 m depth
ascent: 0.41 kwhr over 10.70 hrs, ave pwr: 38.0 w
surface: 0.04 kwhr over 0.60 hrs, ave pwr: 61.4 w
Total energy use: 4.85 kwhr
energy from pack 1: 1.602 2: 1.627 3: 1.616 kwhrs

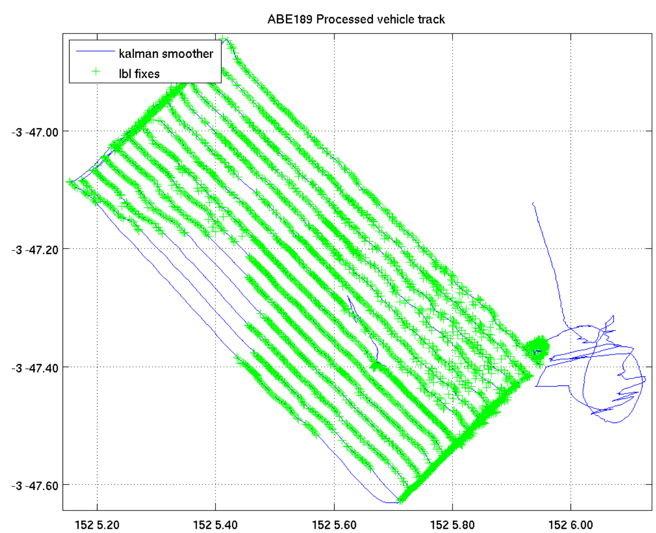

Figure 38: ABE189: This plot shows the first-cut postprocessed LBL fixes and the track from the asynchronous kalman smoother. An area where the 11.5 transponder was shadowed can be seen on the western side. The LBL track also suffers from some slightly long returns on the 11.5 channel. These were removed by hand editting

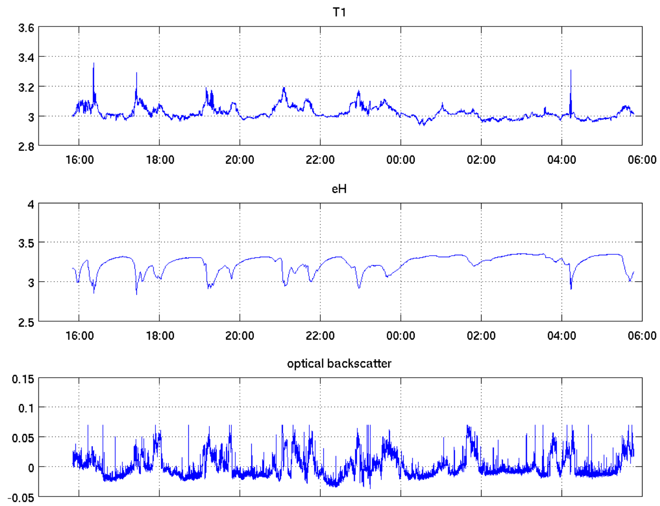

Figure 39: ABE189: Substantial correlation can be seen between temperature, eH, and optical backscatter.

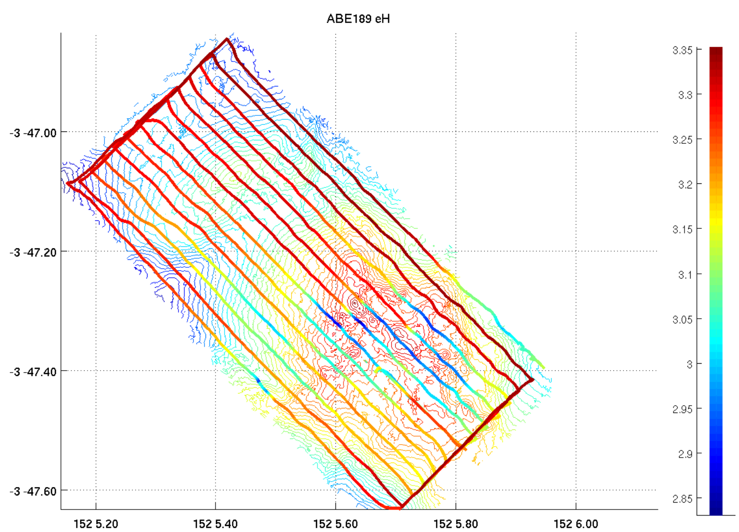

Figure 40: ABE189: Several areas with strong eH signals can be seen. This survey employed a spiral track, the tracks to the northeast side are all heading to the southeast and all the tracks to the southwest are heading northwest.

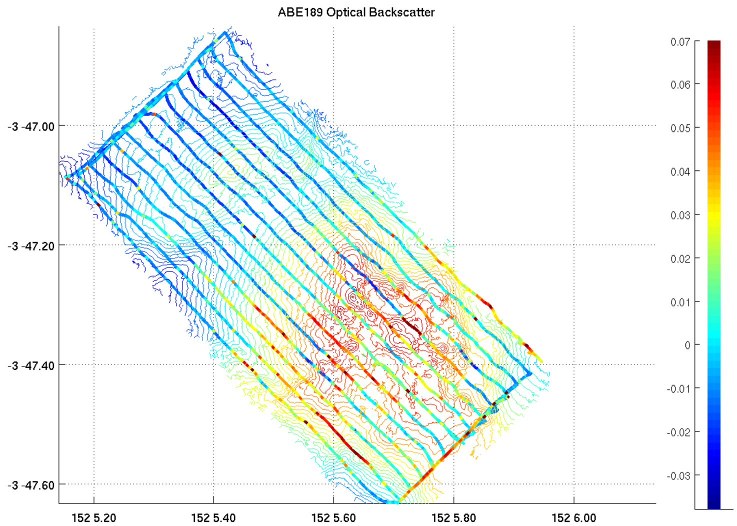

Figure 41: ABE189: optical backscatter anomalies show good correspondance to the eH signals.

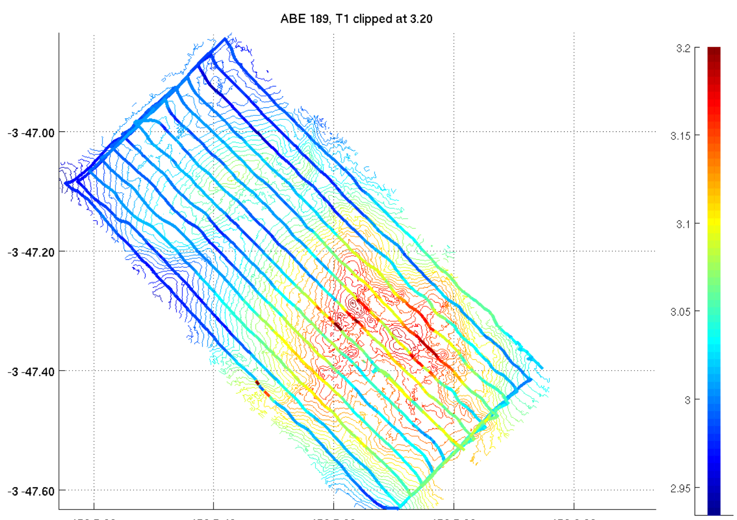

Figure 42: ABE189: This plot shows the temperature (T1) with the maximum value clipped at 3.2 so the largest hits don't expand the color scale and obscure the smaller anomalies. This plot is probably the best guide to pinpointing the sources of venting

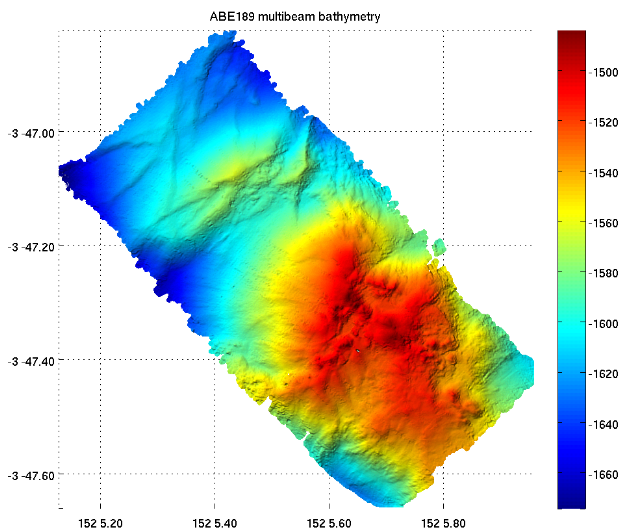

Figure 43: ABE189: the multibeam bathymetry improved substantially after the hand-editting of the lbl fixes. Also, the cross-track median filter was needed to eliminate DVL crosstalk, which were a problem due to the overall low backscatter levels.

12 ABE190

ABE 190 enlarged the survey at Pacmanus on all sides. ABE was launched normally and ABE anchored for about an hour at the end of the dive. This survey got solid plume hits over Fenway and an extension of Roman Ruins, which was also seen in ABE188.

Figure 44 postprocessed navigation track. Transponder returns were solid on all channels (8.5, 9.5, 10.0).

Figure 45 shows the eH data. The strongest hits were over Roman Ruins to the northwest and with weaker hits at Fenway on the eastern edge and (unnamed) field in the southwest. The Fenway and unnamed hits do not show up well in the figure as the magnitude of the hits at Roman Ruins is much larger but can be seen clearly in the time plot.

Figure 46 shows the optical backscatter data. The most prominent feature is a large cloud on the northwest side, which due to a lack of corresponding eH and temperature hits is most likely fluid from another source, probably one of those spotted in abe188.

Figure 47 shows the temperature data. A large increase can be seen over Roman Ruins in the northwest side. The large cloud seen in the optical backscatter plot to the west has a small temperature increase. The temperature changes over Fenway and the unnamed spot to the southwest are smaller.

Figure 48 shows the time plots for T1, eH, and optical backscatter. This plot shows the large clouds of high optical backscatter and the strong coregistered signals on all three sensors at Roman Ruins (04:30 and 06:45). the smaller hits the possible unnamed field (21:00) and Fenway (just before 02:00).

Figure 49 shows the combined bathymetry from dives 188 and 190.

Summary: abe190
Start time: 2006/08/05 17:25:57
Survey start: 2006/08/05 18:57:01
Survey end: 2006/08/06 09:35:41
Surface time: 2006/08/06 12:32:00
Recovery time: 2006/08/06 12:51:02
Launch: 03 43.949'S 151 39.993'E
Recovery 03 42.987'S 151 41.662'E
Origin 03 45.000'S 151 39.000'E
descent: 0.18 kwhr over 1.50 hrs, ave pwr: 117.9 w
survey: 4.28 kwhr over 14.64 hrs, ave pwr: 292.4 w over 30.5km 1621 m depth
ascent: 0.13 kwhr over 3.51 hrs, ave pwr: 38.4 w
surface: 0.02 kwhr over 0.32 hrs, ave pwr: 51.7 w
Total energy use: 4.59 kwhr
energy from pack 1: 1.523 2: 1.544 3: 1.527 kwhrs

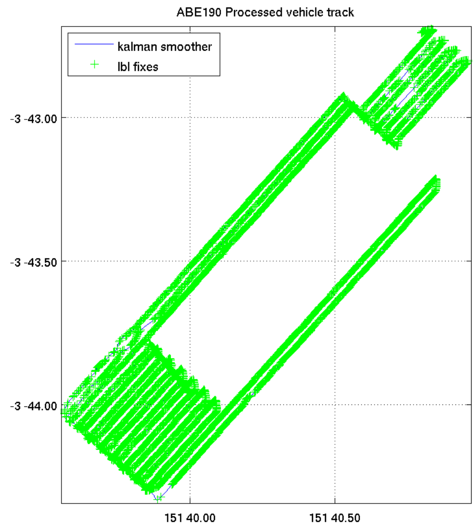

Figure 44: ABE190: This plot shows the postprocessed navigation track, nearly all fixes used all three transponders

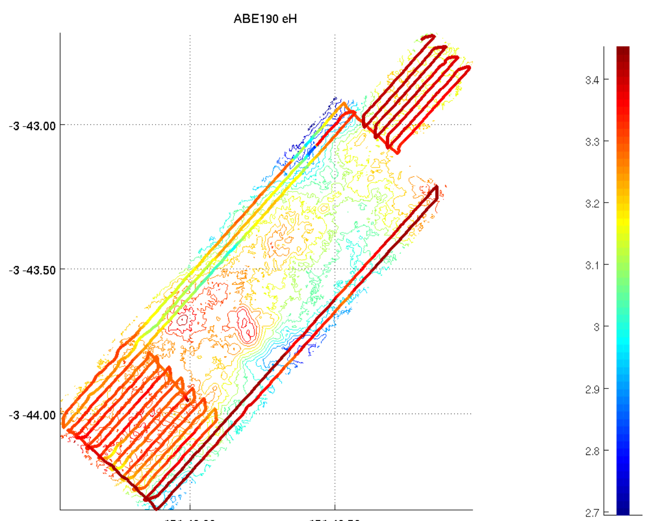

Figure 45: ABE190: The largest eH hits were seen over Roman Ruins (-3 -43.11 151 40.41) with smaller hits over Fenway (-3 -43.70 151 40.43) and an unnamed possible field (-3 -44.17 151 39.73). Other than Roman Ruins, the other hits are hard to see in this representation as the hits at Roman Ruins are very large.

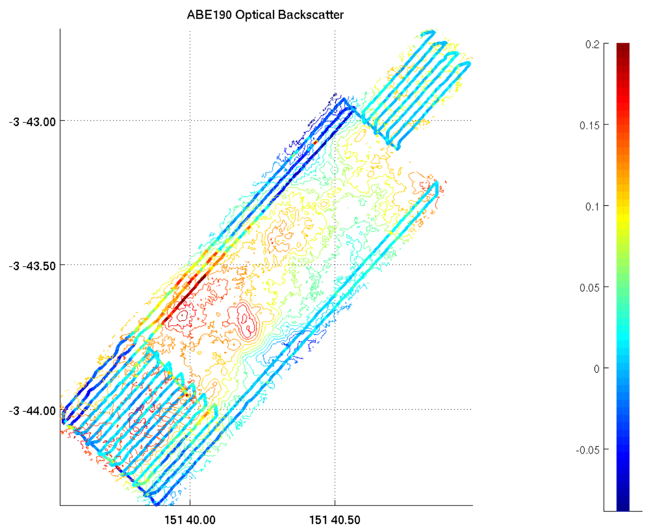

Figure 46: ABE190:The optical backscatter plot shows a large cloud to the west (which had no corresponding eH hits)

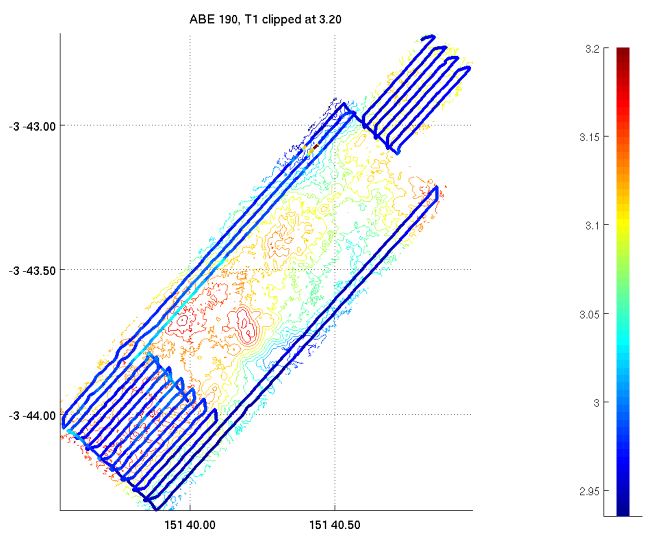

Figure 47: ABE190: The temperature hits over Roman Ruins are much larger than any other readings. The cloud to the west seen in the optical backscatter plot also has a moderate temperature anomaly

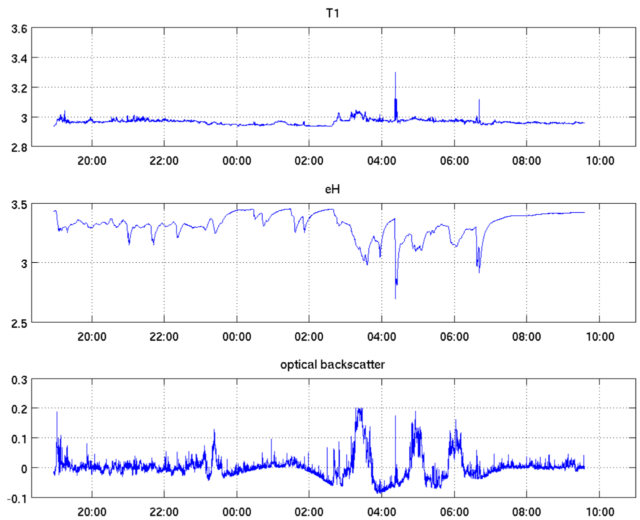

Figure 48: ABE190: This time plot shows the large optical backscatter clouds in the west and the strong hits over Roman Ruins. The smaller hits over Fenway and the possible unnamed field can also be seen

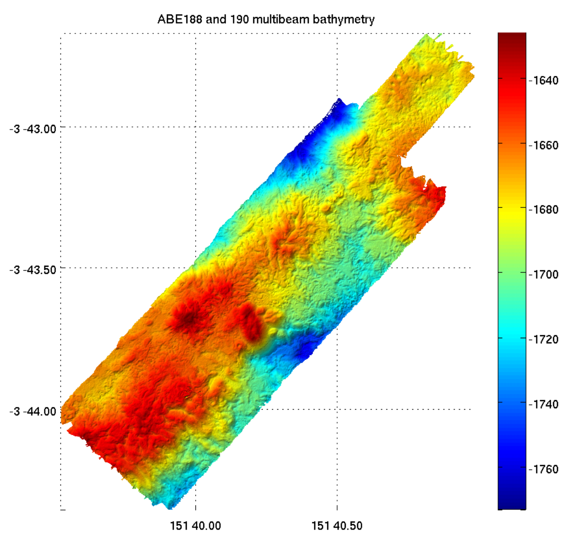

Figure 49: ABE190: This plot shows the combined bathymetry from 188 and 190

13 ABE191

ABE191 was conducted in the Pacmanus area. The dive gathered some useful data, but ABE failed to follow its tracklines properly due to a navigation error precipitated by a program blunder. The dive was planned for a 3 transponder net, but I (DY) had forgotten that one of the transonders (the 10.0khz C transponder) had already been recovered. Operation in a two element net normally works well, but the net geometry was very unfavorable.

The survey tracks took ABE across the baseline within 50 meters of one of the transponders. The LBL algorithm fumbled the baseline crossing two times. The algorithm has a model of net geometry and rejects fixes that are too close to the baseline using a criteria based on the crossing angle of the range rings. This criteria works fine except very close to the transponders, when it underestimates the error as it does not consider the effect of errors in the transponder locations. Rather than ignoring the LBL fixes that were both near the baseline and very close to one of the transponders and using the compass and DVL during the crossing, the algorithm considered the fixes to be good when they were not. This prevented the vehicle position estimate from crossing the baseline. We had never seen this problem before, but we had never had the vehicle attempt to cross a two element net close to one of the transponders before.

Figure 50 shows the postprocessed navigation track. With the proper estimate of vehicle position, the fixes along the baseline are not accepted (the gap). So in postprocessing, using an approximate DR estimate to determine the baseline side, the algorithm worked properly. The vehicle incorrectly drove as far south as the Fenway field and also drove far north of the intended tracklines.

Figure 54 shows the temperature (T1), the eH, and optical backscatter as functions of time. The large hits early in the dive at about 15:00 occured when ABE passed over Fenway while improperly driving south of the planned tracks. The coregistered hits later in the record, from 16:30 to 17:00, occurred when ABE was in the planned survey area. These hits were investigated by Jason, areas of oxidized sediments were found but no focussed venting.

Figure 51 shows the eH data as a function of vehicle position. The anomaly investigated by Jason can be seen at around -3 -42.80. Nothing of great significance was found, just some oxidized sediments. Likewise, the temperature (figure 51) and optical backscatter anomalies (figure 52) did not seem to correspond to significant active venting sites.

Figure 55 shows the combined bathymetry from dives 188, 190, and 191.

A solution was found to this problem and testing in simulation. In addition to the angle criteria, two transponder fixes are also rejected if the range from either transponder drops below a prescribed minimum (set as a fraction of the baseline distance).

Summary: abe191
Start time: 2006/08/07 11:29:59
Survey start: 2006/08/07 13:06:56
Survey end: 2006/08/07 18:19:59
Surface time: 2006/08/08 13:10:36
Recovery time: 2006/08/08 13:21:37
Launch: 03 43.227'S 151 40.591'E
Recovery 03 43.325'S 151 40.630'E
Origin 03 45.000'S 151 39.000'E
descent: 0.21 kwhr over 1.60 hrs, ave pwr: 128.1 w
survey: 1.44 kwhr over 5.21 hrs, ave pwr: 276.4 w over 10.6km 1621 m depth
ascent: 0.70 kwhr over 19.28 hrs, ave pwr: 36.4 w
surface: 0.01 kwhr over 0.18 hrs, ave pwr: 57.9 w
Total energy use: 2.35 kwhr
energy from pack 1: 0.776 2: 0.788 3: 0.784 kwhrs

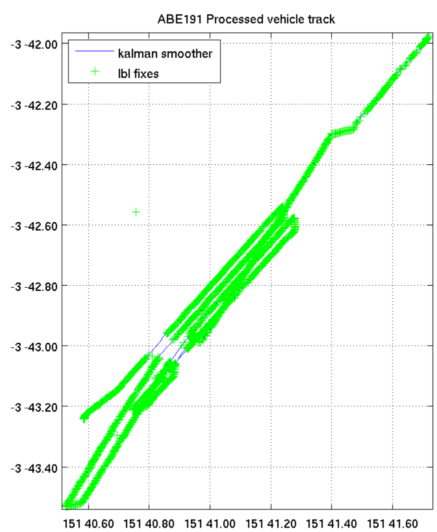

Figure 50: ABE191: this plot shows the postprocessed navigation track. The dive was planned for three transponders, but one had already been recovered. The tracklines passed very close (lt 50m) to one of the remaining transponders. Normally, the vehicle can deal with baseline crossings with only two transponders, but the algorithm failed when passing very close to one transponder.

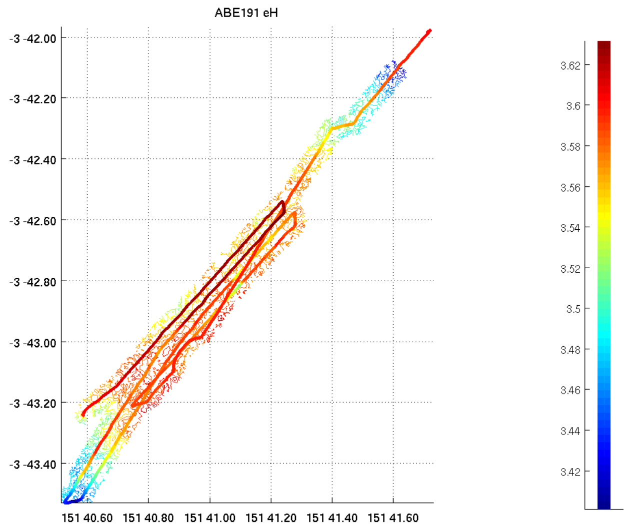

Figure 51: ABE191: The eH anomalies to the south correspond to the Fenway field, the anomaly to the at -3 -42.80 was investigated by Jason but no active venting was found

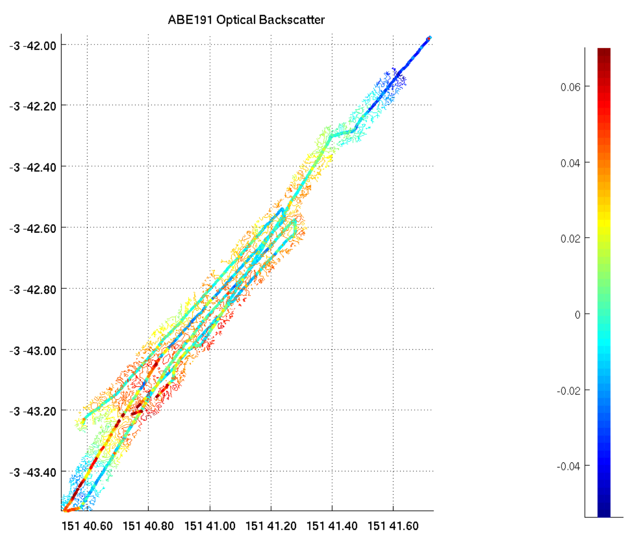

Figure 52: ABE191: optical backscatter anomalies can be seen at Fenway to the south and also near the eH anomaly at -3 -42.80

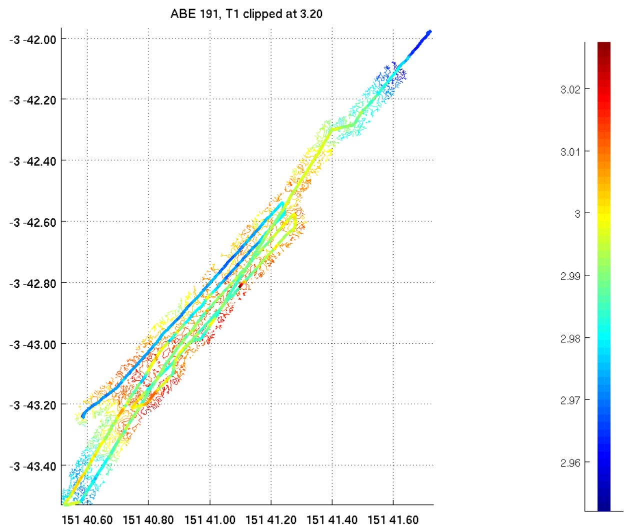

Figure 53: ABE191: a temperature anomaly corresponds to the eH and optical backscatter anomalies at -3 -42.80

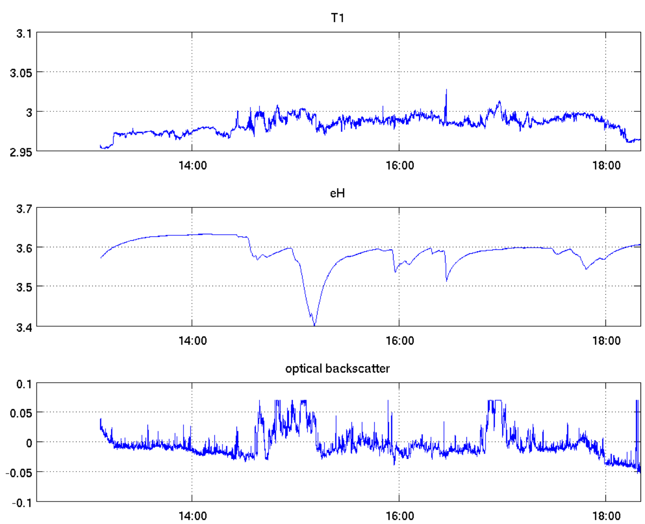

Figure 54: ABE191: the possible new sites are seen in this record after 16:00. Correlation can be seen between temperature, eH, and optical backscatter. Jason did not find any active venting, however.

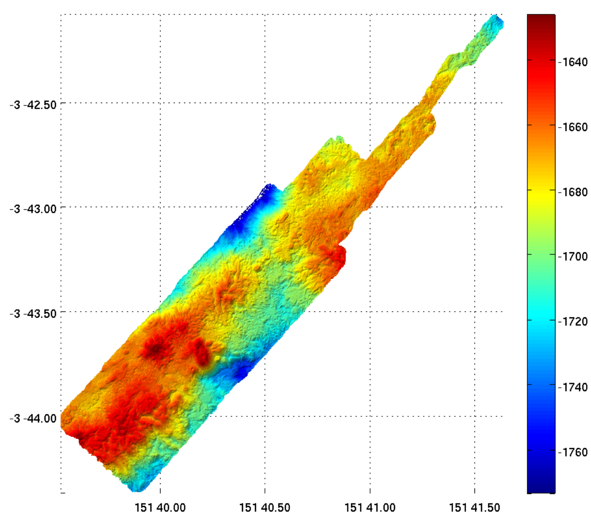

Figure 55: ABE191: This plot shows the assembled bathymetry from dives 188, 190, 191

14 ABE192

ABE 192 was conducted at NE Pual, the vehicle execuated all tracklines and returned all expected data until its batteries were expended, after which the vehicle anchored for about 6 hours. The vehicle ran in a two-element transponder net and had some trouble hearing direct returns from the A (8.5) transponder on the SW-bound legs. Due to some compass calibration error in the SW direction, the vehicle tracklines are a bit bent on those legs. Figure 56 shows the postprocessed LBL fixes and the postprocessed track.

The vehicle spotted several areas of possible venting, although the signals were fairly weak. Jason investigated two of these spots and found only weak, diffuse venting. The strongest indicators were some eH hits, shown in figure 57. As shown in figure 60, the two eH hits before 0400 and 0600 are quite sharp, although of moderate magnitude. The eH hits and some possibly correlated temperature hits can be seen more clearly in figure 61. These two hits were located near each other on consecutive tracklines (see figure 57) and probably corresponded to the weak venting sites visted by Jason. Most likely, ABE found a source of venting but not a very interesting one. Another area of possible interest based on two temperature hits on consecutive lines, shown in figure 58. These did not correlate with eH or optical backscatter hits and were not investigated by Jason.

Figure 62 shows the estimated current, derived from the differences between the vehicle bottom-track and water-track velocities. This plot was used by the Jason team to help guide the vehicle from the locations of the two strong eH hits to their probable sources on the seafloor.

Figure 63 shows the bathymetric data collected on the dive. Processing proceeded with no surprises.

Summary: abe192
Start time: 2006/08/10 16:22:31
Survey start: 2006/08/10 18:06:52
Survey end: 2006/08/11 09:05:59
Surface time: 2006/08/11 16:12:59
Recovery time: 2006/08/11 16:29:01
Launch: 03 40.422'S 151 43.414'E
Recovery 03 40.855'S 151 43.378'E
Origin 03 43.000'S 151 41.000'E
descent: 0.23 kwhr over 1.73 hrs, ave pwr: 130.4 w
survey: 4.24 kwhr over 14.98 hrs, ave pwr: 283.2 w over 32.4km 1824 m depth
ascent: 0.29 kwhr over 7.64 hrs, ave pwr: 37.6 w
surface: 0.01 kwhr over 0.27 hrs, ave pwr: 49.9 w
Total energy use: 4.76 kwhr
energy from pack 1: 1.574 2: 1.597 3: 1.586 kwhrs

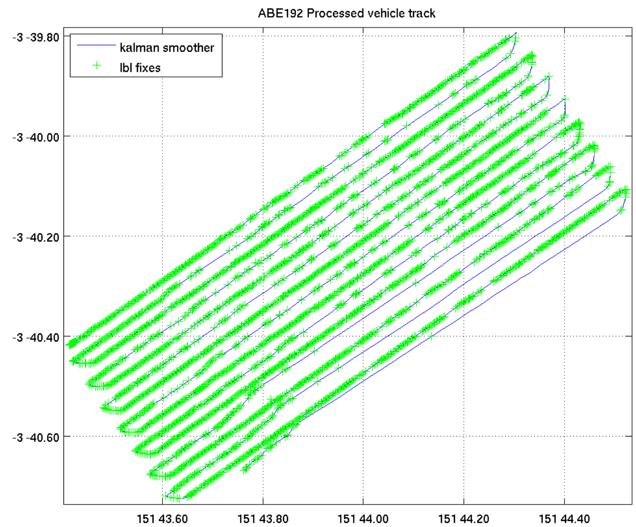

Figure 56: ABE192: This dive used two transponders. One transponder could not be heard on the SW-bound legs at the southern edge of the survey area and the vehicle drifted off the tracklines due to compass error

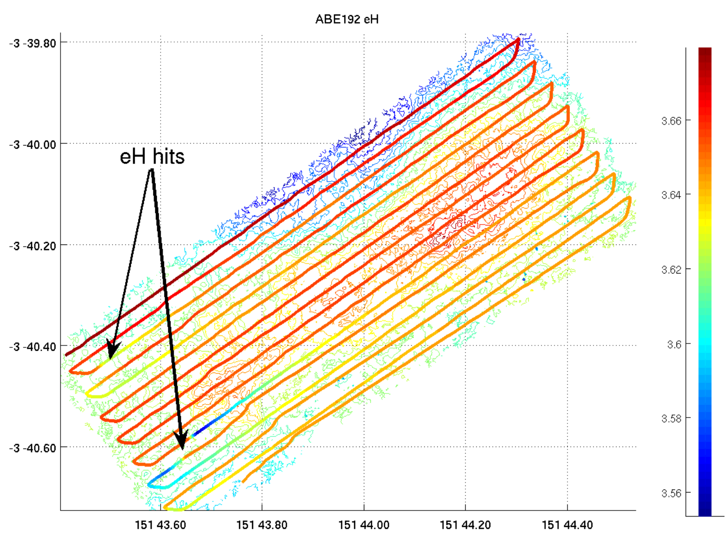

Figure 57: ABE192: This plot shows the eH data and points out the strongest eH hits. The strongest two hits were related by Jason to low temperature venting

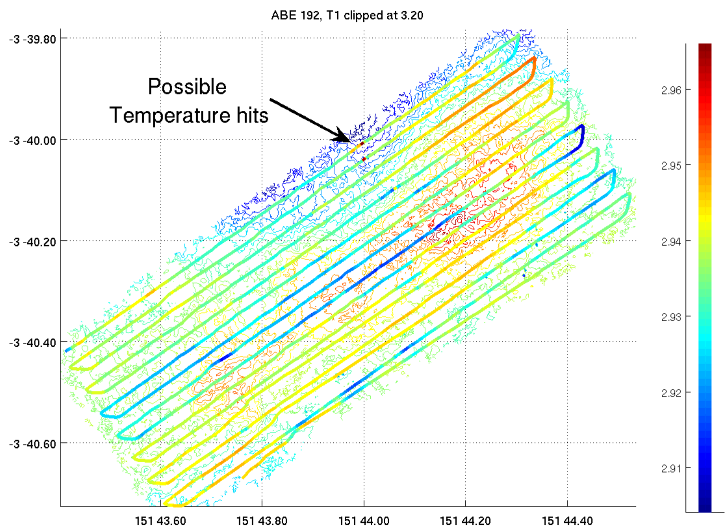

Figure 58: ABE192: No substantial temperature anomalies were seen in the vicinity of the eH hits, but temperature rises were seen on consecutive tracklines on the northern edge of the survey. These were not investigated by Jason

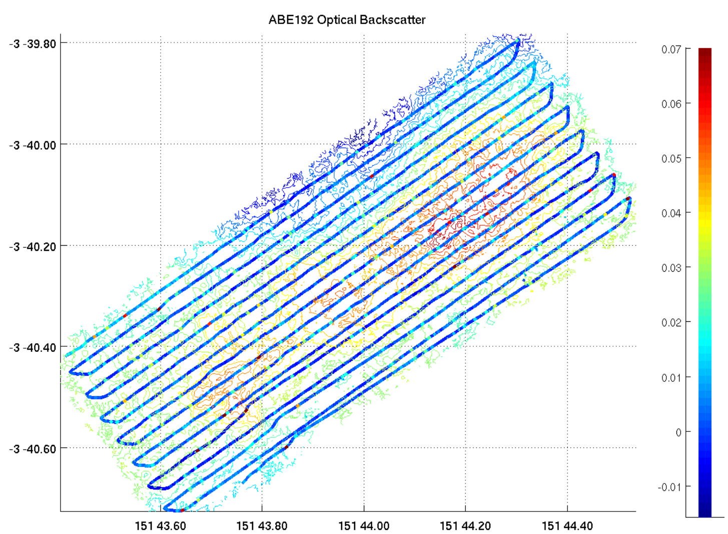

Figure 59: ABE192: The optical backscatter data did not produce any substantial anomalies that correlated with either temperature or eH

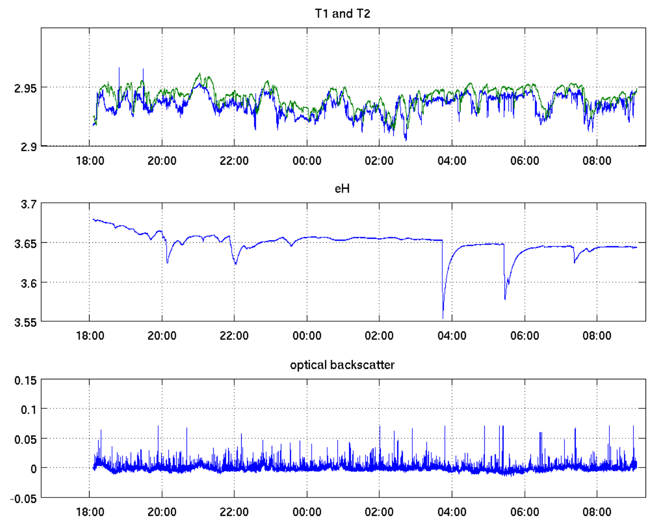

Figure 60: ABE192: This plot shows that the later eH hits in the SW corner of the survey area were fairly sharp but not of high magnitude. The correspondance with temperature or optical backscatter is not strong

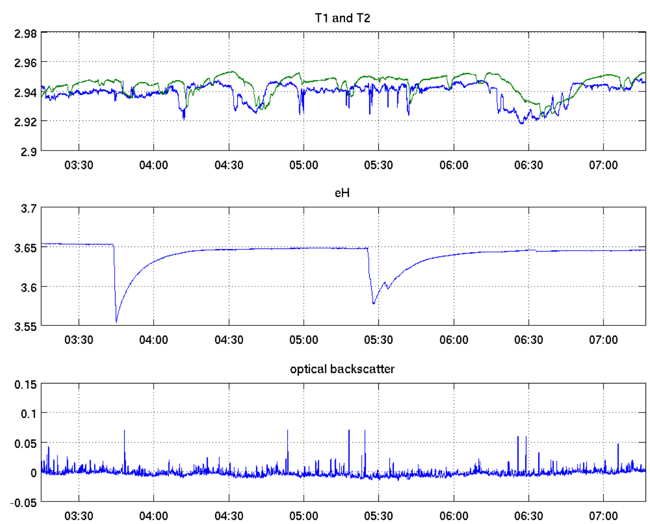

Figure 61: ABE192: In this zoomed view, the strongest eH anomalies may line up with some small temperature hits

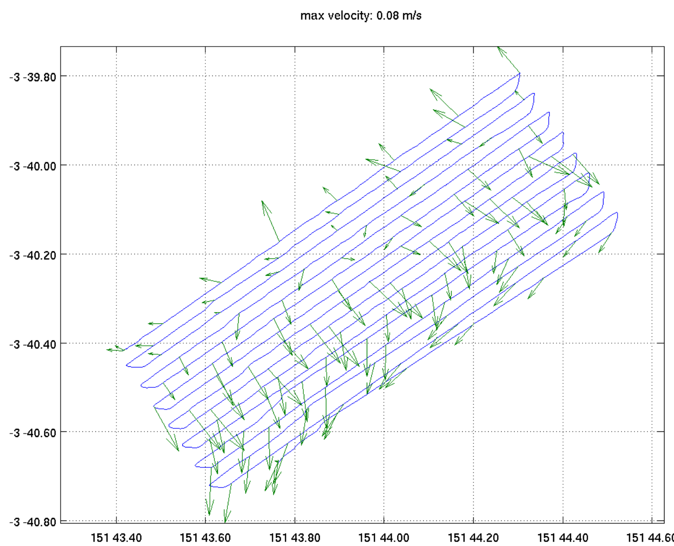

Figure 62: ABE192: This plot shows the estimated current, determined by transforming the difference between the bottom lock and water lock DVL data into world coordinates. This plot was used by the Jason team to trace the eH hits back to their sources

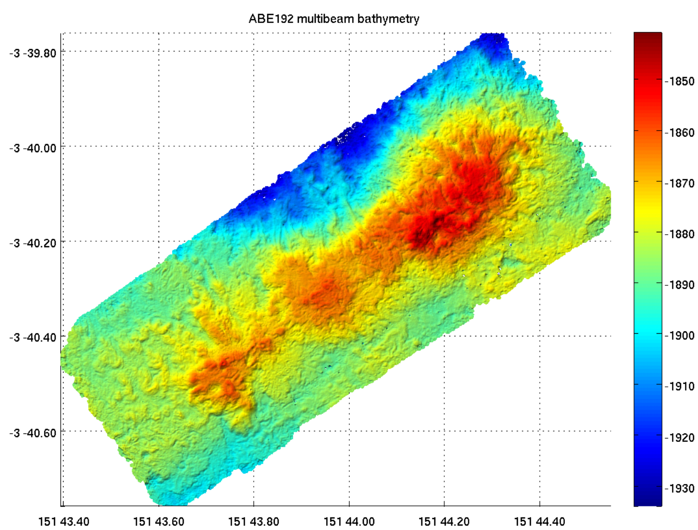

Figure 63: ABE192: the bathymetric data from this dive was processed in a straightforward manner.

15 ABE193

ABE193 was intended to enlarge the survey of NE Pual. The dive was shortened substantially by a technical problem. ABE's depth sensor reported that ABE's depth suddenly increased by about 500 meters. This bad value made it through the filters designed to reject noisy values and triggered an abort condition for exceeding the maximum allowed depth (set several hundred meters below the deepest possible depth in the survey area). The measured depth trace, including the bad reading, is shown in figure 64. In 192 dives and several thousand hours of bottom time, we had never seen this problem.

ABE's routine that processes the depth information includes a 5-point median filter to reject erroneous, inconsistent readings. In this case, the filter was not effective since the interface module can return identical readings on consecutive interrogations if the input data from the depth sensor has not updated. Repeated readings for which the actual sensor data has not been refreshed are not flagged (this is one of our oldest interface modules and this deficiency has been corrected in newer versions). If the reading in the interface module was bad, it could have been read out 3 times (we tested for this) before it changed, which would have allowed it to be accepted by the filter. While an unlikely event, this is the best explanation

Figure 65 shows the postprocessed navigation tracks. The vehicle completed 2 tracklines and had begun the third when the abort occurred.

No substantial activity was seen on this short run on T1, eH, or optical backscatter, as shown in figure 66. The two temperature hits seen in ABE192 were not supported by any data from this dive.

Figure 67 shows the bathymetry from both ABE192 and ABE193.

Summary: abe193
Start time: 2006/08/12 13:16:17
Survey start: 2006/08/12 15:00:38
Survey end: 2006/08/12 17:23:20
Surface time: 2006/08/13 15:25:00
Recovery time: 2006/08/13 15:36:31
Launch: 03 40.400'S 151 43.399'E
Recovery 03 40.444'S 151 43.957'E
Origin 03 43.000'S 151 41.000'E
descent: 0.22 kwhr over 1.73 hrs, ave pwr: 127.6 w
survey: 0.67 kwhr over 2.37 hrs, ave pwr: 284.2 w over 4.8km 1851 m depth
ascent: 0.82 kwhr over 22.44 hrs, ave pwr: 36.5 w
surface: 0.01 kwhr over 0.19 hrs, ave pwr: 56.6 w
Total energy use: 1.72 kwhr
energy from pack 1: 0.569 2: 0.578 3: 0.569 kwhrs

Figure 64: ABE193: This plot shows the bad depth reading that triggered the abort. ABE is programmed to abort if it reads depth below a preset maximum. In this case, the bad reading trigged the abort.

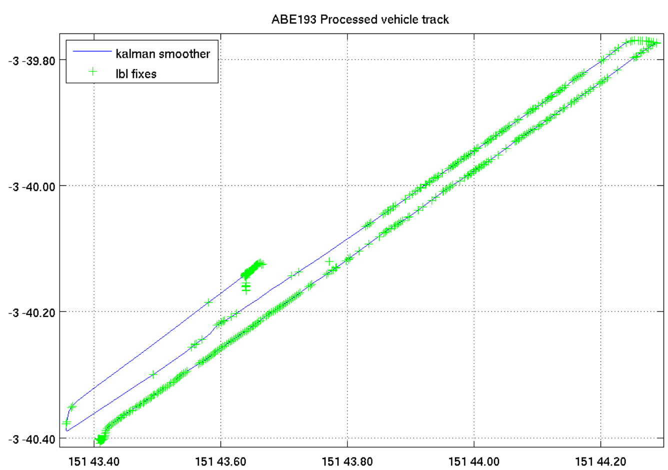

Figure 65: ABE193: The vehicle completed two tracklines and was on the third when the abort occurred. The acoustic returns were poor on the 8.5 (A) transponder in the western section

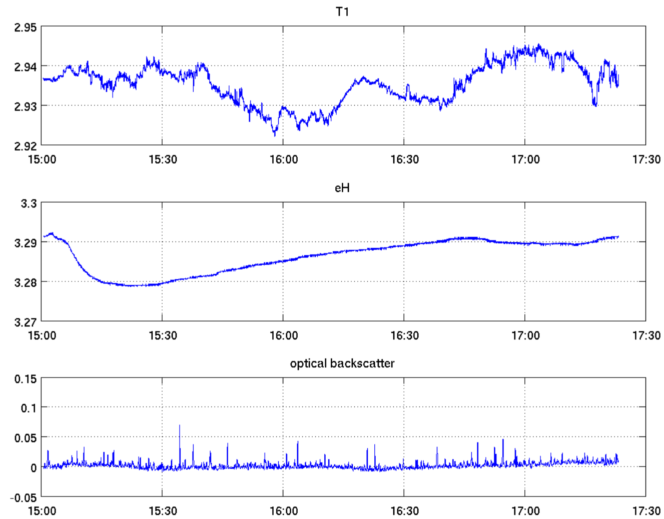

Figure 66: ABE193: No substantial activity was seen on any of the plume sensors. The two temperature hits seen on the northern two legs of ABE192 were not confirmed

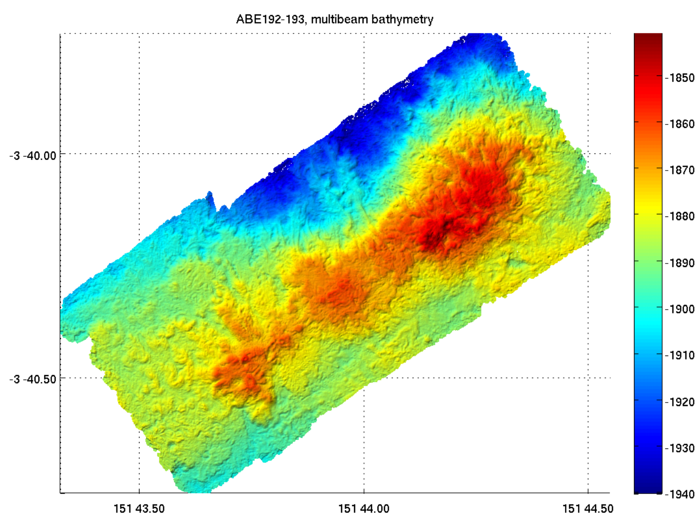

Figure 67: ABE193: The combinated bathymetry from ABE192 and ABE193

16 ABE194

ABE194 surveyed the tops of both North and South Su. The dive returned all expected data. The vehicle had some trouble hearing transponders due to direct paths being blocked by terrain. Most of the navigation was recovered in postprocessing and the resulting map shows nav problems in only a few areas.

The realtime LBL nav had several problems that were addressed in post-processing. The 11.5 khz transponder (D) showed slightly erratic returns, as it had on previous dives in other locations. Either the transponder or the receiver channel in ABE clearly has problems. As the returns on the 455 (topside LBL receiver) alsways appeared clean, the receiver channel in ABE is suspect. These erratic routines were slightly long (20 msec) and somewhat consistent so they were not filtered out in realtime. They were very difficult to filter with an automated filter in postprocessing, as the bad returns were often consistent and usually outnumbered the good returns. The solution was to hand-edit the 11.5 returns, keeping the shortest, consistent routine. Second, the vehicle often did not have two good transponder returns due to shadowing by terrain. The most substantial hole, between the two peaks and over South Su, was filled using surface bounce returns from the 9.5 transponder (B) located to the north. Sea conditions were very calm, and that may have contributed to the quality of the bounce results. Also, the transponder locations were adjusted to minimize jumps in the estimated position as the available transponders changed. This was very successful, the mean error for 3 transponder fixes dropped from about 2.5 meters to around 0.6 meters. Figure 68 shows the real time fixes, the post-processed fixes. The postprocessed fixes are far more consistent and substantial holes were filled over South Su and in between the two peaks.

As expected, the vehicle registered strong plumes over both peaks. In addition, a smaller plume was probably spotted on the northern flank of South Su. Figure 69 shows the eH data on the vehicle trackline, figure 71 shows the temperature data, and figure 70 shows the optical backscatter data. As can be seen in figure 72, the hits are very large over N. Su, especially the optical backscatter and the hits on all sensors are coregistered in many places. In addition to the vents on the peaks, a possible smaller venting area was spotted on the north flank of South Su, the corresponding plume data is shown in figure 73

Summary: abe194
Start time: 2006/08/14 16:04:31
Survey start: 2006/08/14 17:15:00
Survey end: 2006/08/15 07:24:59
Surface time: 2006/08/15 13:56:43
Recovery time: 2006/08/15 14:07:44
Launch: 03 47.894'S 152 5.953'E
Recovery 03 48.586'S 152 6.180'E
Origin 03 50.000'S 152 4.000'E
descent: 0.15 kwhr over 1.16 hrs, ave pwr: 132.7 w
survey: 4.27 kwhr over 14.16 hrs, ave pwr: 301.8 w over 23.2km 1299 m depth
ascent: 0.26 kwhr over 6.97 hrs, ave pwr: 37.0 w
surface: 0.01 kwhr over 0.18 hrs, ave pwr: 45.5 w
Total energy use: 4.69 kwhr
energy from pack 1: 1.552 2: 1.573 3: 1.560 kwhrs

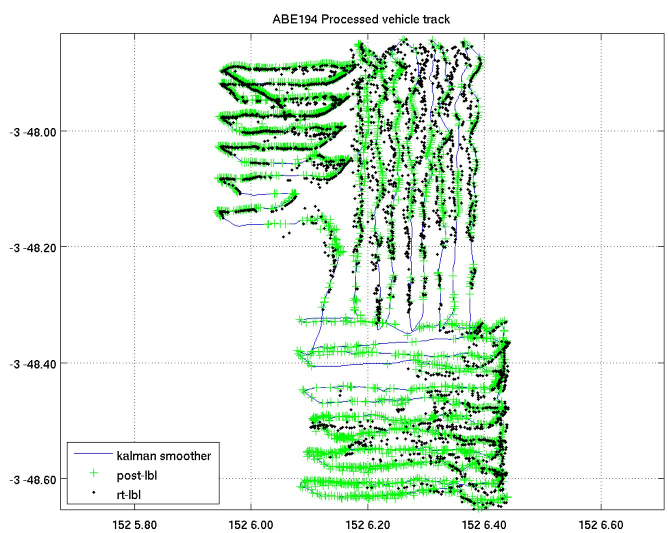

Figure 68: ABE194: This plot shows the realtime (bllack dots, postprocessed LBL (green), and postprocessed track (blue). The substantial areas with no real-time fixes were filled in postprocessing using surface bounces from the 9.5 transponder. The erratic nature of the real-time fixes was achieved by hand editting the noisy 11.5 returns. Also, the transponder adjustment reduced jumps when the combination of transponders changed.

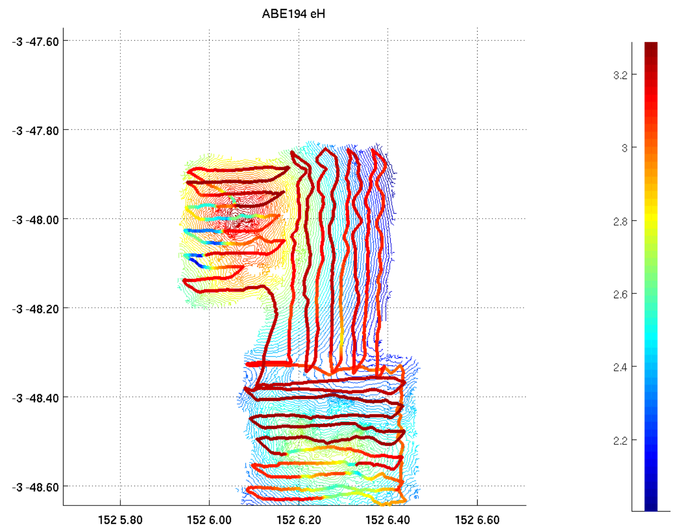

Figure 69: ABE194: Strong eH hits can be seen over both peaks, with a smaller hit on the northern flank of South Su

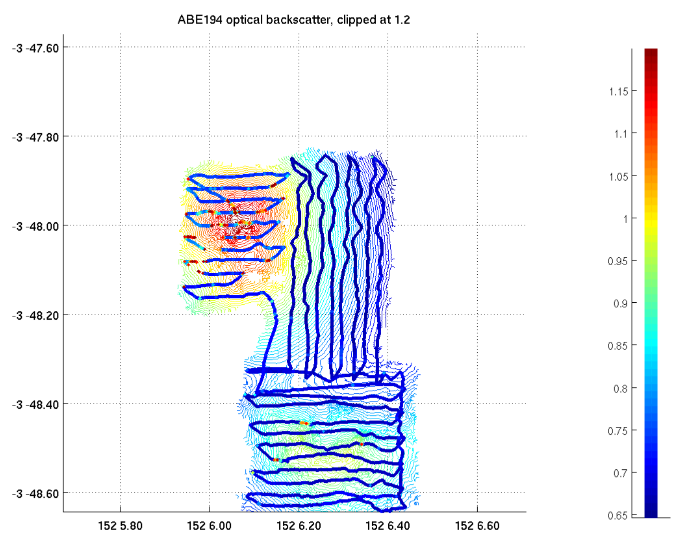

Figure 70: ABE194: The optical backscatter gives comparable results to eH. The maximum values over North Su were very high, and their values were clipped in this plot so that other significant backscatter changes could be seen.

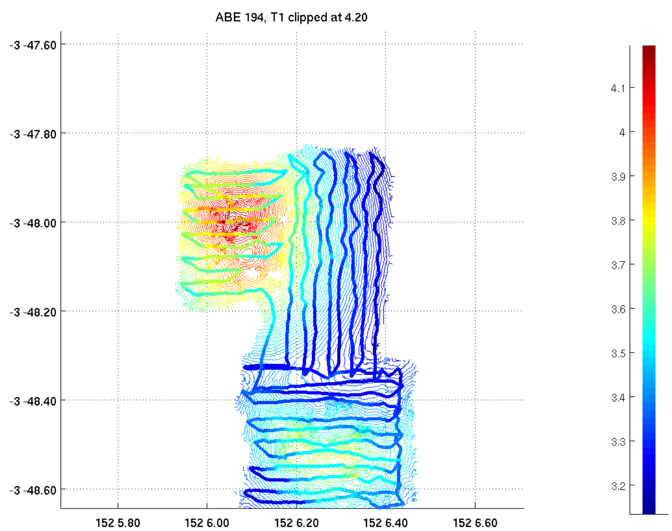

Figure 71: ABE194: The temperature hits correspond substantially to the eH and optical backscatter hits

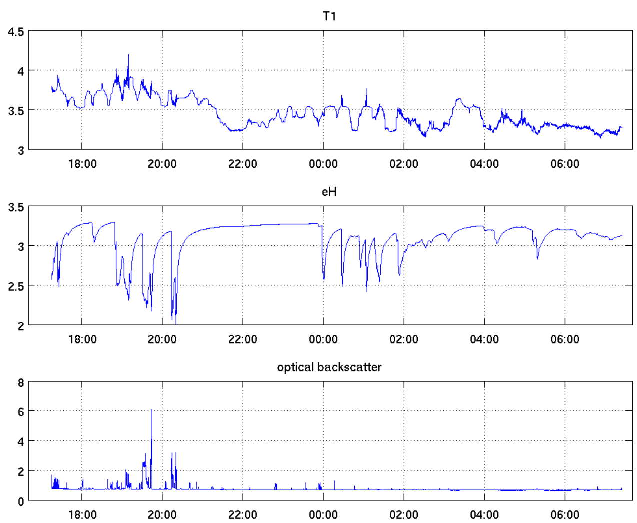

Figure 72: ABE194: This plot shows the coregistered hits on all three plume sensors. The first group of hits occured over North Su, the group in the middle of the time record happened over South Su, and the hits later in the record happened on the north flank of South Su and the eastern flank of North Su. The plot also emphasizes the large amplitude of the optical backscatter signals over North Su.

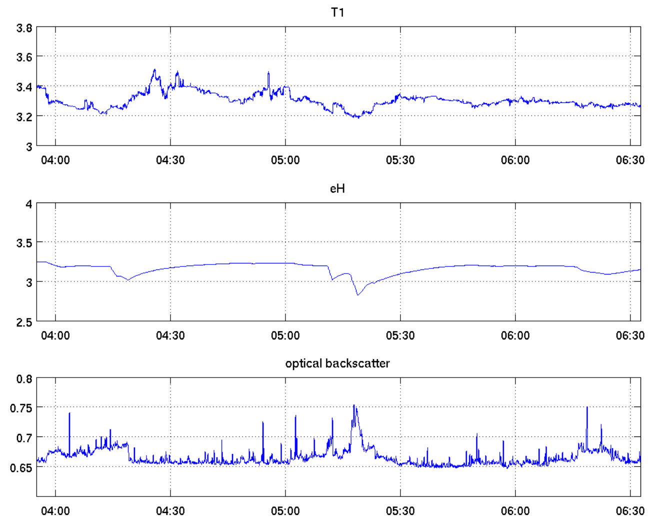

Figure 73: ABE194: This expansion of the previous plot (figure 72) shows the smaller hits seen later in the record when the vehicle was on the northern flank of South Su and the eastern flank of North Su

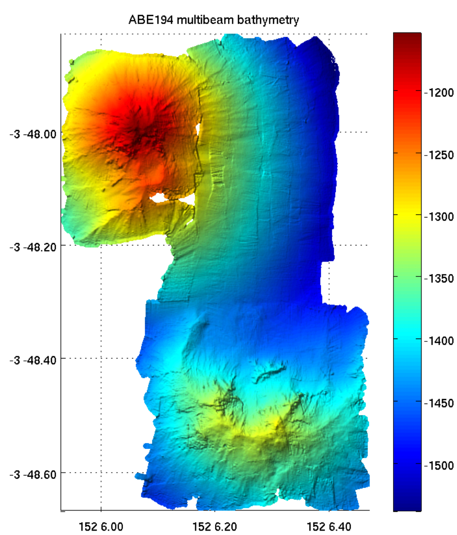

Figure 74: ABE194: The bathymetry shows some misregistration, probably due to navigation problems. But much of the area that was editted or filled with surface bounce looks reasonable.

17 ABE195

ABE195 covered two blocks on the SE flank of South Su. The vehicle anchored at the end of the run when the batteries ran low, but we released it a few minutes later. The run returned solid data from all sensors. The vehicle ran in a two transponder net, as the 11.5 transponder was obscured for the entire dive as expected (it was on the eastern side of South Su). One transponder, the 8.5, could not be seen for the northern half of the second block, which was renavigated using surface bounce in postprocessing.

Figure 75 shows the nav track, including fixes recovered in post-processing, some from surface bounces. The real-time track was missing returns from the 8.5 transponder to the east due to shadowing by terrain. In this case, the fixes recovered from surface bounces were not as consistent as those from abe194, most likely due to weather conditions.

Signals from plumes were registered at several points in the dive, but they were not very strong and Jason did not find any active venting in following them up. Figure 76 shows the eH data. The hits in the northwest corner did not have especially high rates of change of the eH voltage. These hits did show good correspondance with optical backscatter, as shown in figure 77, but with no increase in temperature as shown in figure 78. The combination of weak eH, moderate optical backscatter, and no temperature increase implies stale plume fluids. The region of moderate temperature rise on the eastern edge of the northern block seen in figure 78 did not have corresponding activity in either eH or optical backscatter. The temperature, eH, and optical backscatter are shown as functions of time in figure 79. The large optical backscatter signal at the beginning of the record is unexplained, it did not correlate to any activity in temperature or optical backscatter. It began when the vehicle was about 50 meters above the seafloor, and continued until the vehicle started the survey.

Figure 80 shows the gridded bathymetric map. The results are good except in the northern section where the missing fixes were filled using surface bounce returns on the 8.5 transponder.

Summary: abe195
Start time: 2006/08/16 18:24:41
Survey start: 2006/08/16 19:49:07
Survey end: 2006/08/17 10:20:12
Surface time: 2006/08/17 12:29:59
Recovery time: 2006/08/17 12:42:31
Launch: 03 49.295'S 152 5.729'E
Recovery 03 48.960'S 152 5.888'E
Origin 03 50.000'S 152 4.000'E
descent: 0.16 kwhr over 1.39 hrs, ave pwr: 118.1 w
survey: 4.31 kwhr over 14.51 hrs, ave pwr: 297.3 w over 26.1km 1530 m depth
ascent: 0.13 kwhr over 2.60 hrs, ave pwr: 49.8 w
surface: 0.01 kwhr over 0.21 hrs, ave pwr: 70.6 w
Total energy use: 4.61 kwhr
energy from pack 1: 1.529 2: 1.551 3: 1.532 kwhrs

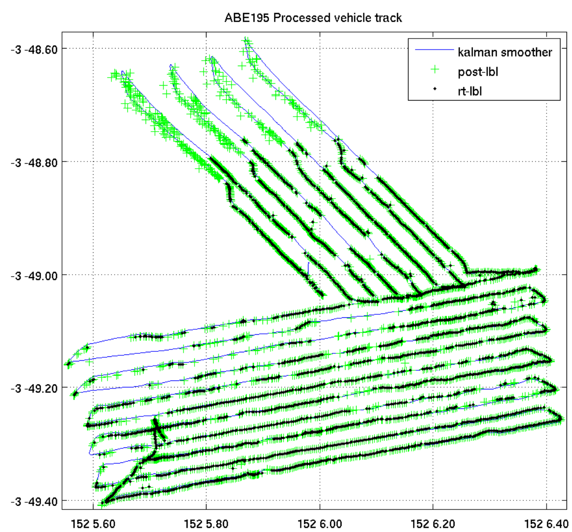

Figure 75: ABE195: The plot shows the real time and postprocessed LBL fixes and the final filtered track. Only one transponder could be heard at the northern edge of the survey due to shadowing by terrain. These areas were partially filled using surface bounce returns, but these results were not as consistent as they were for ABE194

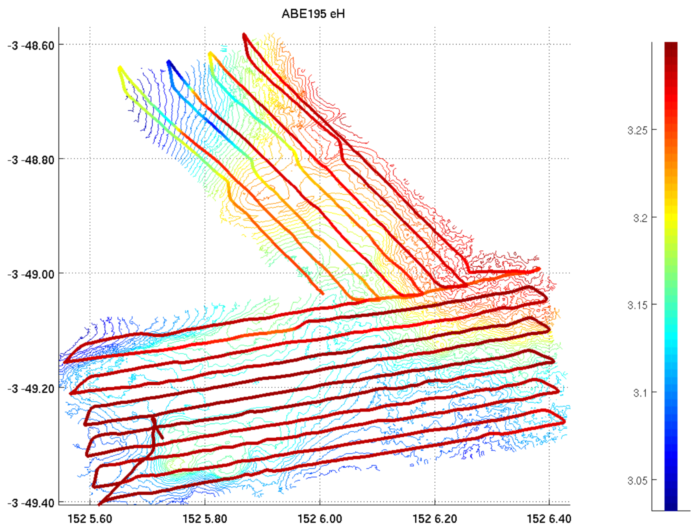

Figure 76: ABE195: Several areas of eH activity can be seen, but the transitions were not very sharp. The hits to the northwest had the highest rates of change.

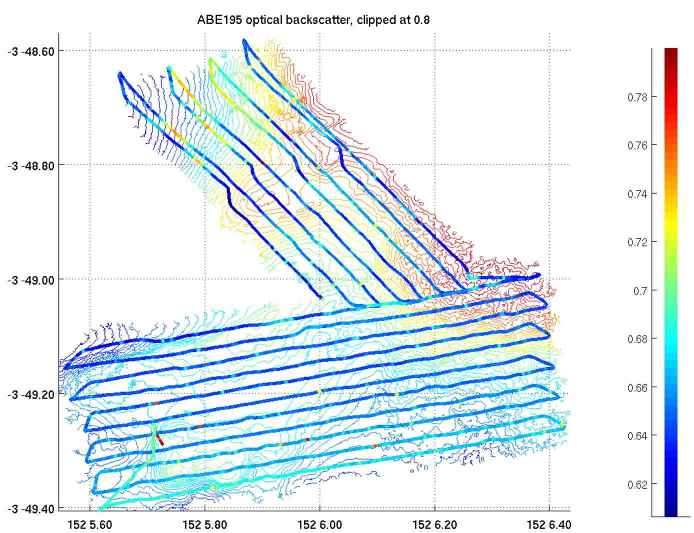

Figure 77: ABE195: The large optical backscatter signal at the start is unexplained, the hits to the northwest correlate to the mild eH hits

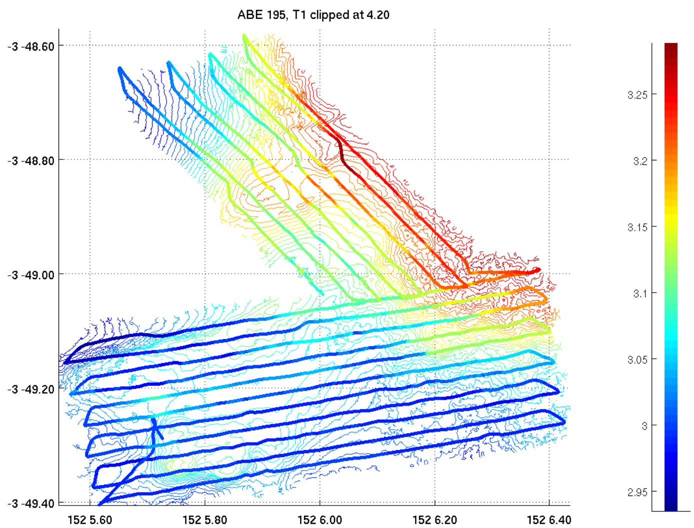

Figure 78: ABE195: The temperature data shows no correspondance to the eH or optical backscatter hits in the northern area, but does show a possibly significant anomaly over a possible volcanic structure on the eastern side of the nothern block

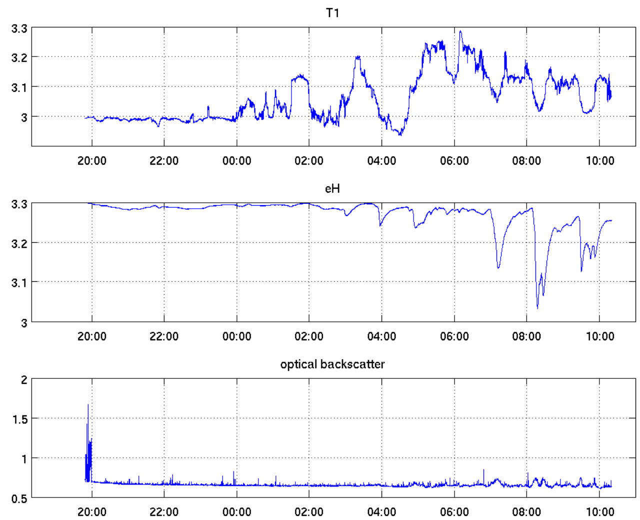

Figure 79: ABE195:the time plots show the large optical backscatter signal at the start (unexplained) and the correspondance between optical backscatter and eH at around 0800

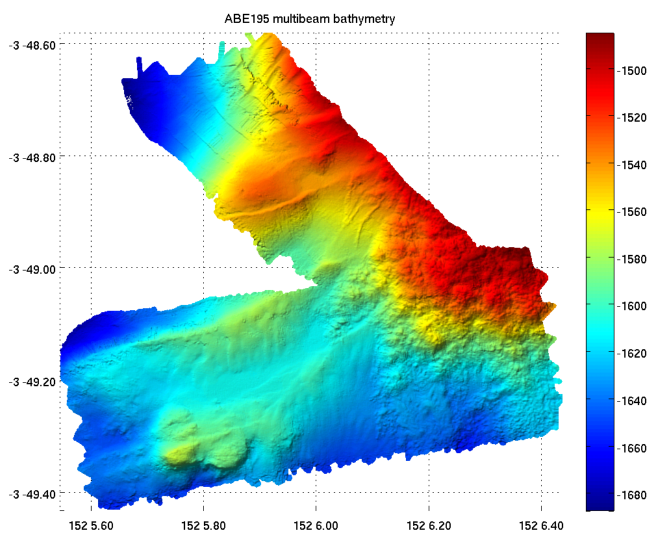

Figure 80: ABE195: The gridded bathymetry appears very consistent with the exception of the northeast corner of the northern block, apparently the surface bounce navigation was not very accurate

18 ABE196

ABE196 was planned to fill in the coverage of South Su. The plan was fairly complicated with four different blocks designed to obtain the desired coverage while following along contours as much as possible.

The dive ended after about 1/2 hour due to a hard electrical failure on the port thruster (#T8). On inspection, one of the thruster control boards had burned through. The oil in the thruster was highly contaminated, it was milky white and contained black crud, certainly from the areas of the board where the shorted 5 volt supply had burned through. Overall, the oil was not conductive although through a series of tests we believe the oil was contaminated by seawater. We were able to recreate a similar appearance by adding seawater to clean oil, but that oil was not conductive either. Andy reported he found traces of seawater in the crane seal, which is the likely source of seawater intrusion. However, we expect our compensation system to be under positive pressure, so any leaks should have resulted in a loss of oil rather than intrusion of seawater. We should think this through carefully. The Jason guys report occasional seawater intrusion in their thrusters despite a spring-loaded compensator.

The lower thruster (#T6) also had questionable behavior on this dive as shown in figure81. At about 1957, the lower thruster slowed down dramatically as did the vehicle forward speed. Since the vehicle really slowed, we know it was not just a problem reporting the thruster rpm. The prop speed recovered slightly. When commanded to reverse after the abort, the thruster ran briefly at normal speed in reverse, then slowed to the magnitude similar to that after the initial failure. Then driving on the surface, the lower thruster behaved normally. The log showed no communiations errors to the lower thruster.

figure 82 shows the vehicle nav track. The vehicle completed the first line and was half way through the second line when the failure occurred. No plume activity was observered during the short run.

Summary: abe196
Start time: 2006/08/18 16:25:01
Survey start: 2006/08/18 19:45:56
Survey end: 2006/08/18 20:19:59
Surface time: 2006/08/19 12:22:33
Recovery time: 2006/08/19 12:36:34
Launch: 03 50.000'S 152 4.000'E
Recovery 03 49.122'S 152 6.145'E
Origin 03 50.000'S 152 4.000'E
descent: 0.87 kwhr over 3.34 hrs, ave pwr: 261.3 w
survey: 0.14 kwhr over 0.56 hrs, ave pwr: 258.4 w over 0.8km 1549 m depth
ascent: 0.60 kwhr over 16.47 hrs, ave pwr: 36.3 w
surface: 0.01 kwhr over 0.23 hrs, ave pwr: 48.6 w
Total energy use: 1.62 kwhr
energy from pack 1: 0.549 2: 0.531 3: 0.541 kwhrs

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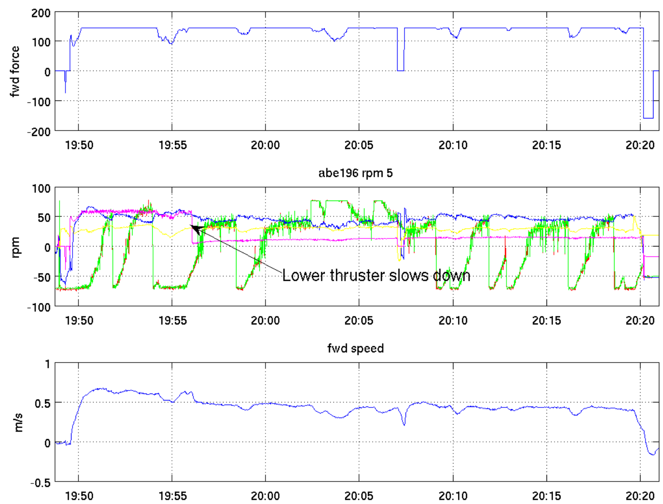

Figure 81: ABE196: This plot shows the commanded forward thrust, the thruster rpms, and the vehicle forward speed. The partial failure of the lower thruster can be seen at 1957. The rpm drops immeidately as does the vehicle forward speed. When the mission-ending failure occurs at the end of the run the port thruster (yellow) fails to report updated rpm values. When the vehicle executes the extraction manuever on abort (hard astern and hard up) the lower thruster reports full rpm briefly, then slows down

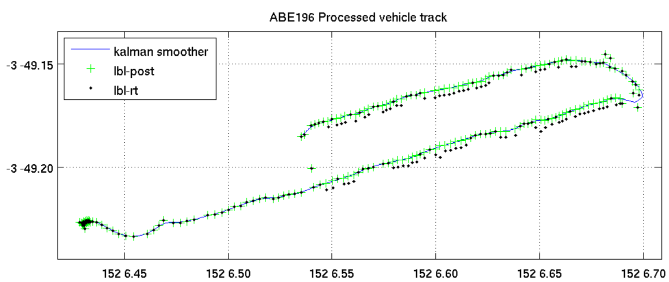

Figure 82: ABE196: The vehicle executed the first trackline and part of the second before the failure.

19 ABE197

ABE197 was our second attempt to execute the dive that would fill in the missing parts of our coverage of the south, west, and east side of South Su. It failed as well when the lower thruster, which had acted strangely in the previous dive, failed on descent while the vehicle was driving to the descent point. The thruster had been disassembled, inspected, cleaned, and tested before the dive. The thruster worked fine after recovery and the cause of the failure is unknown. If the problem was strictly communications, then we would expect the thruster to keep turning until the timeout expired (30 sec?). Examination of the dvl water track record and the power record was not definative as to whether the thruster continued to spin after the failure. The power switch log also indicated that the thruster was powered up until the fault detection routine powered it down.

ABE was launched with Jason in the water. As Jason was working at Suzette, the vehicle had to drive about 1500 meters to reach the northern edge of the survey area. The dive plan from the previous dive was altered to have ABE expand previous surveys with single lines as it drove near the seafloor to the original starting spot. As ABE was descending when the fault occured, ABE anchored from about 900 meters up. We had specifically programmed for this possibility so an abort on descent would not interrupt the Jason launch. We had concerns about entanglement, as the descent weight and anchor mooring would be deployed simultaneously, but we saw no problems. In the future, it would be preferable to alter the abort behavior during descent so the anchor was not deployed (the descent weight would be sufficient).

The symptoms with the thruster failure are consistent with any of the following explanations:

1. An open circuit in the communications to the thruster. A short would have interrupted communications to the other thrusters.

2. An open circuit in the power connection to the thruster. Again, a short would have resulted in a blown fuse or damage to the thruster.

3. A pressure-related problem in the thruster that interrupted communications. We have never seen such a failure.

We had serviced the thruster after its strange behavior on the last dive so the "last place you worked" concern applies.

20 ABE198

ABE198 successfully ran the mission to fill in the missing sections on the west, south, and east side of South Su. The vehicle was launched with Jason in the water, and the vehicle had to drive about 1.5 km from launch to reach the descent point. The vehicle was swept about 300 meters to the northwest by a strong current before reaching the 500 meter depth when it began listening to the LBL transponders and executing active homing. The dive ran until the batteries were depleted then anchored.

Figure 83 shows the real time and post processed navigation tracks. Good coverage was obtained except for the nortwest corner, where both the 8.5 and the 11.5 transponders were shadowed. The 11.5 channel showed many slightly long returns, implying that the first return was missed. Another difficult area was encountered near the turn in the center of the eastern block. In this area the LBL receiver seemed to miss first arrivals on the 11.5 and the 8.5 channels, instead getting slightly long returns that could get through the median filters. These bad returns were removed in post processing by hand editting. the entire net was adjusted to minimize errors for all 3 transponder fixes.

The dive registered lots of plume activity, although we think only one area represented active venting, specifically the previously known Surprise field. The surprise field can clearly be seen in figure 84 by the sharp drops in eH signal at top of the triangular survey block in the center of the overall survey. These same spots have modest optical backscatter anomalies, shown in fiure 85 with stronger fluctuations in temperature as shown in figure 86. Substantial plume signals can also be seen over large areas of the eastern part of the survey, but the low rate of change of the eH signal implies that these areas contain plume fluids from other sources. Figure 87 shows the time plots of T1, eH, and optical backscatter. Just after 03:00, we see sharp eH hits and corresponding anomalies in temperature and optical backscatter. The signals later in the record have eH hits with much slower rise rates.

The bathymetric map is shown in figure 88. The spots with difficult LBL coverage show some problems, otherwise the map appears sensible. Mounds can be seen in the vicinity of the Surprise field where the eH hits were seen and a possible area with extinct mounds can be seen in the northwest corner.

Summary: abe198
Start time: 2006/08/22 20:53:59
Survey start: 2006/08/22 22:48:38
Survey end: 2006/08/23 12:14:34
Surface time: 2006/08/23 16:37:02
Recovery time: 2006/08/23 16:48:02
Launch: 03 48.915'S 152 5.966'E
Recovery 03 48.575'S 152 6.145'E
Origin 03 50.000'S 152 4.000'E
descent: 0.34 kwhr over 1.89 hrs, ave pwr: 177.3 w
survey: 4.02 kwhr over 13.43 hrs, ave pwr: 299.1 w over 25.7km 1427 m depth
ascent: 0.17 kwhr over 4.78 hrs, ave pwr: 36.1 w
surface: 0.01 kwhr over 0.18 hrs, ave pwr: 46.0 w
Total energy use: 4.53 kwhr
energy from pack 1: 1.499 2: 1.520 3: 1.507 kwhrs

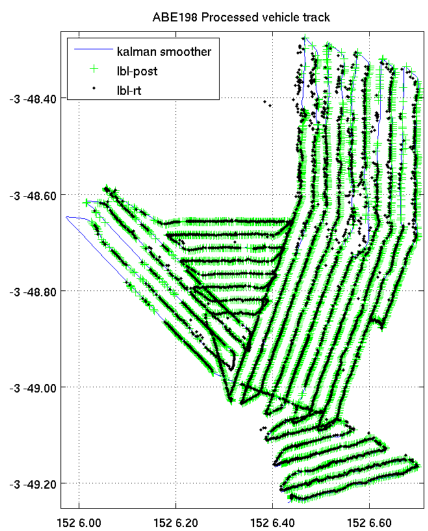

Figure 83: ABE198: This plot shows the real time and postprocessed navigation data. An area in the NW corner had only coverage by a single transponder due to shadowing. The area to the east had problems with ragged returns on the 11.5 channel, which seemed to be worse around the turn in the center of the eastern survey block

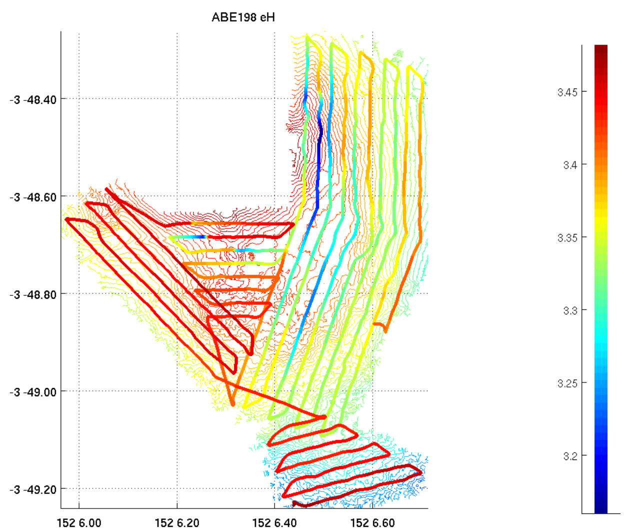

Figure 84: ABE198: The plots shows the eH signal ploted on the postprocessed vehicle tracks. The area with sharp transitions at the top of the triangular survey block corresponds to the Surprise Field (-3 -48.69 152 6.29). The area to the east shows areas of much slower changes in the eH signal indicating fluid that had not been freshly vented

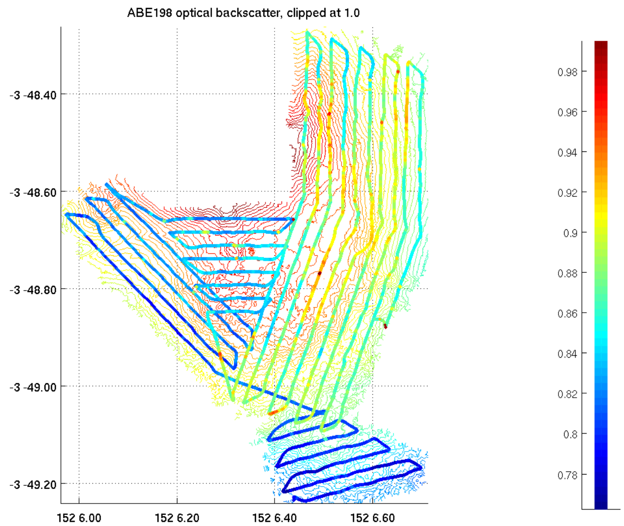

Figure 85: ABE198: The optical backscatter signal shows some modest anomalies over the Surprise field, although the strongest optical backscatter signals do not correspond to areas of strong eH.

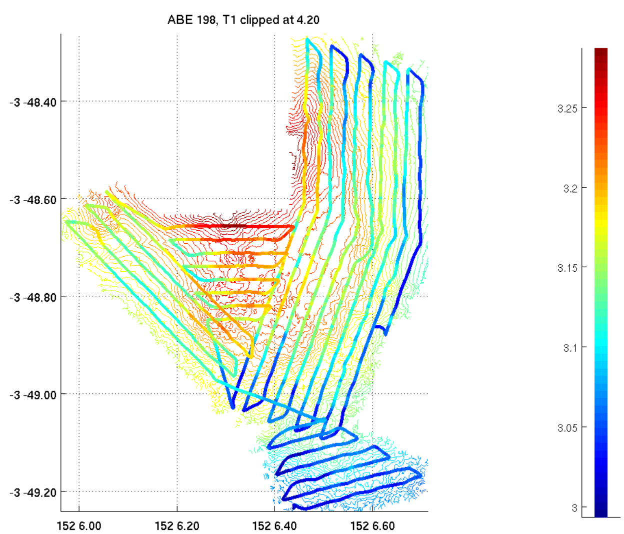

Figure 86: ABE198: the temperature record shows some signals over the Surprise field and mild increases over a broad area to the east

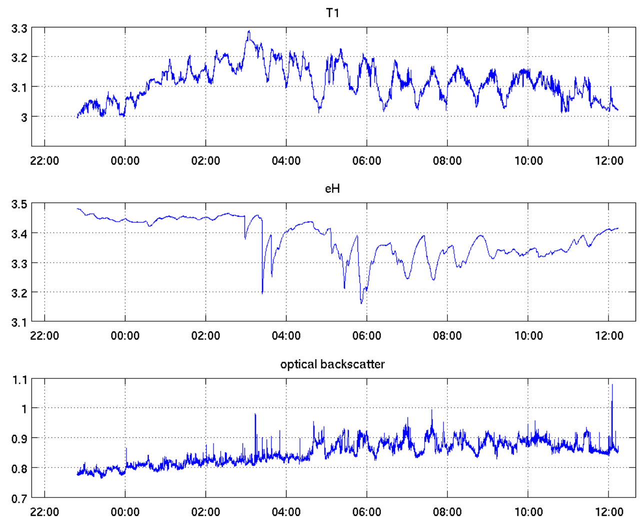

Figure 87: ABE198: This plots shows the relationship between T1, eH, and optical backscatter. The passes over the Surprise field ocurred between 0300 and 0400

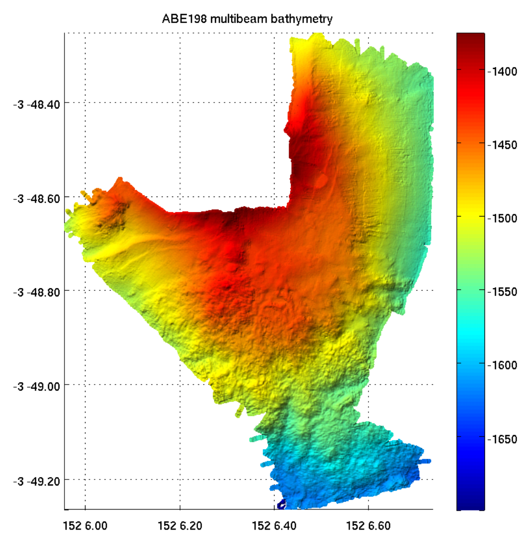

Figure 88: ABE198: The bathymetric map appears satisfactory. The eastern part has some lack of registration due to navigation problems including the ragged 11.5 transponder navigations and the noisy returns at the turn.

21 ABE199

On ABE199 we tried to locate a vent site at the Umbo site that had been seen on several CTD casts, the last one indictating it must be close. ABE worked fine, but we got only a few anomolous hits at the very end of the dive. The dive was short, about 6 hours of survey time, which was forced by the ship's schedule.

Figure 89 shows the postprocessed navigation. This dive used a two transponder net (9.5 and 10.0), and returns were solid on both channels the entire run. Postprocessing required no exceptional measures.

The plume data was disappointing, with few solid hits. Figure 90 shows the temperature data, which shows some a rise in temperature on the last trackline which corresponds to some small increases at the nearest part of two previous tracklines. As shown in figure 91, the temperature activity did not correlate with eH or optical backscatter signals. So the temperature increases could indicate ABE was getting closer to the source, but the lack of eH or optical backscatter activity implies that the source was probably a significant distance away.

Figure 92 shows the bathymetric map gridded at 2 meters.

Summary: abe199
Start time: 2006/08/24 16:02:18
Survey start: 2006/08/24 17:50:19
Survey end: 2006/08/24 23:25:46
Surface time: 2006/08/25 01:34:46
Recovery time: 2006/08/25 01:47:18
Launch: 03 42.651'S 151 56.865'E
Recovery 03 42.286'S 151 56.728'E
Origin 03 46.000'S 151 53.000'E
descent: 0.25 kwhr over 1.79 hrs, ave pwr: 141.8 w
survey: 1.74 kwhr over 5.58 hrs, ave pwr: 312.3 w over 9.8km 1963 m depth
ascent: 0.14 kwhr over 2.51 hrs, ave pwr: 55.0 w
surface: 0.01 kwhr over 0.21 hrs, ave pwr: 61.1 w
Total energy use: 2.14 kwhr
energy from pack 1: 0.710 2: 0.720 3: 0.709 kwhrs

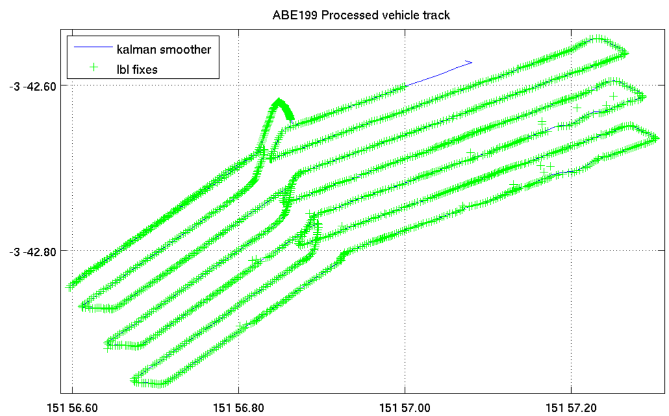

Figure 89: ABE199:

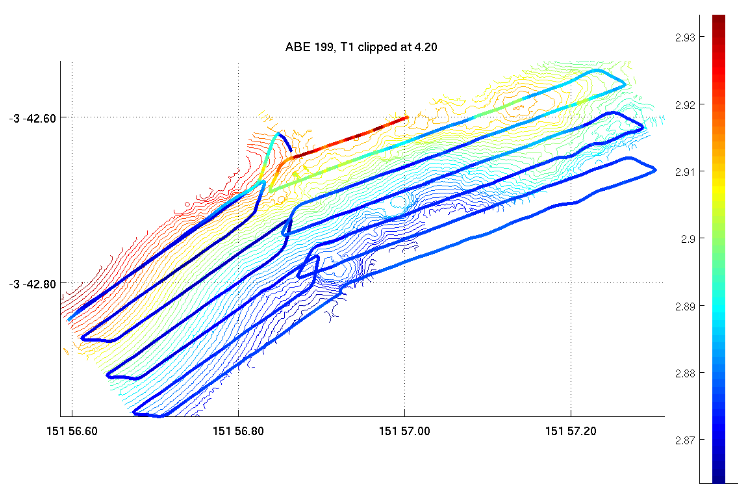

Figure 90: ABE199:

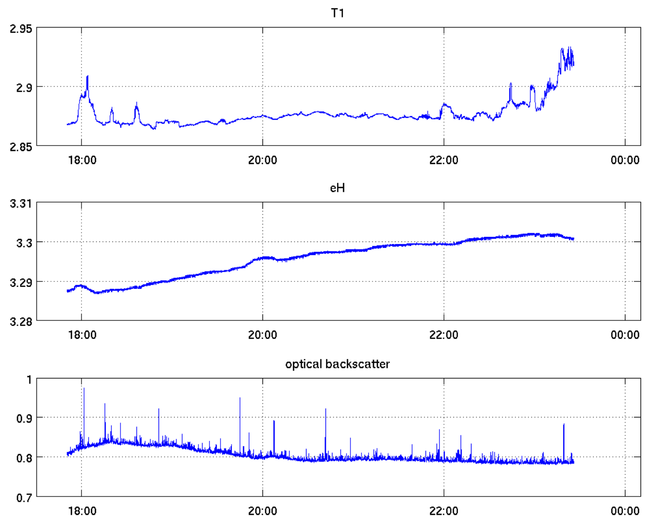

Figure 91: ABE199:

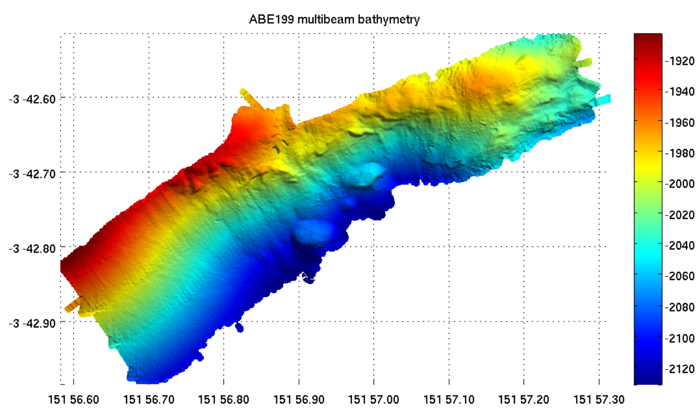

Figure 92: ABE199: