LADDER-1 Cruise Report (AT15-12)

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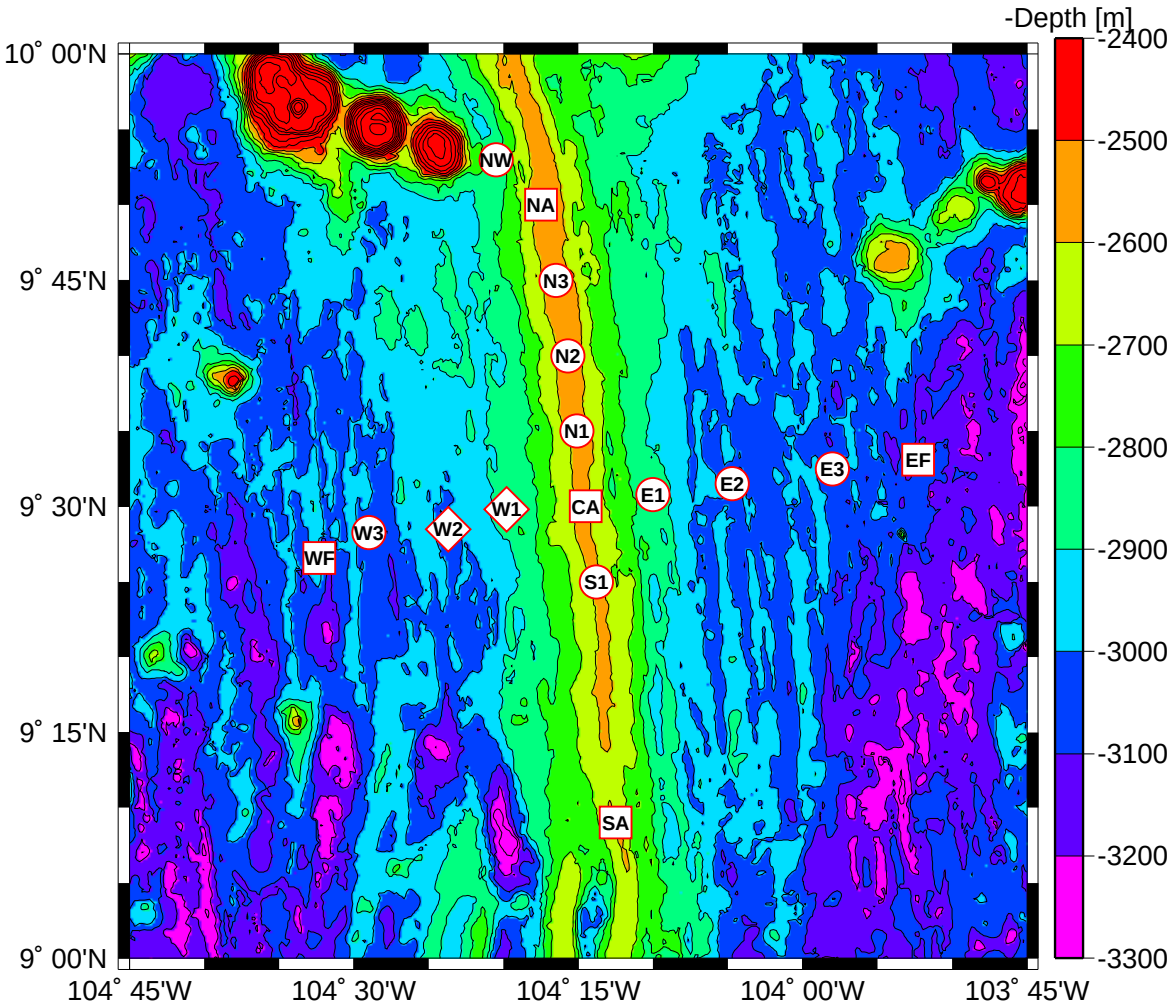

Figure 1: LADDER-1 experiment area with CTD/LADCP stations. All stations except NW & SA were occupied multiple times, at different M_2 phases to remove tidal bias. Squares indicate standard-mooring deployment sites; diamonds indicate profiler-mooring deployment sites.

Acknowledgments

The success of the LADDER-1 cruise, funded primarily by the National Science Foundation through grant OCE-0425361, would not have been possible without the outstanding support provided by the crew and officers of R/V Atlantis, the team of Alvin pilots and engineers, as well as the SSSG techs. Thank you all!

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1 Overview

1.1 The LADDER Project

LADDER-1 is the first of three cruises of the LADDER project. LADDER-2 and LADDER-3 are scheduled for December 2006 – January 2007 and for November – December 2007, respectively. The LADDER project aims to address the following questions[1]:

Bio-1 What are the influences of advection and eddy diffusion on the maximal dispersal distance of vent species with given larval life spans?

Bio-2 What are the effects of ontogenetic changes in larval behavior (i.e., vertical positioning) on species' dispersal distances?

Bio-3 How are the probabilities that larvæwill be lost from the ridge system influenced by topography and flow? Might the axial summit trough[2] inhibit off-axis transport of larvæ, and serve as a conduit between habitable vent sites?

PO-1 What are the mean and temporally varying flows in the vicinity of a mid-ocean ridge crest, and what is their spatial structure and coherence?

PO-2 What is the magnitude of the diapycnal diffusivity near the ridge crest?

PO-3 How rapid is lateral dispersion, and how effective is lateral homogenization by eddy diffusion near the ridge crest?

In order to address these questions, an observational program was carried out near the crest of the East Pacific Rise between 9°10′N and 9°50′N (Figure 1):

Plankton Pumps & Sediment Traps (section 3). The spatial and temporal distributions of larval invertebrates was determined by positioning plankton pumps and sediment traps near the seabed and at the height of the neutrally buoyant hydrothermal plumes to collect larvae and determine where species reside during different stages of heir larval life spans. Sediment traps that had been deployed in June were also recovered.

Colonization Experiments (section 3). Colonization experiments were deployed in order to quantify the influence of larval supply on recruitment, and monitor changes in recruitment as the new vent communities mature.

CTD/LADCP Survey (sections 4 and 6). A CTD/LADCP survey was carried out in order to determine a quasi-synoptic snapshot of the hydrography and velocity field around the tracer-injection site.

Physical-Oceanography Moorings (section 7). Seven moorings equipped with 15 current meters and 2 velocity profilers were deployed in order to determine the velocity field near the EPR crest. Recovery of the ADCP is planned at the beginning of the LADDER-2 cruise in December 2006. Recovery of the moorings is planned during the LADDER-3 cruise in November 2007.

Tracer Release (section 8). Three kilograms of sulfur hexafluoride were released with a special tracer release system mounted on Alvin. The tracer will be measured on the LADDER-2 cruise in December 06/January 07 with CTD/rosette casts.

[1] See `http://www.ldeo.columbia.edu/~ant/LADDER` for details

[2] The axial trough on the EPR crest is sometimes called AST or ASCT. The PIs of the LADDER project prefer to call it "trough" although the acronyms are also used in this cruise report.

1.2 Other Projects

The following activities carried out during the cruise are not part of the LADDER project:

Dye-Entrainment Experiment (section 9). During one of the Alvin dives a couple of dye-release experiments were carried out in order to visualize entrainment into near-source black-smoker plumes.

Hydrothermal Vent Meiobenthos (PI: Bright; section 10). The aim of this project is to study the present status of the meiobenthic community shortly past eruption and to follow the succession of colonization and development of communities. Cruise activities included collection of meiofauna from different natural substrates, from the water column at various heights above the bottom, and from off-axis sediments. Additionally, meiofauna settlement devices were deployed and recovered.

Development of *Riftia pachyptila* (PI: Bright; section 11). The aim of this project is to study the infection process, growth, and developmental processes in *Riftia pachyptila* symbiosis as well as cell kinetics in symbiont-containing and symbiont-free host tissue. Cruise activities included recovery and re-deployment of tubeworm settlement devices, and recovery of basalt from warm vents to collect small tubeworms.

Early Life Stages of *Alvinella pompejana* (PI: Pradillon; section 12). this project aims to understand how embryos of the polychaete annelid *Alvinella pompejana* are able to disperse and colonize new vent sites. Two main activities were carried out during the cruise: 1) *In situ* experiments to analyze early development and larval colonization in relation to local environmental conditions. 2) *In vitro* development experiments were conducted on board to analyze sensitivity of early embryos at different pressure levels.

Prokaryotic and Viral Communities (PI: Williamson; section 13). The aim of this project is to estimate abundances, carry out prophage induction experiments and metagenomic analysis of prokaryotic and viral communities in water samples from hydrothermal vents and in off-axis non-vent water. The main cruise activity was *in-situ* filtration of large volumes of water.

Photographic Dive Tracks (PIs: Rzhanov & Beaulieu; section 14). The goal of this project is to develop software for creating geo-referenced video mosaics using Alvin navigation and image data. This cruise served as a test bed for the software.

extreme4kids (section 15) Outreach program for Austrian school children.

2 Alvin Dives

2.1 Hydrothermal Sites

2in1 (new site). $x = 4381\,\mathrm{m}$, $y = 79852\,\mathrm{m}$, $z = 2508\,\mathrm{m}$; 9°51.32′N, 104°17.61′W. Two areas, one with patches of white bacterial mats, the other one on the eastern wall of steep, narrow ASCT with lots of diffuse flow and *Tevnia,* not accessible for Alvin. *(Note: This site is possibly called* Hobbit Hole *by the Alvin team.)*

StaBB (new site). ≈150 m North of Tica. New diffuse vent in ASC near East Wall 18:19 – 18:22 GMT Dive 4273 (renav. not available). Estimate ≈2.5–3 m^2 with abundant *Tevnia* and vigorous diffuse flow. Bythograeids abundant.

Sketchy (new site). $x = 4684\,\text{m}$, $y = 77524\,\text{m}$, $z = 2506\,\text{m}$; 9°50.06′N, 104°17.44′W. L-M Deployment site, new marker S. Relatively narrow fissure with submersible access at 180°, then turning to 150° to manipulate experiments.

PBR600 (new site). $z = 2567\,\text{m}$; 9°29.27′N, 104°14.39′W. High-temperature vents discovered by Pat, Brian & Ryan during Pat's dive#600. Looks like a castle on top of a 14–16 m-high pillar with many spires and some curved spires (like a crown; Figure 24). One distinct black smoker on top, others probable behind the pillar.

9-35 (new site). 2 CTD profiles carried out at 9°35.0′N, 104°15.1′W intersected a near-field (buoyant) plume; no dive confirmation of site.

9-40 (new site). 2 CTD profiles carried out at 9°40.0′N, 104°15.7′W intersected a near-field plume; no dive confirmation of site.

Finn (new site; old Marker 119?). $x = 4706\,\text{m}$, $y = 77331\,\text{m}$, $z = 2504\,\text{m}$; 9°49.95′N, 104°17.43′W. Thriving *Tevnia,* extensive bacterial mat along crack. Along the steep, eastern wall of ASCT, but not accessible, on top of ASCT may be some place where deployments or collections are possible.

Choo-choo (new location). Old location: $x = 4807\,\text{m}$, $y = 76714\,\text{m}$; 9°49.62′N, 104°17.38′W. Paved with new basalt, patches of diffuse flow. New Location: $x = 4841\,\text{m}$, $y = 76547\,\text{m}$; 9°49.53′N, 104°17.36′W. Found Choo-choo marker (flag is partially paved, says marker 371) and dead mussel community 170 m south of original location.

BioVent. 19:29–19:34 GMT Dive 4268 (position from renav: $x = 4368\,\text{m}$, $y = 79199\,\text{m}$) 2 smokers with *Alvinella,* surrounded by pillow lava, white bacterial mats in cracks; Diffuse flow in vicinity with bacterial mats and limpets observed on Dive 4261 at 21:28 GMT (position from renav: $x = 4386\,\text{m}$, $y = 79151\,\text{m}$).

M Vent. $x = 4420\,\text{m}$, $y = 78877\,\text{m}$, $z = 2500\,\text{m}$; 9°50.79′N, 104°17.59′W. Inactive smoker. RESET Marker 13, note lava pooled at base.

Q Vent. $x = 4428\,\text{m}$, $y = 78783\,\text{m}$, $z = 2502\,\text{m}$; 9°50.74′N, 104°17.58′W. Inactive smoker with dead *Alvinella* tubes; swarms of amphipods around it and also in some of the basalt areas there are these amphipods. HOBO 20 and RESET Marker 1.

Mussel Bed. No diffuse flow, appears to be filled in with new basalt.

East Wall. $x = 4557\,\text{m}$, $y = 78425\,\text{m}$, $z = 2500\,\text{m}$; 9°50.55′N, 104°17.51′W. No vigorous diffuse flow; large accumulations of mussel shells and tubes of *Riftia;* also on higher parts of East Wall some patches of mussel shell and tubes of *Riftia* that appear to be in original place and have not been covered with lava; also some patches with live mussels *Bathymodioulus thermophilus.*

Tica. $x = 4580\,\text{m}$, $y = 78174\,\text{m}$, $z = 2510\,\text{m}$; 9°50.41′N, 104°17.5′W. Still very active area of diffuse flow, although no black smoker, several patches of *Tevnia* on the false eastern wall of ASCT and also in ASCT, back side towards the east has also a patch of *Tevnia;* a few live *Riftia* and mussels (survivors); one patch found with *Alvinella/Tevnia.*

Bio 9 area. $x = 4615\,\text{m}$, $y = 77968\,\text{m}$, $z = 2508\,\text{m}$; 9°50.30′N, 104°17.48′W. A series of small chimneys. Alvinellid Stump is now a smoker complex (multiple chimneys). Large table (southern) structure now a smoker complex with multiple spires (>20 spires). Rusty Riftia field (10 m

off complex) is gone. Shape of Bio9 same as pre-eruption. Bio 9 prime and Bio9 proper are still recognizable according to Pat Hickey. Nearby, in depression, is "Fish Hole" area (renav. position: $x = 4612\,\mathrm{m}$, $y = 77958\,\mathrm{m}$). This area had diffuse flow with *Tevnia* and bacterial mats.

Hole-to-Hell (part of the Bio9 complex). $x = 4609\,\mathrm{m}$, $y = 78005\,\mathrm{m}$; 9°50.32′N, 104°17.48′W. Series of multiple smokers/smoker field (where the old marker should be), *Riftia* are extinct, *Alvinella* present.

P Vent. $x = 4627\,\mathrm{m}$, $y = 77910\,\mathrm{m}$, $z = 2508\,\mathrm{m}$; 9°50.27′N, 104°17.47′W. Still active, first higher spire is clear, second lower one is gushing; with *Alvinella* on sulfide walls, with patches of *Tevnia,* one large, old *Riftia.* RESET Marker 10 and HOBO 21. RESET Marker 5, new marker L-O.

Alvinella Pillar. Not found during LADDER-1 dives.

Ty-Io. $x = 4672\,\mathrm{m}$, $y = 77616\,\mathrm{m}$, $z = 2504\,\mathrm{m}$; 9°50.11′N, 104°17.45′W. It is not clear whether this is Ty or Io smokers. A series of several small to a few meters high black smokers with extensive *Alvinella* populations is present. Diffuse flow area (including Marker 8/11 and L-M Deployment site) extends towards the south with many patches of diffuse flow, white bacterial mats, fish, limpets and both bythograeid and galatheid crabs and patches of *Tevnia* up to 30 cm length, most *Tevnia* patches are probably not accessible for Alvin.

L-41 Marker (old Marker 141?). $x = 4743\,\mathrm{m}$, $y = 77137\,\mathrm{m}$; 9°49.85′N, 104°17.41′W. Several collapse pits, two of which had extensive *Tevnia* clumps.

Tubeworm Pillar. Not found during LADDER-1 dives.

K Vent. $z = 2564\,\mathrm{m}$; 9°29.73′N, 104°14.48′W. Hi-T vent with nearby inactive sulfide structures and old marker X-6. Alvinellids, few *Riftia,* anemones, crabs, serpulids, and bacterial mats observed.

2.2 Dive Summaries

The following dive summaries have been culled primarily from the dive reports submitted by the port observers. No attempt has been made to edit them e.g. to correct grammar, unify nomenclature, etc.

Dive 4259 (Oct. 31)

Pilot	Pat Hickey
Port Observer	Andreas Thurnherr
Starboard Observer	Mike McCarthy (Pilot in Training — PIT)

Summary

The ADCP was deployed in the axial trough near 9°30′N. Eight cross-axis Imagenex transects were run between 9°29.6′N and 9°30.3′N. A benchmark was deployed near probable site of K vent.

Dive 4260 (Nov. 1)

Pilot	Gavin Eppard
Port Observer	Monika Bright
Starboard Observer	Carly Strasser

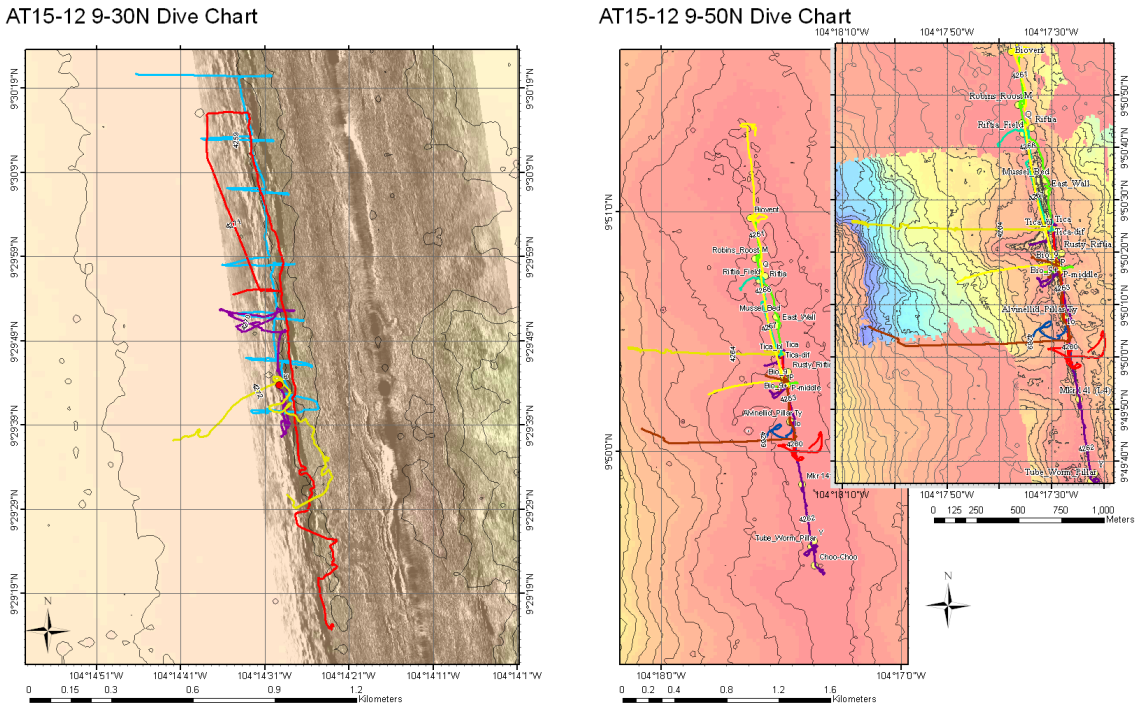

Figure 2: Alvin dive tracks. Maps for those dives where re-navigation worked can be found in the Renav-subdirectories of the individual dives on the science data DVD #2 (appendix B).

Activities

1. Release TrapR2
2. Position PumpL1
3. Recover Lauren's sandwiches (3) Monika's TASCs (3, #37, 38, 39) at Marker 8/11
4. Deploy Monika's TASCs (3, #24, 25, 26), Monika's sponges (3, #42, 43, 44), collect 2 pelagic pump samples, collect 2 basalt samples at a new diffuse flow site
5. Deploy 5 sandwiches and 1 hobo in 10°–30°C zone and 5 sandwiches and 1 hobo in 2°–4°C zone. This was attempted, but temperatures were not recorded, so sandwiches were repositioned and measured on subsequent dive
6. Collected *Alvinella,* a *Riftia* tube, large *Tevnia* and more basalt
7. Explored south towards Tubeworm Pillar, find Ty and Io, and other diffuse vent fields south of there
8. During transits 3-chip video mosaic

Dive 4261 (Nov. 2)

Pilot	Bruce Strickrott
Port Observer	Stace Beaulieu
Starboard Observer	Alice Kohli

Summary

We started the dive with colonization experiments at P Vent and then transited north to Bio9 for additional biological sampling. The second half of the dive was devoted to exploring the previously known vent sites to the north from Tica Vent to BioVent. Of all sites visited, Tica Vent had the most biological activity, with a few remaining *Riftia* but many new clusters of *Tevnia.* We started noticing dead *Riftia* tubes and mussel shells in the new lava flow ≈100–130 m S of the Tica site, suggesting a southward flow of lava during the eruption. Except for the diffuse flow ≈100 m N of Tica (CHECK VIDEO FOR TIME AND CONFIRM DISTANCE W/ RENAV), all sites with venting were at previously known sites. During all transits, we used the starboard arm 3-chip for video mosaicking. Dive activities included:

- recovery of Lauren Mullineaux' colonization experiment deployed at P Vent Marker 5 on the RESET cruise,
- deployment of new colonization experiments for Lauren and Monika Bright at P Vent Marker 5,
- collection of pelagic pump and basalt samples in association with Monika's experiment at at P Vent Marker 5,
- collection of Alvinellids at Bio9 for Florence Pradillon,
- collection of basalt for Monika at Tica Vent in vicinity of surviving *Riftia,*
- exploration of P Vent, Bio9, Tica Vent, East Wall, Q Vent, M Vent, and the vicinity of BioVent.

Dive 4262 (Nov. 3)

Pilot	Pat Hickey
Port Observer	Lauren Mullineaux
Starboard Observer	Bettina Pflugfelder

Summary

We landed in the axial trough and found Dan Fornari's tide gauge. We moved to Tica to check out overall layout and find suitable spots for colonization studies. Then south to Bio9 and P vents to look for a spot to put alvinellid colonization TRACs. We found the TrapR1 mooring and released it. Then moved south past P vent down to Ty&Io where we observed the vents, Luther's INSECT and our colonization experiment. At Ty&Io we took measurements at the alvinellids and collected some. During the transit south to Markers 119 and 141, we noticed many pits with diffuse flow, bacterial scum, fish, limpets and both bythograeid and galatheid crabs. The community and vent at 119 appeared to be gone. The community at 141 was completely different than before; several collapse pits, two of which had *Tevnia.* We searched for Tubeworm Pillar and Choo-Choo but didn't find them. Then 180 m south we stumbled on remains of Choo-choo marker and dead mussel community. Searched again for Tubeworm Pillar in case nav was off, then left bottom.

Dive 4263 (Nov. 4)

Pilot	Gavin Eppard
Port Observer	Florence Pradillon
Starboard Observer	Ryan Jackson

Summary

The main objectives for this dive were completed. The first part of the dive included locating and moving two moorings. Mooring NA was located about 200 m to the west of the ASC and moved due west to the ASC and placed in a wide (> 50 m), deep (> 7 m) section of the trough with no visible columns or pillars that will affect the flow around the first current meter. The second mooring, Trap L1, was located 100 m to the east of the ASC and repositioned due east to the ASC (83 m north of the NA mooring). The second part of the dive was dedicated to the deployment of 3 Hi-T colonization experiments. After visiting Ty/Io where deployments were initially planed, PVent and Bio9, Hi T colonization experiments (TRAC Alvi 1, 2, 3) were deployed at Tica, on an Alvinellid patch, next to a *Tevnia* area, and on a basalt boulder.

Dive 4264 (Nov. 5)

Pilot	Bruce Strickrott
Port Observer	Sabine GÏlner
Starboard Observer	Mike McCarthy (PIT)

Summary

The main objectives of this dive were to position a pump at Tica, to deploy several experiments (sandwiches, basalt blocks, TASCs, sponges) within the *Tevnia* site at Tica and at the periphery site at Tica. Further a basalt block with *Tevnia* was grabbed at this site. Afterwards we went off-axis, directly to the west to see where the new lava meets the old lava. There we took basalt samples (old and new) and slurped in sediment (old and new). It was surprising that after the contact zone we did not find only old lava with sediment (as we expected it), but found differently formed new lava.

Dive 4265 (Nov. 6)

Pilot	Pat Hickey
Port Observer	Monika Bright
Starboard Observer	Francesca Terenzi

Activities

1. Exploration of Riftia Field, Riftia Mussel Bed, East Wall
2. At Q deployed 2 sponges
3. Found Riftia Field, it had a little *Tevnia* and an old sulfide (Michael's vent?).
4. No live mussels found at E. Wall (they were found in a later dive), so Lauren's deployments not made there, but Monika deployed 3 sponges and pelagic pump
5. Positioned elevator at Tica, collected pump sample

6. Checked Florence's *Alvinella* experiment (one was upside down)
7. During transits 3-chip video mosaic
8. collected a basalt from Bio9
9. extreme4kids' Styrofoam cups

Dive 4266 (Nov. 7)

Pilot	Gavin Eppard
Port Observer	Andreas Thurnherr
Starboard Observer	Irene García Berdeal

Summary

Launch of Alvin was delayed about an hour (09:00 local, 15:00 GMT), due to problems with the zodiac. The dive started at Tica, where we worked on Shannon's elevator and deployed benchmark L2. We proceeded southward to Bio-9. At a site of several tall structures with diffuse flow at the base, we deployed Monika's sponges, collected fluid samples with Monika's pumps collected a basalt and grabbed a basalt fragment with a lot of *Alvinella* but little sulfide(?) for Florence and Monika (later at Bio-9 we collected a second sample with more sulfide). Also at Bio-9 we found a suitable smoker to conduct the dye-entrainment experiment. We headed southward to P-vent, where we found a vigorous smoker that was too tall to conduct further entrainment experiments. Further south, at Ty/Io we found a smoker site suitable for the experiment, and deployed there the 2 remaining dye-ball strings. This second experiment was cut short as the sub was running out of power.

Dive 4267 (Nov. 8)

Pilot	Bruce Stickrott
Port Observer	Lauren Mullineaux
Starboard Observer	Scott Worrilow

Summary

At Riftia Field we positioned pumpL5 into the axial trough. At Tica, we moved and re-temped the 10 sandwiches, 6 basalt blocks, and 2 hobos in the tubeworm (10°–30°C) and suspension-feeder (2°–4°C) zones. Then we deployed 5 more sandwiches, 3 basalts and another hobo in another patch with mussel-zone temperatures. For Monika we collected 1 pump sample, and for macrofaunal colonization we collected a rock from the tubeworm and mussel zones. We got called up early due to weather and were unable to get a Tica fly-over or explore to north.

Dive 4268 (Nov. 9)

Pilot	Pat Hickey
Port Observer	Monika Bright
Starboard Observer	Amy Guan

Activities

1. Position elevator at Bio9
2. At P-vent — recovered Monika's sponges,
3. At Bio9 collected *Alvinella,* basalt with *Tevnia* (*Riftia* there too)
4. At Q vent collected old sulfide and unusual polychaetes associated with it
5. Bio9 — collection of *Alvinella* for Florence
6. Q-vent — collection of dead sulfide, basalt from periphery, 1 pelagic pump periphery
7. Noted that M vent is dead
8. Video mosaic as often as possible
9. At Biovent, lots of *Munidopsis,* 2 smokers surrounded by pillow lava, white bacterial mats in cracks, two spires with *Alvinella.* Nearby is a large area with bacterial mat and *Tevnia*
10. new vent (2in1) with lots of patchy bacterial mats and *Tevnia*
11. extreme4kids' yeast experiment

Dive 4269 (Nov. 10)

Pilot	Bruce Stickrott
Port Observer	Stace Beaulieu
Starboard Observer	Sean Kelley (PIT)

Summary

During this dive at the 9N EPR ISS "Bulls Eye", we visited Bio9, P Vent, and Ty / Io, and then we transited west off axis for ≈1 km in search of the new/old lava contact. We started the dive by turning valves on Shannon Williamson's pump elevator at "Fish Hole" near Bio9. Then we deployed 1 *Alvinella* colonization experiment for Florence Pradillon at a mushroom at Bio9. Then we deployed new Marker L-O at the colonization experiments at P Vent RESET Marker 5. Then we conducted an ≈400 m on-axis video transect from P Vent to Ty / Io. The final biological work of the dive was at the "TevDS" (= *Tevnia* deployment site) area south of Ty / Io. We measured temperatures and repositioned Lauren Mullineaux' colonization sandwiches, recovered 2 of Monika Bright's sponges, collected basalt from the periphery for Monika, and deployed new Marker S. We finished the dive with an ≈1.1 km off-axis video transect to the west, but did not reach the new/old lava contact.

Dive 4270 (Nov. 11)

Pilot	Gavin Eppart
Port Observer	Lauren Mullineaux
Starboard Observer	Shannon Williamson

Summary

During this dive near the CA mooring and K vent, we confirmed or positioned the CA, TrapL2 and PumpL7 moorings, and then explored for Hi-T and Lo-T animal communities. We found CA in a good spot in the trough, moved TrapL2 to the trough about 80 m south of it, and moved PumpL7 to the 9°30′N benchmark. There were crabs and fish in the vicinity, and we found K vent only ≈30 m away. K vent had a fascinating fauna including alvinellids and anemones on top of the sulfide structure and live serpulids at the base. We moved south to look for other communities. We found a senescent patch of mussels (only a few were alive, but more live ones were hiding under the rocks), and then further on a large area of serpulid worms covering basalt pillars. At both these more southern sites, none of the serpulids appeared to be alive. On the way back north, we deployed a set of 5 sandwiches and a hobo in diffuse flow in the mussel patch. Then we revisited K vent and deployed a set of 5 colonization sandwiches and a hobo.

Dive 4271 (Nov. 12)

Pilot	Pat Hickey
Port Observer	Ryan Jackson
Starboard Observer	Brian Guest

Summary

The main objectives for this dive were completed. Shortly after reaching the bottom, we drove east to the trough and set the sub down on the bottom which kicked up enough sediment that the cloud remained suspended for 10 minutes. No current was observed, so we proceeded north to NT off the axis. We drove 100 m north of NT and turned into the trough and began the switch from primer to tracer. We headed south at about 10 m per minute and injected the tracer over about 1200 m within the ASC. The tracer injection system functioned exceptionally well and provided a continuous output of about 15 ml/minute. When we reached ST we flushed the injector with primer and shut off the system. We then proceeded south in the ASC and explored for new vents. A new vent was discovered at the end of the dive and it included several black smokers and dead sulfide structures sitting atop a 14–16 m pillar.

Dive 4272 (Nov. 13)

Pilot	Gavin Eppard
Port Observer	Florence Pradillon
Starboard Observer	Sigrid Katz

Summary

We started the dive by turning valves on Shannon Williamson's pump elevator near K Vent. Then at K Vent, we collected *Alvinella* and 3 Anemones, measured temperatures and positioned 5 colonization sandwiches and 1 Hobo probe for Lauren Mullineaux. We turned off Shannon's elevator and released it. We proceed to the benchmark L1 and collected there 2 water samples 2.5 m above bottom with the pelagic pumps for Lauren. We finished the dive with exploration for ≈0.4 km south of K Vent, mostly on the western edge of the ASCT, saw the patch of senescent mussels with Lauren deployments, but did not find any new diffuse flow community or smokers.

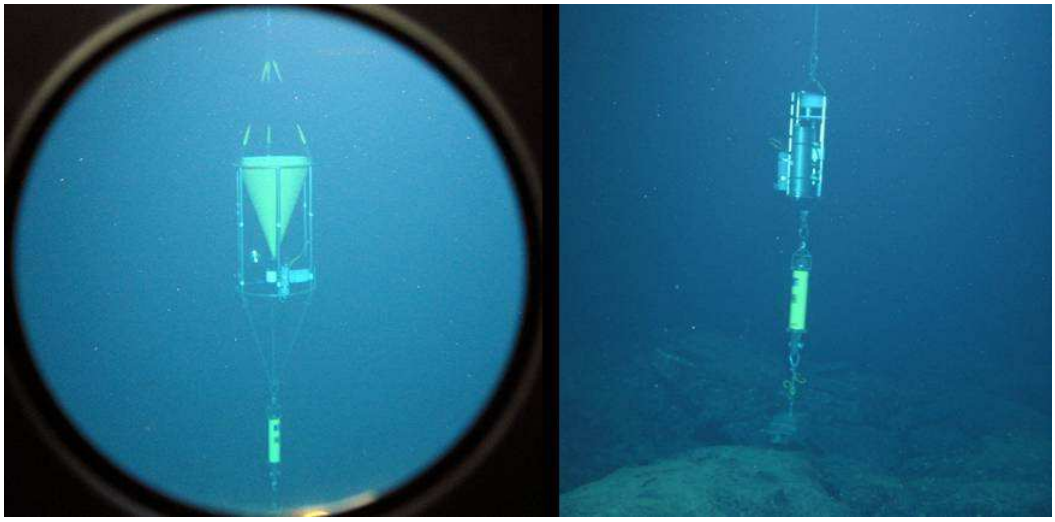

Figure 3: Seafloor image of moored sediment trap (left) and plankton pump (right).

Dive 4273 (Nov. 14)

Pilot	Bruce Stickrott
Port Observer	Stace Beaulieu
Starboard Observer	Brian Hogue

Summary

We started the dive at Tica Vent to deploy a colonization experiment for Florence Pradillon and Monika Bright. Then, we drove the boundaries of the Tica diffuse vent field. Then, we recovered sponges for Monika that were deployed with Lauren Mullineaux's sandwiches experiment. Then, we drove one South-to-North transect over the Tica experiment sites, and continued North on-axis towards East Wall. Along the way, we encountered a new diffuse vent site with *Tevnia,* in the ASCT. Then, we went upslope and found live mussels at East Wall near Monika's sponges. Then, we proceeded off-axis and found the lava contact within a few hundred meters, and we followed its scalloped edge northward until the end of the dive. We took two rock samples at the lava contact: one old and one new, prior to dropping weights.

3 Larval Studies

[*Lauren Mullineaux, Stace Beaulieu, Irene García Berdeal, Carly Strasser (with help from Scott Worrilow and Brian Hogue).*]

3.1 Overview

The main objectives of our group are to characterize the vertical and horizontal positions of larval invertebrates in the water column, to measure temporal changes in their supply to vent communities, and to examine the relationship between larval supply and recruitment into the benthos. These

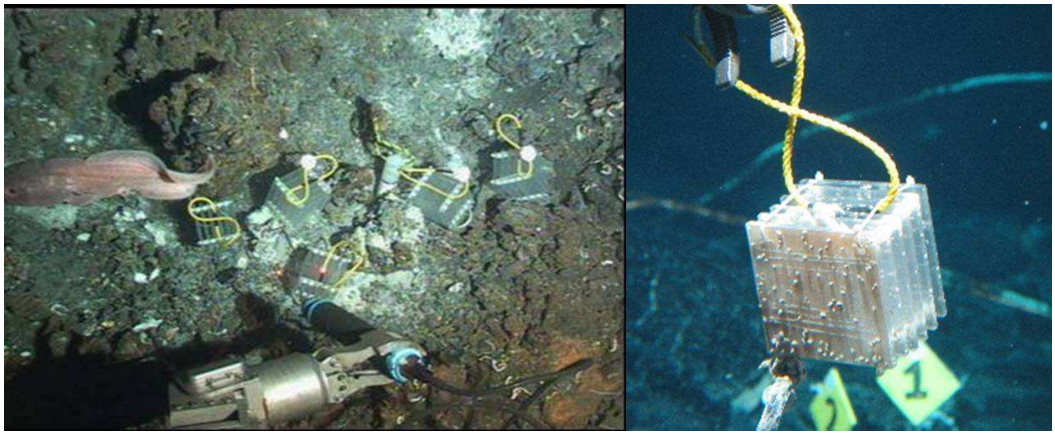

Figure 4: Colonization surfaces (sandwiches) in situ at K vent (left) and on recovery (right).

larval studies are coordinated with the LADDER tracer release and other physical oceanographic measurements, and will be integrated into a coupled biological-physical model. The timing of these studies is fortuitous because they are being conducted during the early stages of ecological succession after the Jan. 22, 2006 eruption at the 9°50′N area.

Our approach includes sampling with plankton pumps synoptically at locations near and above bottom, within and outside the axial trough. These pumps provide a snap-shot of larval distributions over a 24-hour period. We use sediment traps to monitor changes in larval supply over longer time scales of weeks to months. Colonization experiments are placed on the seafloor at the same sites and for the same durations as the larval supply measurements. Seafloor images of a moored pump and trap are in Figure 3; images of the colonization experiments are in Figure 4.

3.2 Larval Supply

We deployed and recovered four sets of paired moorings (PumpL1 through L8), each with a plankton pump at 3 m above bottom and another just below the level of the neutrally buoyant plume. At 9°50′N, the upper pump was located at 74 m above bottom; at 9°30′N the upper pump was at 139 m above bottom. For each pair of moorings, one was placed directly at a vent site within the axial trough and the other 100 m east. Mooring sites were located near Ty/Io, Tica and Riftia Field vents near 9°50′N and at K vent near 9°30′N. The moorings were lowered on the hydrographic wire and navigated in using a relay transponder, the Alvin LBL net, and DVLnav software in the computer lab. A wire-mounted Edgetech acoustic release was used to release the mooring from the wire and individual acoustic releases were used to release the mooring from the seafloor. The pumps were scheduled to run for 24 hrs, starting at 15:30 GMT (9:30 LT) for the off-axis ones and 17:30 for on-axis. This timing allowed for submersible relocation of the on-axis mooring if necessary and recovery of both moorings during the Alvin dive. All pump samples looked excellent with the exception of one off axis, above-bottom pump at Tica vent (the pump did not start) and one on-axis, near-bottom pump at K vent (filter clogged). Two 10-min samples from the Alvin pelagic plankton pumps were collected near K vent to quantify larvae at that site.

Two sediment traps, TrapR1 and TrapR2, were recovered after a 4-month deployment from the RESET06 cruise, and five additional ones were deployed for the upcoming year. Traps were recovered

from locations near Ty/Io and P-vent using mechanical pull-pin releases. Recovered traps had been suspended 3 m above bottom. Two new moorings, TrapL1 and NA were deployed south of Ty/Io vent, 85 m apart in the axial trough. TrapL1 mooring suspended a sediment trap 4 m above bottom and NA had one at 75 m above bottom. Two other new moorings, TrapL2 and CA were positioned 80 m apart in the axial trough north of K vent. The Trap L2 mooring suspended a sediment trap 4 m above bottom and mooring CA had one 130 m above bottom. The fifth sediment trap was positioned on the eastern flank on mooring EF at a height of ≈1000 m above bottom (2000 m deep). An RCM11 current meter was attached above each sediment trap. The traps start on 17 Nov. 2006 and end 23 Sept. 2007, with a sampling scheme that is synchronous with the spring-neap tidal cycle (period of 14.765 days). The cups open at the neap-to-spring transition (90 degree phase prior to spring tidal velocities). The exact cup opening times are listed in the files `*_deploy.txt` on the Science Data Disk 2 (appendix B) in directory `/science/Sediment_Trap_Files`.

3.3 Colonization Studies

A set of three colonization sandwiches was recovered from each of two sites, near Ty/Io (TamTown) and P-vent. These had been deployed on RESET06. A sandwich consists of 6 layers of roughened plastic plates assembled into a cube 10 cm on a side. Four additional colonization sites were initiated over the course of the LADDER1 cruise, Tica, P vent, and Sketchy vent (south of Ty/Io) near 9°50′N and K vent near 9°30′N. Each site had three different habitats, corresponding to the vestimentiferan (10°–30°C), bivalve (4°–10°C) and suspension-feeder zones of the former established metazoan communities near 9°50′N. In each habitat we place 5 sandwiches and a hobo temperature recorded. At Tica we also placed 3 basalt blocks in each habitat. At Sketchy we had space only for the high and low temperature habitat deployments. A full description of these experimental sites, with images and diagrams, is found in the file `ladder1_expts.doc`, available on request from L. Mullineaux.

4 CTD Operations

[*Andreas Thurnherr, Jim Ledwell, Amy Guan, Francesca Terenzi, Alice Kohli.*]

4.1 Overview

Two CTDs were used on Atlantis Cruise AT1512. The main CTD was a SeaBird SBE 9-plus mounted on the rosette with the bottles. It had dual pumped C/T sensors and a pressure sensor for the primary variables. Auxiliary sensors were a SeaBird 43 Oxygen Sensor, a WETLabs Eco Combination Meter FLNTU fluorometer/turbidity sensor, a WETLabs Transmissometer, and a Datasonics Altimeter. The rosette pylon was a SeaBird SBE 32 Water Sampler. For this cruise there were eight 10-liter Niskin bottles on the rosette frame, at positions 5 through 8 and 17 through 20. These Niskin bottles were used for salinity samples for almost every cast. Water samples were taken for background measurements of sulfur hexafluoride from the first seven of these bottles at casts 9, 11, 12, and 19. Height above the bottom was recorded at the bottom of each cast on the written cast sheets.

The CTD casts collected with the main CTD/LADCP/rosette system were carried out at the stations shown in Figure 1. Each station was occupied multiple times (see table on p. 51), in order to remove high-frequency variability. In order to do so, a tidal analysis was carried out by I. García Berdeal based on current-meter data collected by D. Adams in 2004 near station NA and care was taken to re-occupy stations at different phases of the semidiurnal tide.

Notes:

1. CTD cast 7 only went to 160 m depth due to a problem with data acquisition. Cast 8 was done at the same location.

2. Potential density calculated by SeaBird software, and entered in some of the files listed below, differed from that calculated using the full equation of state, as described below.

3. The Turbidity Sensor voltage is converted to "Nephelometric Turbidity Units" (NTU) using a user polynomial, the constants of which are in the `.CON` files. The equation is:

$$\text{NTU} = \text{ScaleFactor} \times (\text{OutputVoltage} - \text{CleanWaterOffset})$$

   The manufacturer's calibration gives CleanWaterOffset = 0.148 V and ScaleFactor = 5μg/l/V. However, this gives slightly negative values for most of the water column on this cruise. A result that is always positive could be obtained by modifying the polynomial constants on line 76 of the `.CON` file.

4. Information on the constants used for all the sensors are in the `.CON` files. See the help pages in the SeaSoft Software package for a map of where these constants are. The help pages are also the best resource for explaining how to use the software, set up the processing modules and also for creating batch files for automated processing.

4.2 SBE 911plus

The SBE 911plus CTD system was used for vertical casts in conjunction with a 24-bottle rosette and a LADCP system.

Data Files

Original data files for the SBE 9 are in the directory `/ctd` on the Science Data Disk 1 (appendix B):

`*.DAT`	binary files with the raw data
`*.HDR`	header information for each file
`*.BL`	information on when the Niskin bottles were tripped
`*.CON`	Configuration files for each cast

The following files were produced and saved for the SBE 9 data, and can be found on the Science Data Disk 2 in the directory `/science/PhysicalOceanography/CTD/911`:

`./hf/*.cnv`	24 Hz data, aligned, filtered and cellTM applied. No derived variables, except for depth.
`./hf/*.ros`	The records at 24 Hz that are needed for the bottle summary data.
`./avg1m/*.cnv`	1-m averages of the data in `./hf/*.cnv` after loopedit, with derived variables S0, S1, θ, and σ_2.
`./avg1s/*.cnv`	1-s averages (no loopedit), including S0, S1, θ, and σ_2.
`./bottle/*.btl`	Average data from the CTD pertinent to the bottle trips. Note that the actual rosette position is not recorded in the first column of these files, but only the number in the sequence of bottle firing. For cases when the operator fired bottles at rosette positions that did not have bottles, there are extra records that must be sorted out according to the depth recorded in the cast sheets.

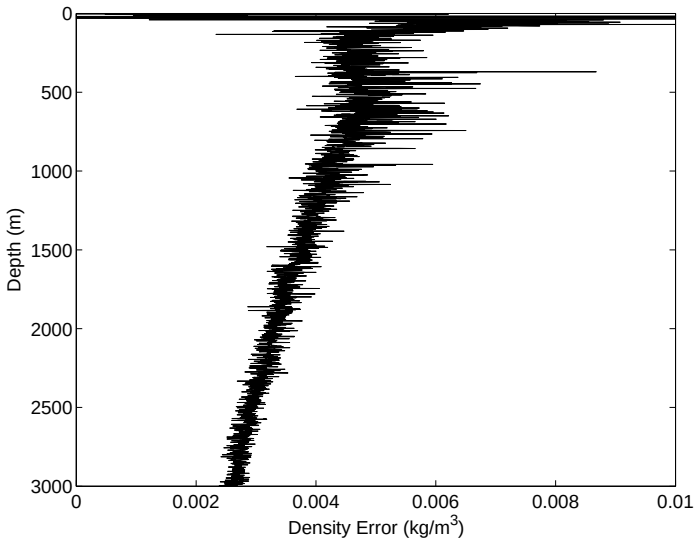

Figure 5: σ_2 calculated by SeaSoft for the SBE 911 CTD minus $\sigma_2(S, T, P)$ from the UNESCO 1983 equation of state, where S, T, and P are from the CTD data.

The directories listed above also have the SeaBird `.psa` files with the set up parameters for processing and they have `process*.txt` files that are used in batch processing, with the batch command in the following directory:

`./Batch/*.bat` These are batch files that will re-process the CTD data. Paths will need to be modified when out of the Atlantis network environment.

Data Processing Decisions

The values suggested by SeaBird were used in Align, Filter, and CellTM. In LoopEdit all pressure reversals were excluded. The parameters actually used are always listed in the header of each file, along with the history of the processing steps applied to the file.

Inaccuracy in the SeaBird 911 Potential Density

Users of these data should beware that the potential densities derived by SeaSoft for the SBE 9 in the 1-meter and 1-second average files differ from those from the full equation of state provided by Phillip Morgan (which is consistent with routines used at the NOC in the UK). Figure 5 shows the difference for cast 24 as a function of depth. Care has been taken in this analysis to convert the temperature scale from ITS-90 to IPTS 68, i.e., multiplying by 1.00024, before applying the equation of state.

4.3 SBE 19

An SBE 19 CTD was used on every dive of the cruise. This instrument is an internal recording, battery-operated CTD with a strain gauge pressure sensor, temperature sensor and conductivity

$N = 467$	SBE19 mean	SBE19 stderr	SBE911 mean	SBE911 stderr	Difference SBE19 − SBE19
P (dbar)	2538.9	0.06	2542.9	0.02	-4.0
T (°C)	1.8326	3.00×10^{-5}	1.8346	1.49×10^{-5}	-0.0020
C (mS/cm)	31.4486	2.92×10^{-5}	31.4469	1.42×10^{-5}	0.0017
S	34.6749	4.86×10^{-5}	34.6689	0.32×10^{-5}	0.0060

Table 1: Statistics from the intercalibration of the SBE 19 and SBE 911 CTDs.

cell, but with no pump to aid matching between temperature and conductivity. When on Alvin the instrument is usually mounted athwartships just aft of the main basket. Flow through the cell is often not sufficient to attain good matching between T and C since the cell tube is roughly perpendicular to the flow and Alvin is moving much slower than the ideal speed of 60 m/min. The one exception is Dive 4271, the tracer injection dive, on which the conductivity cell was pointed in the direction of travel and was near the leading edge of the basket. Still the speed of the sub was only 10 m/min during the tracer injection.

The SBE 19 was intercalibrated with the SBE 9 during cast 23. An attempt was made during cast 19 also, but the record was too short to make an accurate comparison. The intercalibration is described in section 4.4.

Data Files

Data files for the SBE 9 are found in directory `/science/PhysicalOceanography/CTD/SBE19` on the Science Data Disk 2:

`./Hex/*.hex`	Raw data in files with the header and the data stream in hex format. This directory also includes `8-2005-100-Hz.CON`, the configuration file used for this instrument throughout the cruise.
`./ASCII/*.cnv`	Files converted to ASCII, with no processing applied, with the header.
`./Flat/*.flt`	The same as `*.cnv`, but with the header removed to make flat ASCII files for importing into Matlab.
`./Plots/*.jpg`	Plots of pressure, temperature, salinity, and σ_2 for the part of the dive near the bottom, in the case of Alvin dives.

4.4 CTD Intercalibration

The SBE 19 was secured to the rosette frame with the sensors about 1 m meter higher than the SBE 911 sensors during casts 19 and 23. During cast 23, the package was held 30 meters off the bottom for around 15 minutes to allow the package to come close to thermal equilibrium with the surroundings and then to obtain a sufficiently long record for an accurate comparison. The record from cast 19 is shorter and less useful. The results for cast 23 are shown in Figure 6 and Table 1. The statistics in the table are for the period between the two vertical dotted lines drawn on the temperature time series in the figure.

4.5 Cleaning of the Conductivity Cells

None of the conductivity cells on the SBE 9 or SBE 19 had been cleaned for a long time prior to the cruise. However, they seemed to have been kept with distilled water in them quite consistently.

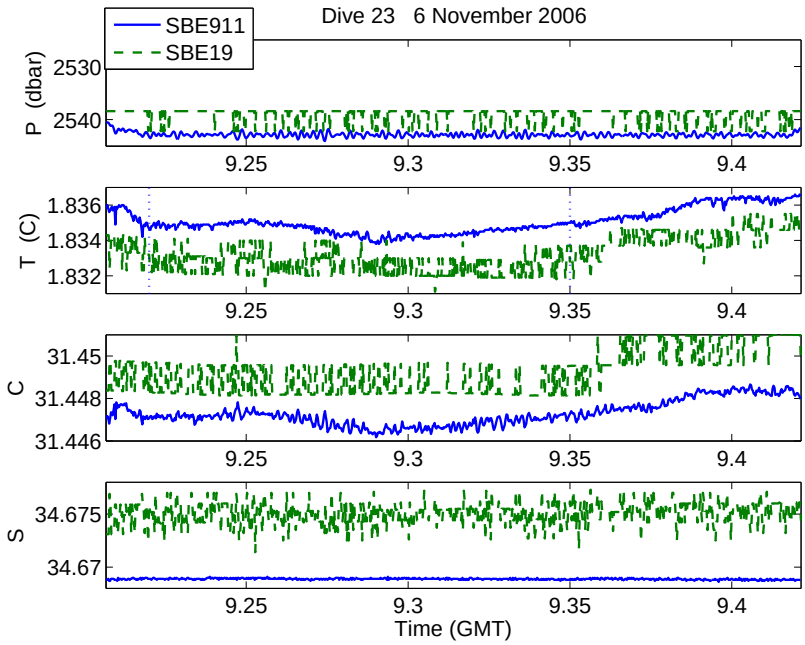

Figure 6: Pressure, Temperature, Conductivity and Salinity as a function of time for the SBE 19 (dashed) and the SBE 911 (solid) CTDs 30 m above the bottom during cast 23.

During the cruise, the conductivity cells in the SBE 9 and SBE 19 were cleaned by soaking with a 1% solution of Triton X 100 for approximately 2 hours on 29 Oct 2006, two days before the first CTD cast. The SBE 9 was cleaned again by soaking for 30 minutes between casts 11 and 12. The cell on the SBE 19 was cleaned again prior to the first intercalibration on cast 19.

5 CTD Salinity Calibration

[*Jim Ledwell, Amy Guan, Alice Kohli, Andreas Thurnherr.*]

5.1 Shipboard Portasal Calibration

Calibration of the CTD salinity was done through bottle samples taken from the eight Niskin bottles on the rosette and analyzed with a Guildline Portasal salinometer. The results from all the bottles for all depths are shown in Figure 7, left panel. The data are in the file `sal_data.txt`, available on request. The Portasal was not being standardized properly for the first 18 casts in that the peristaltic pump for the liquid sample was turned off before taking a reading for the samples but not during standardization. Hence, the data through cast 18 have unknown systematic errors.

Fortunately the CTD salinities seem to have been stable during this period, as evidenced by the difference between the two sensors (Figure 7, right panel). It is unlikely that the two salinities drifted in the same way during this period, since they are independent except that they are based on the same pressure. There was a slight rise of about 0.0003 in S2−S1 at all levels between cast 18 and 19,

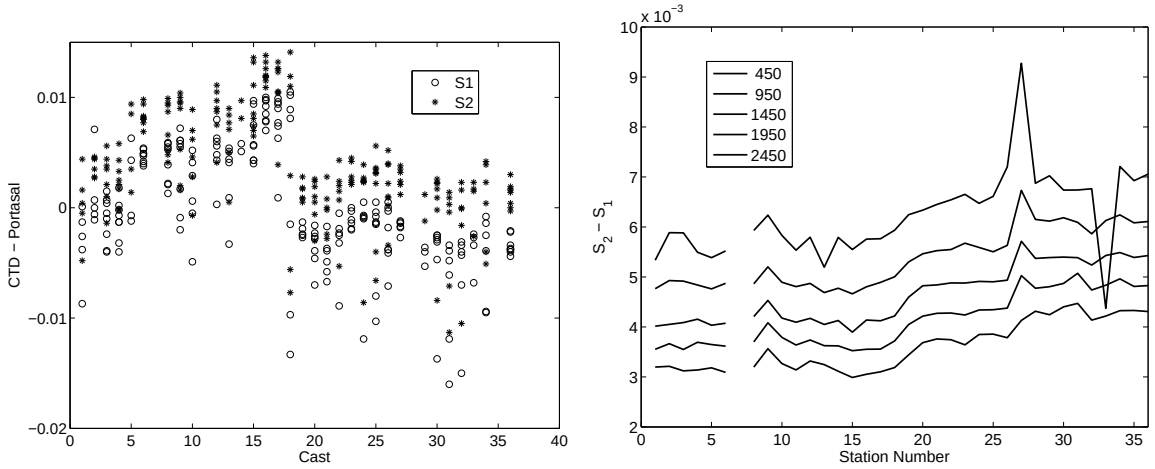

Figure 7: Left panel: Differences between CTD and Portasal salinities for all depths sampled and all casts. Some data lie outside the bounds of this panel and are ignored in all analysis. Right panel: CTD salinity-sensor differences for selected depths as a function of cast number. Differences have been averaged over the 100 m centered at each depth given in the legend.

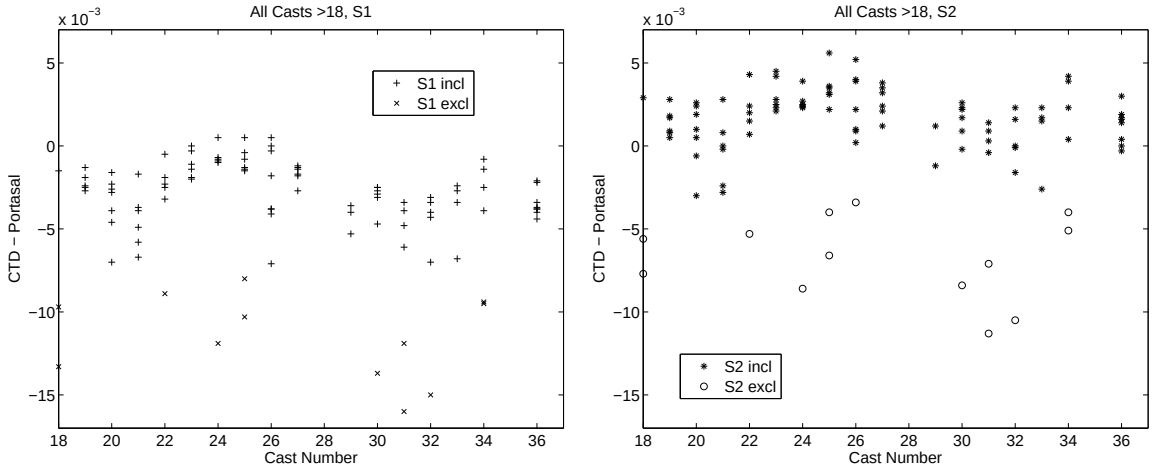

Figure 8: Difference between the sensor salinities and the Portasal measurements. The points plotted as "x" were excluded from statistical analysis as being outliers. Left panel: primary sensor (S1). Right panel: secondary sensor (S2).

which gives an estimate of the (unknown) error in applying the calibration for cast 19 to all the casts from 1 to 18, which is essentially what we must do.

The data from casts 19–36 have been used to calibrate the CTD salinities. The left panel of Figure 8 shows the difference between the CTD sensor S1 and the Portasal measurements for all depths at which we have samples. The undulations in this difference with cast number are followed very closely for the same data for the secondary sensor, S2 (Figures 8 and 9), which suggests that they are due to variations in the Portasal measurements rather than drift in the sensors.

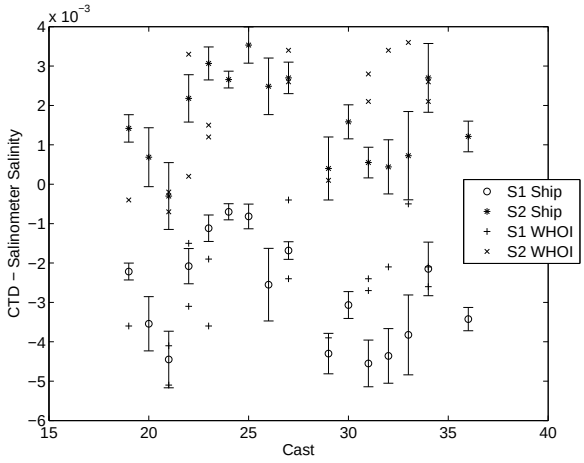

Figure 9: Differences between CTD salinity and salinometer salinity versus cast number. The 'o' and '*' with error bars are the means and standard errors of the data for each cast from the shipboard Portasal salinometer, for the primary and secondary CTD sensor pairs, respectively. The '+' and 'x' are individual results from the Autosal salinometer for samples returned to WHOI (section 5.2), for the primary and secondary sensor pairs.

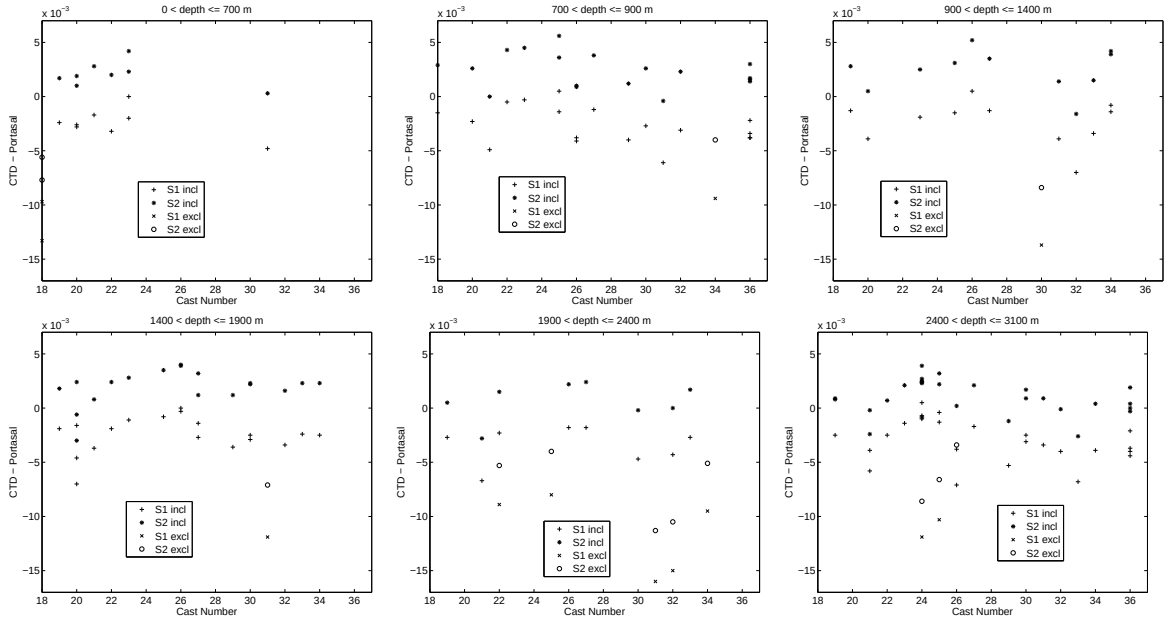

Figure 10: Mean differences between both the primary and secondary salinities, S1 and S2, and the Portasal measurements, for casts 19-36 averaged over samples in the depth intervals (top left to bottom right): 0–700 m, 700–900 m, 900–1400 m, 1400–1900 m, 1900–2400 m, 2400–3100 m.

Depth Interval	S1−Portasal			S2−Portasal		
(m)	count	mean	stderr	count	mean	stderr
0–700	8	-0.0024	0.0005	8	0.0020	0.0004
700–900	17	-0.0028	0.0004	17	0.0023	0.0004
900–1400	11	-0.0024	0.0006	11	0.0025	0.0006
1400–1900	18	-0.0025	0.0004	18	0.0019	0.0004
1900–2400	8	-0.0034	0.0006	8	0.0007	0.0006
2400–3100	29	-0.0028	0.0004	28	0.0011	0.0003

Table 2: Statistics of Salinity Offsets by Depth Interval.

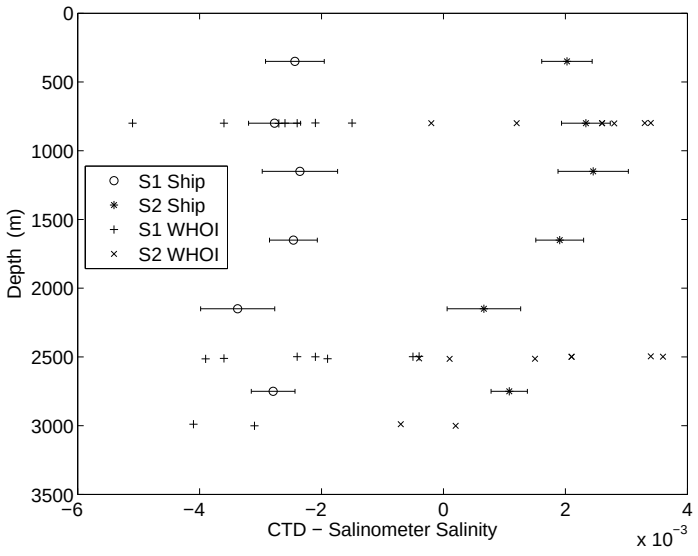

Figure 11: Differences between CTD salinity and salinometer salinity versus depth. The 'o' and '*' with error bars are the means and standard errors of the data for each depth bin from the shipboard Portasal salinometer, for the primary and secondary CTD sensor pairs, respectively. The '+' and 'x' are individual results as a function of depth from the Autosal salinometer for samples returned to WHOI, for the primary and secondary sensor pairs.

Figure 10 shows the salinity differences for both sensors for different depth intervals. There is no discernible trend with depth for the primary sensor, as the statistics summarized in Table 2 and in Figure 11 indicate. The offset for the secondary sensor seems to be about 0.001 greater above 1400 m than below (Figure 11).

5.2 Post-Cruise Autosal Calibration

Because of our problems with Portasal early on during the cruise, we decided to post-cruise analyze some salinity samples. Twenty-one samples were set aside during the cruise and sent to Woods Hole for analysis with a laboratory Guildline Autosal. These samples were analyzed by David Wellwood on 11/30/06, with the results listed in the file `sal_whoi.txt`, which is available on request. Most of

	S1-Portasal	S1-Autosal	S2-Portasal	S2-Autosal
mean	-0.0027	-0.0026	0.0017	0.0017
standard error	0.0004	0.0003	0.0005	0.0004
N	91	16	90	16

Table 3: Statistics of the Calibration of the SBE9plus CTD with the Shipboard Portasal and the WHOI Autosal.

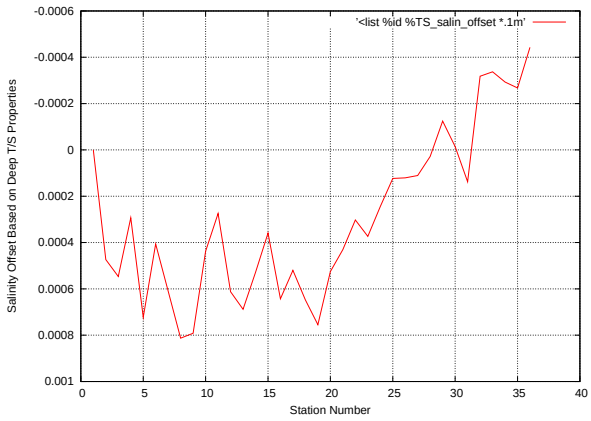

Figure 12: Secondary sensor (S2) salinity corrections wrt. cast 1 from deep T/S properties.

the results agree closely with those obtained with the Portasal on Atlantis. The differences between the Autosal salinity and that from the primary sensor pair were greater than 0.006 for five of the samples, however, and these were deemed outliers and were not included in the analysis. Four of these differences were greater than 0.01, one was 0.0064, and could arguably have been included.

The results are included as a function of cast in Figure 9 and as a function of depth in Figure 11. Individual salinity differences from the Woods Hole samples are shown as '+' for the primary sensor pair and as 'x' for the secondary sensor pair, along with the means for the samples analyzed on the ship. There is some reinforcement of the rise in the salinity difference between CTD and Portasal with cast number between Cast 19 and Cast 27 but little for the drop seen in the CTD minus Portasal differences beyond Cast 27 in Figure 9. The absence of a trend with depth for the primary sensor pair is supported by the Woods Hole samples, while the trend with depth for the secondary sensor pair is weakly supported in Figure 11. The mean values are very close for the two data sets, as seen in Table 3.

5.3 Stability of the C/T Sensors

The scatter of deep T/S properties (not shown) indicates that the secondary salinity data are somewhat more stable than those of the primary sensor. Figure 12 shows the S2 salinity offset relative to the first cast, based on deep T/S properties. The significant trend starting approximately at cast 20 is too small to be detected by the Portasal measurements.

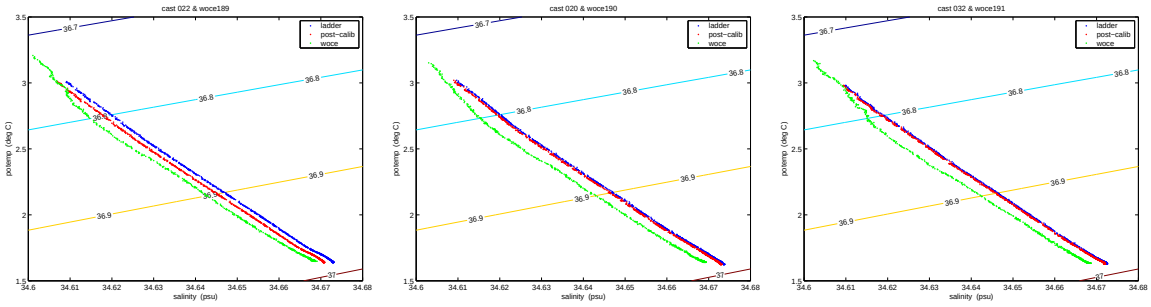

Figure 13: T/S comparison of LADDER-1 and nearby WOCE P04 CTD casts.

5.4 Comparison with WOCE Data

In 1989 the hydrography across the EPR crest near 9°30′N was sampled during the WOCE P04 cruise. Three of the WOCE stations are within a few km of LADDER-1 stations. The corresponding deep T/S properties (both before and after Portasal calibration) are shown in Figure 13. Based on these plots there appears to be either a temporal shift or a salinity bias error of order 0.003 (with the LADDER-1 data being high). A more detailed analysis is required to distinguish between those two possibilities.

5.5 Summary

There does not appear to be any significant trend with either depth or with cast number of the difference between the primary salinity S1 and the Portasal measurements. The Portasal data suggest that the primary salinity be corrected by the mean offset of all the measurements accepted into the analysis, which is:

$$\Delta S_1 = -0.0027 \pm 0.0004, n = 91$$

where the uncertainty given is one standard error. Hence, to correct the salinity from the primary sensor +0.0027 should be added to the recorded salinity.

For the secondary sensor, there does appear to be a significant trend with depth. The data in Table 2 can be used to correct the salinities from this sensor as a function of depth. This sensor is stable enough also to attempt to make a correction based on cast number using the data shown in Figure 12.

6 LADCP Operations

[*Andreas Thurnherr, Francesca Terenzi.*]

6.1 Data Acquisition

Velocity profiles were obtained during all casts using a WHOI LADCP system mounted on the CTD rosette sampler with the following instrument setup:

CAST #	Down	Up	Comments
001–003	4896	7877	
004	7877	4896	uplooker dysfunctional
005–008	7877	1412	
009	7877	1412	uplooker dysfunctional
010–014	7877	1412	
015	7877	1412	uplooker dysfunctional
016–017	7877	1412	
018	7877	1412	no good data
019–036	7877	-	

Table 4: LADCP serial numbers. See `logsheets.pdf` on the Science Data Disk 2 in directory `/science/PhysicalOceanographyLADCP/data/raw` for additional notes.

Number of depth cells	28
Length of depth cells	8 m
Blanking distance	0 m
Coordinate system	radial beam
Pinging setup	staggered pings every 1.5/2.0 s
Ambiguity velocity	$2.5\,\mathrm{m\cdot s^{-1}}$

The initial ADCP configuration used two identical RDI 300 kHz instruments; one as a down-looker, and one as an up-looker. Three separate ADCPs (serial numbers 7877, 4896 and 1412) were used during the cruise (Table 4). Instrument 4896, which was initially used as the downlooker, started out with a weak beam. Therefore, the up- and downlookers were switched for cast 004. However, during that cast the weak beam deteriorated further to the point of the instrument not being useful any more and it was replaced with the spare. This instrument performed well up to cast 017, with the exception of casts 009 and 015 when it returned no data whatsoever. On cast 018 none of the instruments returned good data and, because the uplooker had been flaky before, it was decided to remove it and continue with the downlooker alone. This worked well for the remainder of the cruise. There are no indications that the downlooker-only profiles are of inferior quality.

When instrument 1412 was opened to determine whether there was a bad contact it was found that the board closest to the transducer was badly corroded by seawater. Because the instrument was only used as the uplooker the seawater leak could not have happened during LADDER-1, which was later confirmed by D. Torres (pers. comm.), the maintainer of the instruments.

6.2 Processing

All LADCP data were processed with version IX_3 of the LDEO software package, using bottom-tracking, GPS data and minimally processed on-station shipboard ADCP data to constrain the barotropic flow. During casts 001–009 the SBE deck unit was fed a GPS stream that it could not handle for some reason, and the GPS data in the CTD time-series files contain bad outliers. However, since all casts were done while the ship was in DP mode and since the DP system worked flawlessly there are at most a few m difference between the cast deployment and recovery positions, which allows casts 001–009 to be processed without accounting for ship drift, without any noticeable loss of quality. (This was verified with data from later casts with good GPS data.) From cast 010 onward, a different GPS feed was used and no further GPS problems were encountered. Based on the self-consistent picture of the circulation that emerges from the LADCP-derived velocities at different

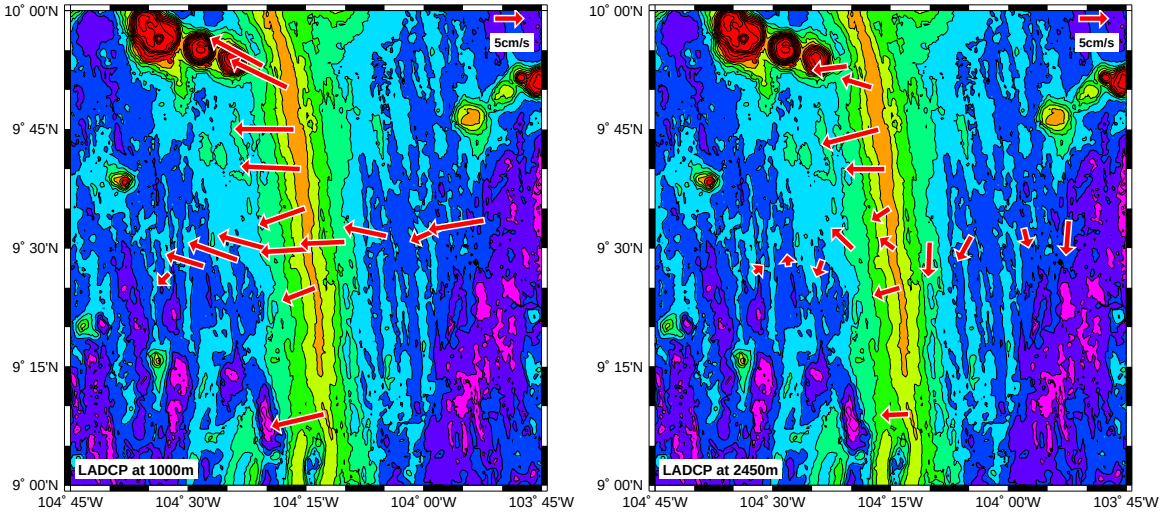

Figure 14: LADCP velocities at 1000 and 2450 m.

id	lat	lon	depth (m)	height (m)	current meters	sed. trap	col. surf.
NA	9:50.0	-104:17.4	2502	103	3×RCM11	McLane	7–12
CA	9:29.9	-104:14.5	2568	158	3×RCM11	McLane	13–18
SA	9:09.0	-104:12.5	2594	173	3×RCM11		31–36
WF	9:26.6	-104:32.3	2990	521	3×RCM11		1–3
EF	9:33.1	-103:52.3	3038	1073	3×RCM11	McLane	4–6
W1	9:29.8	-104:19.8	2807	542	MMP		19–24
W2	9:28.2	-104:29.0	3047	842	MMP		25–30
ADCP	9:30.0	-104:14.5	2572	1	RDI Workhorse		
L1	9:50.0	-104:17.4	2502	81	1×RCM11	McLane	
L2	9:29.8	-104:14.5	2570	81	1×RCM11	McLane	

Table 5: LADDER-1 moorings left installed at the end of the cruise. MMP = McLane Moored Profiler with CTD & acoustic current meter (& Seapoint LSS on the W1 mooring); sed. trap = McLane Sediment Trap — see section 3.2 for details; col. surf. = colonization surfaces (kitchen sponges) for meiobenthos experiment (section 10). See Figure 1 for mooring locations; L1, L2 & ADCP were deployed near NA, CA & CA, respectively.

stations (Figure 14), the LADCP data quality is considered to be very high.

7 PO Deployments

[*Scott Worrilow, Brian Hogue, Andreas Thurnherr.*]

7.1 Moorings

As part of the LADDER cruise, an array of seven moorings was deployed (Table 5, Figure 1). These moorings and the associated instrumentation were prepared and constructed by the sub-surface moor-

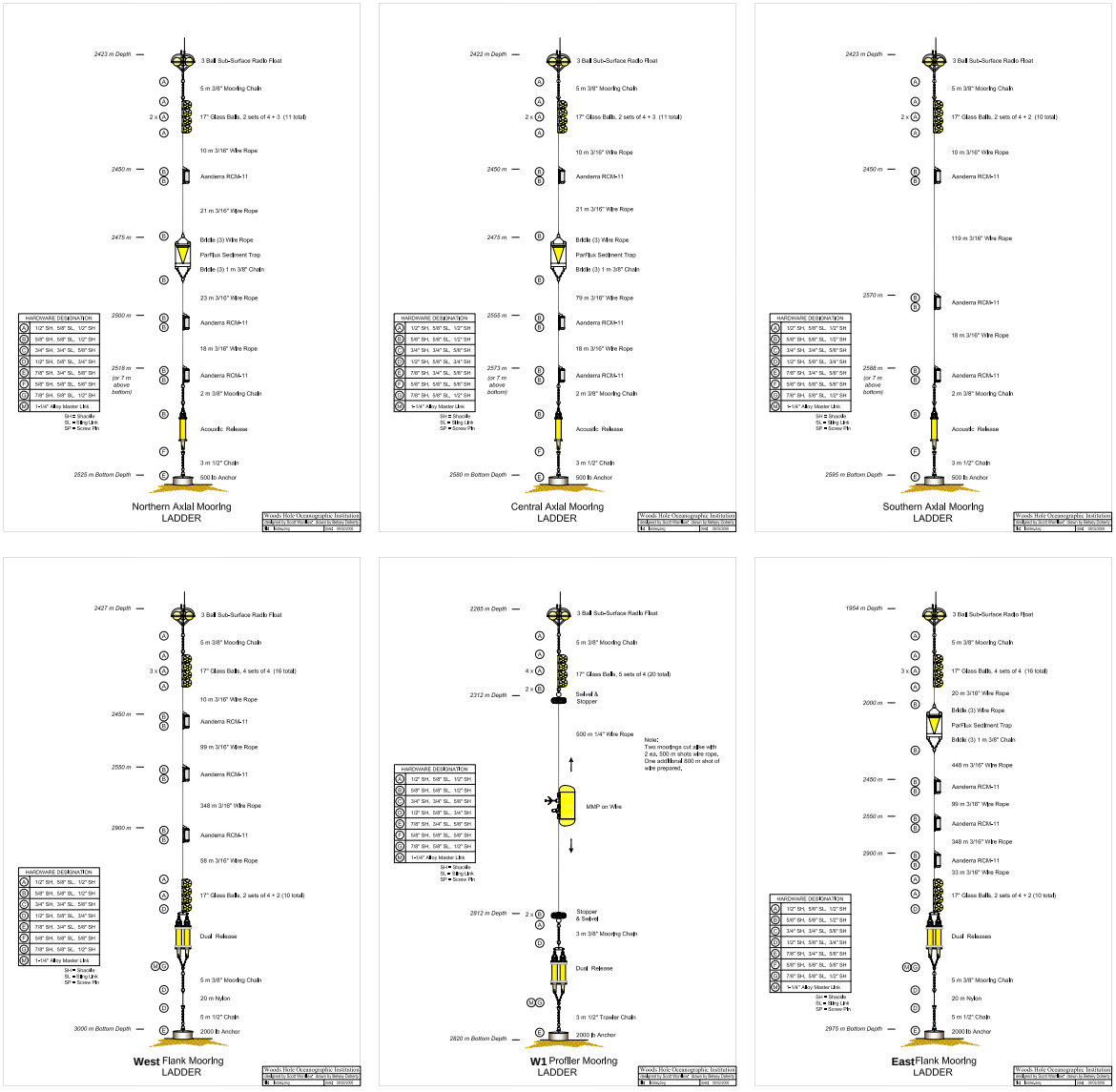

Figure 15: Mooring Drawings. Depths are target depths determined before the cruise — see Table 5 for true deployment depths. The additional profiler mooring W2 is similar to W1, except that the crawling wire is 800 m rather than 500 m long. There are additional 5 m nylon lines between the anchors and the releases of the profiler moorings W1 & W2.

ing operations group from Woods Hole Oceanographic Institution under the direction of Scott Worrilow. The array consisted of two flank moorings located on the east and west sides of the EPR axial summit (EF & WF), three axial summit moorings, (NA, CA & SA) and two McLane Moored Profiler (MMP) moorings (W1 & W2). Sediment traps were deployed on three of these moorings (EF, NA and CA) — see section 3.2 for details. Aanderaa RCM-11 Doppler Current Meters were used on the

	Min	Mean	Max
Time	1707 Z	1819 Z	1930 Z
Latitude	9.4928	9.4980	9.5034
Longitude	-104.2424	-104.2414	-104.2407

Table 6: Time and location of tracer injection, carried out on 12 November 2006.

East and West Flank moorings and all Axial Moorings.

PI, Andreas Thurnherr, predetermined placement of instruments on the moorings. Axial summit moorings were deployed anchor first and lowered and navigated into place by the ship. The NA mooring was later re-positioned by Alvin into the axial summit trough. Positioning of the CA mooring inside the trough was verified by Alvin. The axial moorings were constructed keeping in mind that for proper placement it may be necessary to reposition these moorings with Alvin and therefore were ballasted accordingly. Flank and MMP moorings were deployed in a standard anchor last manner. The final position of the flank moorings was surveyed in to determine exact positions; the MMPs were not surveyed in.

The moorings were deployed during the cruise under the direction of Scott Worrilow, assisted by Brian Hogue and Atlantis Bos'n, Patrick Hennessy, and the ship's deck workers. Mooring deployments were conducted at night so not to interfere with daytime Alvin Operations.

Because of the light ballasting of our moorings a "standoff protocol" was submitted to the R2K EPR ISS site coordinator (Dan Fornari) during the cruise; see Appendix E for details.

7.2 Bottom-Mounted ADCP

In order to investigate the temporal variability and the vertical shear of the flow field in and above the axial trough in the center of the long-term mooring array during the tracer-release experiment, an RDI Workhorse 300kHz ADCP (the same model that was used as the LADCP) was deployed during Alvin dive 4259 in the axial trough near 9°30′N. Recovery of the instrument is planned for one of the early dives of the LADDER-2 cruise in December 2006. On the basis of LADCP observations and a similar deployment carried out on the MAR earlier this year, the estimated range of good velocity observation is somewhat below 100 m. Instrument setup:

beginning of record	2006/10/31, 15:00 GMT
ambiguity velocity	$1\,\mathrm{m\cdot s^{-1}}$
number of depth cells	32
length of depth cells	4 m
hab of first valid velocity	6 m (zero blanking distance, discard 1st bin)
coordinate system	radial beam coordinates
sampling scheme	1 ensemble every 20 minutes; 180 pings per ensemble; max. pinging rate

8 Tracer Injection

[*Jim Ledwell, Ryan Jackson, Brian Guest.*]

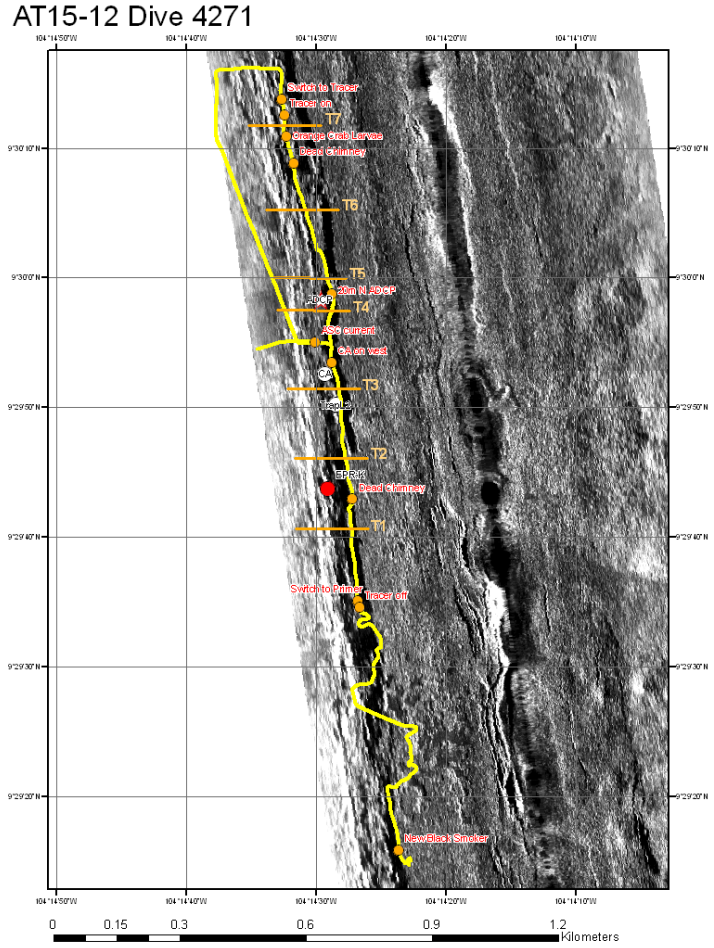

Figure 16: Dive track of Alvin dive #4271, during which SF_6 was injected into the axial trough.

8.1 Overview

A major part of LADDER is a tracer release experiment to help estimate probability distributions of larval dispersion, in conjunction with numerical models. The experiment started with the release of three kilograms of sulfur hexafluoride (SF_6) along a 1200 m track in the axial trough on Dive 4271 near 9°29.9′N, on 12 November 2006 (Figure 16). The tracer went in smoothly over 2.5 hours with Alvin moving from north to south at an average speed of 8 m/min. The injection rate was about 15 ml/min, or about 20 g/min. The injection orifices were 0.56 m above the level of Alvin's "basket" and 0.50 m above the face of the transponder on the Benthos altimeter on Alvin. Alvin maintained a mean height above the bottom of 4.8 m, with a standard deviation of 1.6 m due largely to the rough topography of the trough. Details of the time and location of the injection are listed in Table 6.

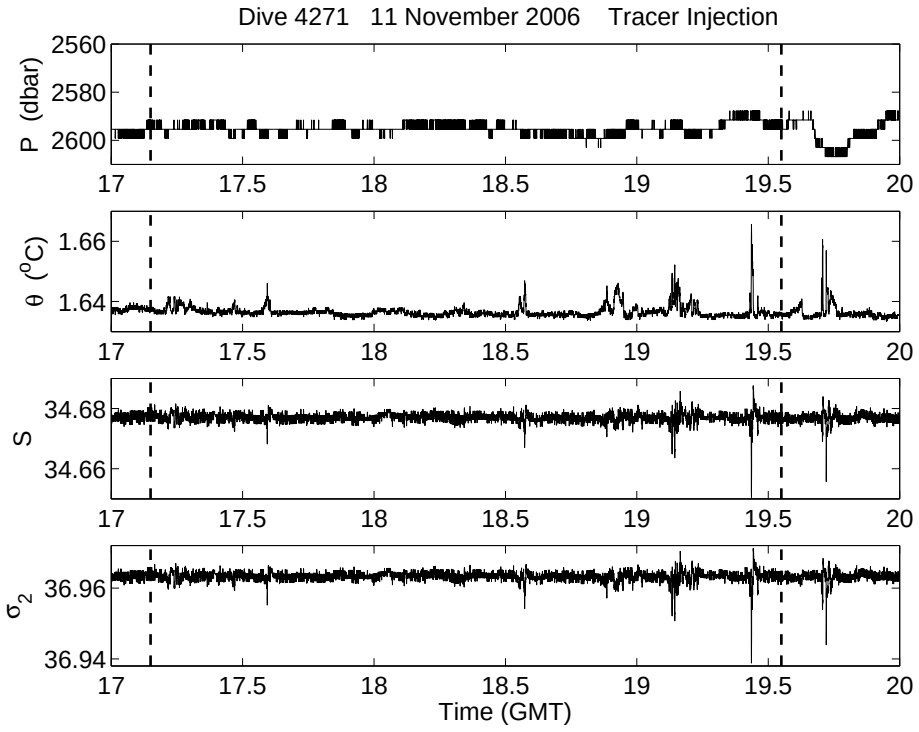

Figure 17: Time series of pressure (P), potential temperature (θ), salinity (S), and potential density (σ_2) during the tracer injection. The start and end times of injection are marked by the vertical dashed lines. These are raw data, to be corrected via comparison with the SBE 9 CTD at Station 23 (Figure 6), and through this instrument with bottle salinity measurements (section 5).

Variable	Mean (raw)	Mean (corrected)	Std. Deviation
P (dbar)	2595	2599	22
T90 (°C)	1.8207	1.8227	
θ (°C)	1.6366	1.6386	0.0020
C (mS/cm)	31.4625		0.0018
S	34.6770	34.6740	0.0015
σ_2		36.9610	0.0013
Altitude (m)	4.78	4.78	1.81
Depth (m)	2564	2568	1.65

Table 7: Statistics of the Hydrography During the Injection.

8.2 Hydrography During the Injection

Time series from the SeaBird SBE 19 during the injection are shown in Figure 17. The instrument was oriented fore/aft on Alvin's basket with the sensors near the leading edge of the basket. The temperature sensor on this instrument is rugged and slow, with a time constant of about 0.7 s; the

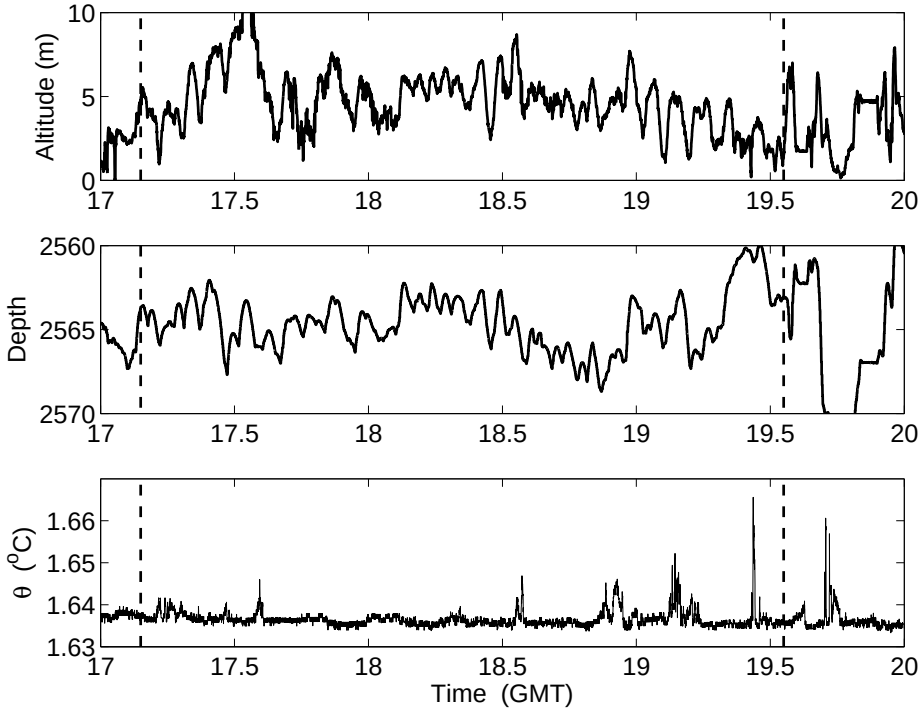

Figure 18: Time series of altitude, depth, and potential temperature at Alvin during the tracer injection. The start and end times of injection are marked by vertical dashed lines. Altitude is the reading from the Benthos altimeter on Alvin, plus 0.50 m to account for the height of the injection orifice above the altimeter. Depth is from a pressure sensor on Alvin. Potential temperature is from the SBE 19 CTD and is repeated from Figure 17.

conductivity cell at the speed of Alvin of $0.16\,\mathrm{m\cdot s^{-1}}$ is about the same. The density variations in the record are almost entirely due to salinity variations, and those in turn are mostly artificially caused by the lag between the conductivity cell and the temperature sensor. Hence the variance of density of the water tagged by the injection is most likely grossly overestimated from the raw data (Table 7). Post cruise processing may be able to reduce this variance. On the other hand, the tracer jet often went immediately toward Alvin, around the hull and through the exterior paneling, and would have been influenced by any heat emitted by the sub. This may add more to the true density variance of the injection than is artificially added by poor matching of C and T. More observations of the injection from the Alvin observers are given below.

Statistics of the time series of hydrographic variables are listed in Table 7. The raw data in the second column are uncorrected for the difference between the SBE 19 and the SBE 9 CTDs and for the difference between the latter and the salinities measured by the Portasal salinometer. To convert to the SBE 9 we must add 4 dbar to the pressure, add 0.0020°C to the temperature and subtract 0.0060 from the salinity. (We correct salinity rather than conductivity). The Portasal correction (section 5) implies that we should add back 0.0027 to the salinity to get the salinity of the injection. The third column in the table summarizes the results. Altitude (height above bottom) and depth in the table are from separate sensors on Alvin (Figure 18). The depth agrees with the uncorrected

date	time	Lat	Lon	depth	altitude	Comment
11/12/2006	16:08:00.23	9.4986	-104.2414	2569	-0.09	ASC current measurement
11/12/2006	17:03:00.23	9.5038	-104.2424	2566	2.1	Switch to Tracer
11/12/2006	17:07:00.23	9.5035	-104.2423	2567	1.76	Tracer on
11/12/2006	19:28:00.23	9.4931	-104.2408	2560	2.68	Switch to Primer
11/12/2006	19:30:00.23	9.4929	-104.2407	2563	1.29	Tracer off

Table 8: Dive 4271 markers

SBE 19 pressure, and so we add 4 m to correct this depth, as for the SBE 19.

8.3 Alvin Observations

A full account of the injection dive can be found in the dive reports under dive 4271 for cruise AT15-12. Prior to diving, the injection system was primed and each of the four orifices was checked for proper flow. The system was turned off and remained off until the sub was placed in the water and the swimmers were clear of the sub. At 14:38 GMT all four orifices were opened and primer was pumped through the system with a pump setting of 0.9 V. Primer effluent was visible from all four orifices. Pumping primer through the system during decent ensures the system has a positive pressure at the orifices and no particulates can work their way into the orifices and clog the system.

Shortly after reaching the bottom at a depth of 2558 m, we drove east to the ASC and set the sub down on the bottom which kicked up enough sediment that the cloud remained suspended for about 10 minutes, well after any noticeable turbulence from the sub had dissipated. While a noticeable 2–5 $\mathrm{cm \cdot s^{-1}}$ westward current existed outside the ASC, no mean current in the ASC was observed and we proceeded north to the waypoint NT (northernmost point of injection path) via an off the axis route (see Figure 16). The bathymetry off the axis consisted of relatively smooth terrain interrupted by large (≥ 3 m deep) collapses and fissures. These pits and fissures may trap tracer and help to smear out the tracer patch. Many of these features appeared to run east-west and may or may not have been connected with the ASC.

We drove 100 m north of NT and then turned into the ASC and began the switch from primer to tracer (at 16:48 GMT we turned orifices 2–4 off leaving the most forward orifice open). Approaching the ASC the terrain changed from relatively smooth sheet flow with fissures to very jagged, broken basalt, basalt pillars, and steep walls. Once we reached the middle of the ASC, we headed south to NT. At about 30 m north of NT we switched from primer to SF_6 tracer (17:03 GMT) and adjusted the pump control voltage to 1.5 V. The pump rpm was timed at 100. At 17:07 GMT the SF_6 reached the orifice and the effluent turned from a relatively clear fluid to a milky white fog (see Table 8 for position). The pressure rose to just under 1000 psi. The fog-like discharge from the orifice initially traveled almost perpendicular to the path of the vehicle off the starboard side of the basket (the orifice nozzle was oriented about 5–10° toward the aft) and within about 10 cm the flow was swept back towards the starboard side of the sub. Most of the white color was gone by the time the tracer stream had reached the body of the sub (1–2 m behind the basket), though in some cases the plume is still visible due to index of refraction changes. The width of the plume was about 20–30 cm by the time the plume reached the sub body. The tracer then likely traveled along the body of the sub (and perhaps within the sub's body panels) until it was ejected out the back of the sub and caught in the turbulent wake of the sub. Based on observations of fine sediment clouds kicked up by Alvin, the tracer was likely spread over a width equal to at least 3 times the width of the sub (about 30 m total) and a height above bottom of about 4 m plus the altimeter reading (top of the sub). This is

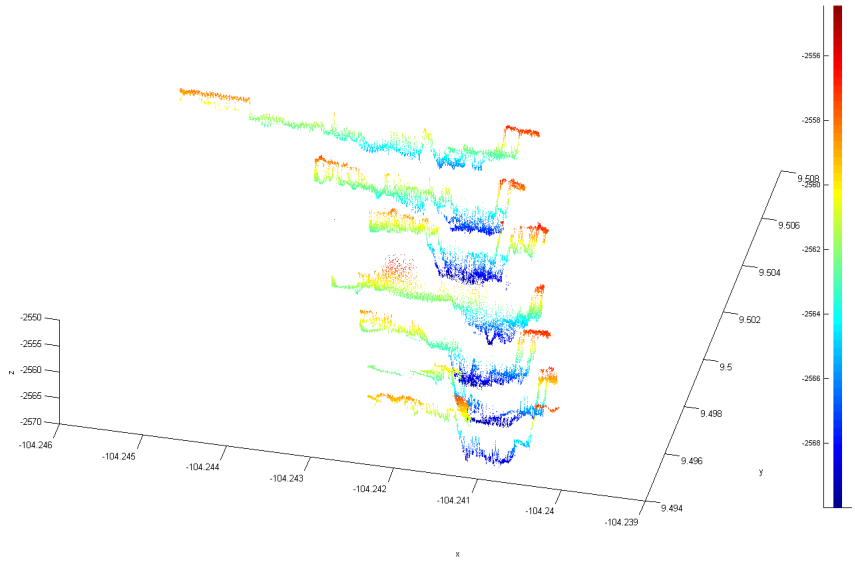

Figure 19: Bathymetry transects across the EPR ASC in the vicinity of 9°30′N latitude. This bathymetry covers nearly the entire injection region. The transects were obtained by the Imagenex system aboard Alvin on dive 4259.

a rough estimate and does not account for any thermal influence of the sub on the tracer. A proper estimate of the initial tracer cloud will be computed at a later date.

During the injection, the sub progressed south at about 8 meters per minute and injected the tracer over a 1200 m stretch within the ASC. The tracer injection system functioned exceptionally well and provided a continuous output of about 15 ml/minute. The topography within the ASC varied dramatically from numerous 5–9 m tall pillars in the north to relatively smooth pillow lava in the south. A number of dead sulfide structures formed mounds or sills within the ASC and the sub had to either maneuver around or over these obstructions. The sub averaged an altitude of about 4.8 m during the injection. The southern half of the injection region had numerous fissures within the ASC, some measuring over 3 m wide and >5 m deep. Hollow pillow lava and collapses may provide dead zones for the tracer. The walls of the ASC were fairly well defined to the south and less well defined to the north. The eastern wall of the trough is about 11 m in height on average and relatively steep and well defined while the western wall is of a variable height (10 m tall and steep to the south, tiered with roughly 6 m and 4 m tiers to the north — see Figure 19). The first dive of the cruise (4259) provided the bathymetry of the injection region shown in Figure 19.

When we reached the southern end of the injection region (waypoint ST) we switched back to primer (19:28 GMT) and flushed the injection system. The flushing was complete at 19:30 GMT as primer effluent was visible at the orifices. At 19:33 GMT the system was shut off. Because the tracer could have been caught in the body panels of the sub, we used the rest of the dive to "wash down" the sub. We proceeded south in the ASC and explored for new vents for approximately then next 75 minutes.

Figure 20: Dye-entrainment experiment.

8.4 Float Launch

A float was launched about 12 hours after the tracer release to aid in tracking the tracer. The float, RF33, was a one-of-a-kind design, with two aluminum tubes, RAFOS electronics, ARGOS tracking at the surface, with no acoustic tracking network in place. It was timed to release its weight at 00:00 Z on 14 December 2006 (i.e. during LADDER-2), and so has a mission of 31 days.

The float was ballasted to settle at 2450 m depth, extrapolating from lab ballasting measurements at about half the pressure and at room temperature. When we deployed it it seemed very reluctant to sink, but this may be due to high T and P coefficients of aluminum and the very warm tropical water.

The float was released on 11/13/06 02:53 Z, at 9°29.95′N 104°14.31′W, about 400 m meters east of the center of the tracer release line to try to compensate for an anticipated westward drift during descent due to the prevailing currents in the region (e.g. Figure 14).

9 Dye-Entrainment Experiment

[*Andreas Thurnherr, Irene García Berdeal.*]

On dive 4266 an *impromptu* dye-entrainment experiment was carried out, using 3 of the dye-ball strings prepared by Ryan Jackson. Each dye-ball string consisted of a 1 ounce lead fishing weight, 1 m of steel leader line (0.032" diameter) with four equally spaced mustache wax balls (≈1 cm in diameter), mixed with plenty of fluorescin dye (enough to thicken the wax' consistency so that balls

could be formed), and ≈ 18cm^3 of syntactic foam for buoyancy. Between the "anchor" and the leader line three different lengths of monofilament fishing line (1.0, 1.5 and 2 m) were used to lengthen these "moorings."

For deployment, the "dye-ball moorings" were coiled up anchor-last in PVC tubes with ≈2" of rubber tubing at one end to compensate for the compression of any air bubbles left inside during descent. The rubber tubing was hose-clamped to the PVC and sealed at the other end with a rubber stopper held in place by another hose clamp. Immediately before the dive, each tube was filled with ice-cold water (vegetable oil might work even better) and closed with another rubber stopper (long enough to avoid it being pushed into the PVC tube) with an attached loop to allow the stopper to be removed with the Alvin manipulator.

At Bio-9 we found a suitable vigorous hot (383.6°C) smoker vent with an orifice diameter of ≈5 cm. Upon opening the mooring deployment tube (more than 3 hours after the tubes were filled with water) a thick cloud of fluorescin escaped into the water column. The dye-ball string was placed so that one of the balls rested at a horizontal distance of 10–15 cm from the smoker orifice. After the dye cloud had been advected away by the prevailing current flowing approximately in the direction of Alvin's heading the dye balls continued to release uninterrupted (but irregular) dye streaks for approximately 20 minutes (Figure 20).

Throughout the experiment dye from the balls was sometimes entrained into the buoyant plume (engulfment was directly observed) and sometimes the dye was advected in close proximity past the plume. Whether dye is entrained or not is quite difficult to determine from the video images, at least partially because of the camera angle (downward on the two brow cameras) and the fact that the background flow was away from the observers, which makes upward and forward flow difficult to distinguish. Nearby diffuse hydrothermal sources further complicate the picture. Nevertheless, we got excellent visual images of the flow in close proximity to a vigorous high-temperature vent — a low-resolution video is available on the Science Data Disk 2 in directory `/science/DyeEntrainment`. The two remaining dye-ball moorings were deployed later during the same dive at a vent at Ty/Io. No good images were obtained from that deployment because of a less suitable viewing angle.

All three dye-ball moorings performed perfectly. They were ballasted enough to make deployment easy and stable and they had enough buoyancy to keep them nearly vertical all the time. While it would be difficult to derive quantitative information from an experiment like the one carried out, in terms of flow visualization the experiment was a resounding success.

10 Hydrothermal Vent Meiobenthos (PI: Bright)

[*Monika Bright, Sigrid Katz, Sabine Göllner, Bettina Pflugfelder.*]

The aim of this project is to study the present status of the meiobenthic community (small animals between 32 microns and 1 mm) shortly past eruption and to follow the succession of colonization and development of communities.

In order to get an overview on the present meiobenthic communities, we followed two approaches: natural substrate collections and deployments and recoveries of artificial substrates. The natural substrate collections will be used to estimate the occurrence of meiobenthic species at specific sites and temperatures. These will be compared with the artificial substrate collections for which abundance, biomass, species richness, and several diversity indices will be calculated. The artificial substrates deployed during the response cruise in June 2006 were recovered.

Upon assessment of the present vent and off-axis communities, we chose to concentrate on the following habitats: *Alvinella pompejana* community on black smoker from Bio9, *Tevnia jerichonana* communities from Tica, P-vent, Ty-Io, *Tevnia/Alvinella pompejana* mix community from Tica, empty

tubes of *Riftia pachyptila* and empty shells of *Bathymodiolus thermophilus* communities from East Wall, empty tubes of *Alvinella pompejana* from inactive black smoker Q vent, and peripheral basalt communities from Bio9, Tica, Ty-Io, P-vent, East Wall, Q vent, and at some distance off axis west of Tica (see appendices D.2 and D.3 for details). The Tica, P-vent, and Ty-Io deployments were recovered after a few days in order to study the short term colonization. These were replaced by new artificial substrates. All these artificial substrates will be recovered during the December 2006 cruise (LADDER-2) and then replaced by new substrates that will remain until the end of 2007 (until LADDER-3) for long term studies.

In order to get an overview on the occurrence of dispersal stages of meiobenthic animals, we collected pelagic pump samples a meter above all collection sites (see above) and deployed artificial settlement devices on several of the moorings (Table 5).

In addition, samples for studying the microbial community were also collected. All natural substrate collections were done in collaboration for Stephan Sievert (Woods Hole Oceanographic Institution, USA). All artificial substrate collections were done in collaboration for Markus Weinbauer (CNRS-UPMC, Villefranche-sur-mer, France) in order to estimate the microbial abundance on the artificial substrates.

11 Development, Growth and Cell Kinetic Studies in *Riftia pachyptila* (PI: Bright)

[*Monika Bright, Sigrid Katz, Sabine Göllner, Bettina Pflugfelder.*]

The aim of this project is to study the infection process, growth, and developmental processes in *Riftia pachyptila* symbiosis (giant tubeworms) as well as cell kinetics in symbiont-containing and symbiont-free host tissue.

For studying developmental processes, we recovered tubeworm artificial settlement devices (TASCs) from Ty-Io region, Marker 8/11 deployed during the response cruise June 2006. New TASCs were deployed at *Tevnia jerichona* aggregations at Tica, Ty-Io, and P-vent and are planned to be recovered and replaced by new TASCs during the December 2006 cruise (LADDER-2). Long term deployments of TASCs are planned until the end of 2007 (LADDER-3).

Upon collection of a basalt colonized by *Tevnia jerichonana* and *Riftia pachyptila* from the area Fish Hole, we conducted window labeling incubations using the tymidine analogs Bromodeoxyuridine for cell kinetic studies in 6 specimens of *Riftia.* In addition, 5 specimens of *Tevnia* were fixed for general morphology, ultrastructure, immunocytology and *in situ* hybridization and 20 specimens were fixed for molecular identification of host and symbionts.

12 *Alvinella* Reproduction (PI: Pradillon)

[*Florence Pradillon.*]

During the cruise, I have been focusing on early development and colonization processes of a pioneer organism of high temperature surfaces at vent sites, the polychaete worm *Alvinella pompejana* (Figure 21). The goal of this work is to understand how physo-chemical environmental parameters may influence embryonic and larval life, which would have consequences on dispersal and colonization processes.

Early embryos of *A. pompejana* are sensitive to temperatures prevailing in adult colonies (usually $> 20°C$), and maybe also to sulfide levels. Outside the vent environment, embryonic development

Figure 21: *Alvinella pompejana.* Upper panel: Specimen after collection. Lower panel: Incubation and Colonization experiment with TRAC at Bio9 (Alvin Dive #4269).

is arrested by low abyssal temperature (1.8°C), and low pressure prevailing near the surface does not allow normal development. Development would then be restricted to the deep-sea, in areas with moderate hydrothermal influence. This leaves the possibility for embryos to disperse between vents, in an arrested state. However, ultimately, juveniles will colonize the hot environment, and have to be able to cope with high temperatures and high sulfide levels. Other factors than temperature might actually limit development of embryos, like sulfide levels at vent sites, or pressure variations during dispersal through the water column.

Date (2006)	Dive	Time (GMT)	site	X	Y	Lat (N)	Long (W)	depth (m)	Action
11/1	4260	19:43	Ty&Io	4672	77616	9:50.11	104:17.45	2505	Alv. collection
11/2	4261	18:35	Bio9	4619	77983	9:50.31	104:17.48	2511	Alv. collection
11/3	4262	17:33	Ty&Io	4670	77617	9:50.11	104:17.45	2505	Alv. collection
11/4	4263	19:25	Tica	4589	78166	9:50.41	104:17.50	2507	Depl. TRAC 1
11/4	4263	19:39	Tica	4589	78167	9:50.41	104:17.50	2510	Depl. TRAC 2
11/4	4263	19:47	Tica	4583	78169	9:50.41	104:17.50	2510	Depl. TRAC 3
11/7	4266	17:43	Bio9	4592*	77970*	9:50.30*	104:17.49*	2508	Alv. collection
11/7	4266	19:16	Bio9	4590*	77978*	9:50.30*	104:17.49*	2509	Alv. collection
11/8	4267	18:33	Tica	4586	78165	9:50.41	104:17.50	2510	Recovery TRAC 3
11/8	4267	18:42	Tica	4586	78165	9:50.41	104:17.50	2510	Recovery TRAC 2
11/8	4267	18:48	Tica	4586	78165	9:50.41	104:17.50	2507	Recovery TRAC 1
11/9	4268	17:16	Bio9	4612	77988	9:50.31	104:17.48	2509	Alv. collection
11/10	4269	16:59	Bio9	4607	77982	9:50.31	104:17.49	2508	Depl. TRAC 2
11/12	4271	20:30	PBR600	10286	39165	9:29.25	104:14.39	2553	1 Alv. collected
11/13	4272	16:41	K Vent	10109	40050	9:29.73	104:14.48	2558	Alv. collection
11/14	4273	16:07	Tica	4588*	78165*	9:50.41*	104:17.50*	2510	Depl. TRAC 1
11/14	4273	16:34	Tica	4592*	78160*	9:50.40*	104:17.49*	2511	Depl. TRAC 3

Table 9: *Alvinella* collection and deployment sites. *: renav XY could not be corrected.

Two main strategies were used during the cruise:

1. *In situ* experiments using small devices (TRAC: Titanium Ring for Alvinellid Colonization, Figure 21) equipped with sensors (temperature and pH monitoring) were deployed at vent sites to analyze early development and larval colonization in relation to local environmental conditions. These devices served as support for colonization surfaces (made of aquarium filter wool) and incubators containing embryos obtained by *in vitro* fertilization.

2. *In vitro* development experiments were conducted on board in pressure vessels (PICCEL & PIRISM: Pressure Incubators for the Culture of Cells, Embryos and Larvæ, & PICCEL Related Imaging System) to analyze sensitivity of early embryos at different pressure levels.

Alvinella colonies were sampled 6 times during Alvin dives using a water tight insulated collection box and 2 series of 3 TRACs were deployed (Table 9). One of the series was recovered during the cruise after short-term deployment (4 days). The second series (deployment on the 10 and 14 of November) will be incubated for about 30–40 days and be recovered during the LADDER-2 cruise.

As a general observation, all *Alvinella* colonies sampled were mainly composed of *A. pompejana.* The sister species *A. caudata,* that may co-occur with *A. pompejana* was only rarely observed. Other species in *Alvinella* samples were *Hesiolyra bergi, Nodopelta sp.* and copepods (occasionally *Lepidonotopodium,* amphipods, *Paralvinella grasslei). A. pompejana* individuals were found to be of a whole range of sizes, from individuals of less then 1 mm S4 width (4th setigerous segment width used as an index of size in Alvinellids) up to 8.5 mm S4. Maximal size observed in *A. pompejana* (12 mm S4) was never found in the samples. This observation, and the fact that all *Alvinella* sites at 9°50′N are rapidly growing spires not yet very solid, with only a thin coverage of *Alvinella* tubes suggest that all these colonies are rather young and might be mostly due to post-eruption recolonization. In all samples, females above 6 mm S4 were found to be reproductive.

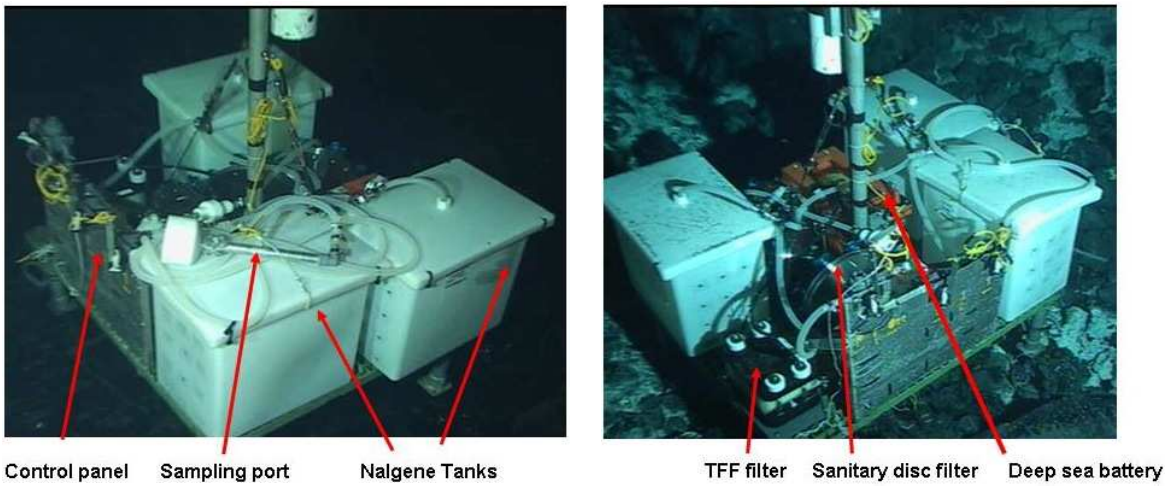

Figure 22: Elevator used for microbial vent sampling. Left panel: collection tanks, sampling port and control panel and arms. Right panel: TFF filtration apparatus, one of the sanitary disc membrane housings and deep-sea battery.

13 Microbial Vent Sampling (PI: Williamson)

[*Shannon Williamson.*]

13.1 Summary

The objective of this project was to size fractionate large volumes of hydrothermal diffuse-flow vent water through in-situ filtration at depth in order to collect enough prokaryote and viral biomass to create whole genome shotgun libraries for DNA sequencing. The water sampler (Figure 22) was assembled on an elevator platform and included the following pieces of equipment:

- One Deep Sea Battery.
- One two-gallon carboy fitted with a 20μm Nytex pre-filter.
- Three stainless steel sanitary disc holders housing 3.0μm, 0.8μm and 0.1μm Supor membrane filters respectively.
- One Pellicon tangential flow filtration (TFF) housing fitted with a 50kDa maxi-cassette.
- Three high-density polyethylene Nalgene tanks (57 L each) housing three Tedlar gas-impermeable bags respectively.
- One control panel with two CTD pumps, one magnetic switch and three tri-directional valves with one control arm respectively.
- One sampling port.
- One homer probe.

The sampler was deployed via crane over the starboard side of the R/V Atlantis on three occasions at ≈6:30 AM. Two diffuse-flow vent samples were collected and one off-axis sample. The DSV Alvin was used to locate the sampler and position it at some point in the dive within an area of diffuse-flow water (20–70°C). Once the sampling port was positioned, the pilot would purge the collection lines for two minutes by moving the main control arm from the "off" position to the "purge" position. After purging, the main control arm was moved to the "fill" position. At this point Alvin was free to leave the sampler and diffuse-flow water flowed sequentially through the 20μm pre-filter and the 3.0μm, 0.8μm and 0.1μm impact filters until a series of secondary control valves were turned by Alvin either the following morning (as for the first two diffuse-flow samples) or later in the dive (as for the last off-axis sample).

The 0.1μm filtrate, containing the viral fraction, was collected into three 70L Tedlar bags housed in the Nalgene tanks. Once the two secondary control valves were turned from their "off" positions to their working positions, water was drawn from these bags and circulated through the TFF filter for approximately three hours. TFF filtration effectively concentrated the volume of viral concentrate from ≈210L to ≈10L in-situ. Once concentration was complete, the sampler was released to the surface via an acoustic signal.

The sampler was recovered on-board where samples were further processed. Supor membrane filters were removed from their housings. One eighth of each filter was sliced with a sterile razor blade, folded and placed in a 15cc conical tube containing ≈10ml of the RNA preservative RNA-Later. Samples for RNA extraction and cDNA library construction were frozen at −70°C. The remainder of each filter was folded and placed in separate seal-a-meal bags containing ≈10ml buffer to protect against nucleases. Bags were sealed and frozen at −70°C. Approximately 20 ml of ambient raw water (unfiltered) was placed in duplicate acid-washed scintillation vials and frozen at −70°C for nutrient analysis. Twelve ml of raw water was placed in six 15 cc tubes, preserved with filtered formalin (1% final concentration) and frozen at −70°C for ambient prokaryote and viral counts. Thirty ml of raw water was removed to eight 50cc foil-wrapped tubes for duplicate prophage induction experiments (2× treatment and 2× control for each experiment). The DNA mutagen Mitomycin C was added to treatment tubes at a final concentration of 0.5μg/ml. All tubes were incubated statically at room temperature for 24 hrs. Glycerol was added to each tube at the end of the experiment (10% final concentration) and all tubes were frozen at −70°C for enumeration of prokaryotes and viruses. The viral fraction was further concentrated from ≈10 L to ≈200 ml on-board using a 30kDa TFF filter. Glycerol was added to the final viral concentrate (10% final concentration) and it was frozen at −70°C.

Upon return to the lab, DNA will be extracted primarily from the 0.1μm size-fraction filter (containing the majority of prokaryotes) and the viral concentrates from one of the diffuse-flow samples and the off-axis sample. Small insert whole genome shotgun libraries will be created from both prokaryote and viral DNA. Approximately 5,000 lanes per library will be sequenced (20,000 total) at the Joint Technology Center (J. Craig Venter Institute) in Rockville, MD. Sequences will be assembled via the Celera Assembler, open reading frames (ORFs) will be predicted, and predicted ORFs will be annotated based on comparison to sequences within public databases. cDNA libraries will be created initially from RNA-preserved 0.1μm filters. The level of sequencing for cDNA libraries is to be determined in the future. Samples preserved for ambient counts and prophage inductions will be enumerated via epifluorescent microscopy. Nutrient samples will be sent to University of Maryland's Horn Point Laboratory for analysis.

13.2 Details of each sample collection

Sample #1: Two-day deployment

- Deployed sampling instrument at a site along the East Pacific Rise known as "Tica" (X = 4383; Y = 78262).
- Placed sampling port in a bacterial mat where diffuse flow water was ≈24°C (ambient = 2°C). Water smelled heavily of sulfur.
- Volume of water sampled in-situ at ≈2500 m depth through 3.0μm, 0.8μm and 0.1μm impact filters = ≈2000L.
- Volume of 0.1μm filtrate (viral fraction) concentrated in-situ via TFF ≈210L.
- Raw water (unfiltered) was preserved for bacterial/archaeal and viral ambient counts.
- Raw water was reserved for nutrient analysis.
- 1/8 of each impact filter was preserved in RNA later for RNA extraction and cDNA library construction.
- Remainders of filters were placed in seal-a-meal bags with appropriate buffer. Significant biomass on filters (all three).
- Prophage induction experiments were conducted on raw water over 24 hrs.
- Viral concentrates were glycerol preserved.
- All samples were frozen at −70°C.

Sample #2: Two-day deployment

- Deployed sampling instrument at a site along the East Pacific Rise known formerly as "Fish Hole" (X = 4568; Y = 77968).
- Placed sampling port in a bacterial mat where diffuse flow water was ≈26°C (ambient = 2°C). Water smelled heavily of sulfur.
- Volume of water sampled in-situ at ≈2500 m depth through 3.0μm, 0.8μm and 0.1μm impact filters = ≈2095L.
- Volume of 0.1μm filtrate (viral fraction) concentrated in-situ via TFF ≈210L.
- Raw water (unfiltered) was preserved for bacterial/archaeal and viral ambient counts.
- Raw water was reserved for nutrient analysis.
- 1/8 of each impact filter was preserved in "RNA Later" for RNA extraction and cDNA library construction.
- Remainders of filters were placed in seal-a-meal bags with appropriate buffer. Significant biomass on filters (all three).
- Prophage induction experiments were conducted on raw water over 24 hrs.
- Viral concentrates were glycerol preserved.
- All samples were frozen at −70°C.

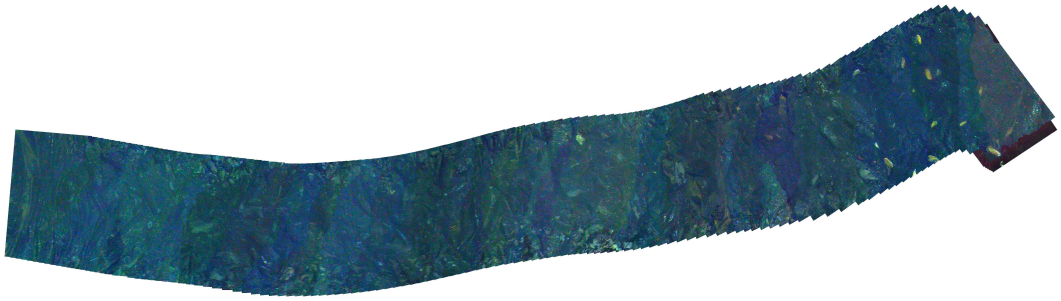

Figure 23: Transect mosaic during Dive 4262, showing mussel shells encountered south of Choo Choo.

Sample #3: One-day deployment

- Deployed sampling instrument at a site north of the East Pacific Rise at an off-axis location for comparison against vent samples. Placed just outside of "K" vent (X = 10088; Y = 40067).
- Placed sampling port in ambient water (≈2°C).
- Volume of water sampled in-situ at ≈2500 m depth through 3.0μm, 0.8μm and 0.1μm impact filters = ≈300L.
- Volume of 0.1μm filtrate (viral fraction) concentrated in-situ via TFF ≈210L.
- Raw water (unfiltered) was preserved for bacterial/archaeal and viral ambient counts.
- Raw water was reserved for nutrient analysis.
- 1/8 of each impact filter was preserved in "RNA Later" for RNA extraction and cDNA library construction.
- Remainders of filters were placed in seal-a-meal bags with appropriate buffer.
- Prophage induction experiments were conducted on raw water over 24 hrs.
- Viral concentrates were glycerol preserved.
- All samples were frozen at −70°C.

14 Video Mosaics (PIs: Rzhanov & Beaulieu)

[*Yuri Rzhanov, Stace Beaulieu, Ryan Jackson.*]

14.1 Summary

During the LADDER-1 cruise AT15-12, the Alvin Video Mosaicking Software Suite (ALVIMOS) underwent the first field trial. Figures 23 and 24 show example mosaics. Alvin pilots and science observers were instructed in how the arm 3-chip camera and external lights should be positioned during transects to guarantee the highest possible quality of acquired video. After each dive the

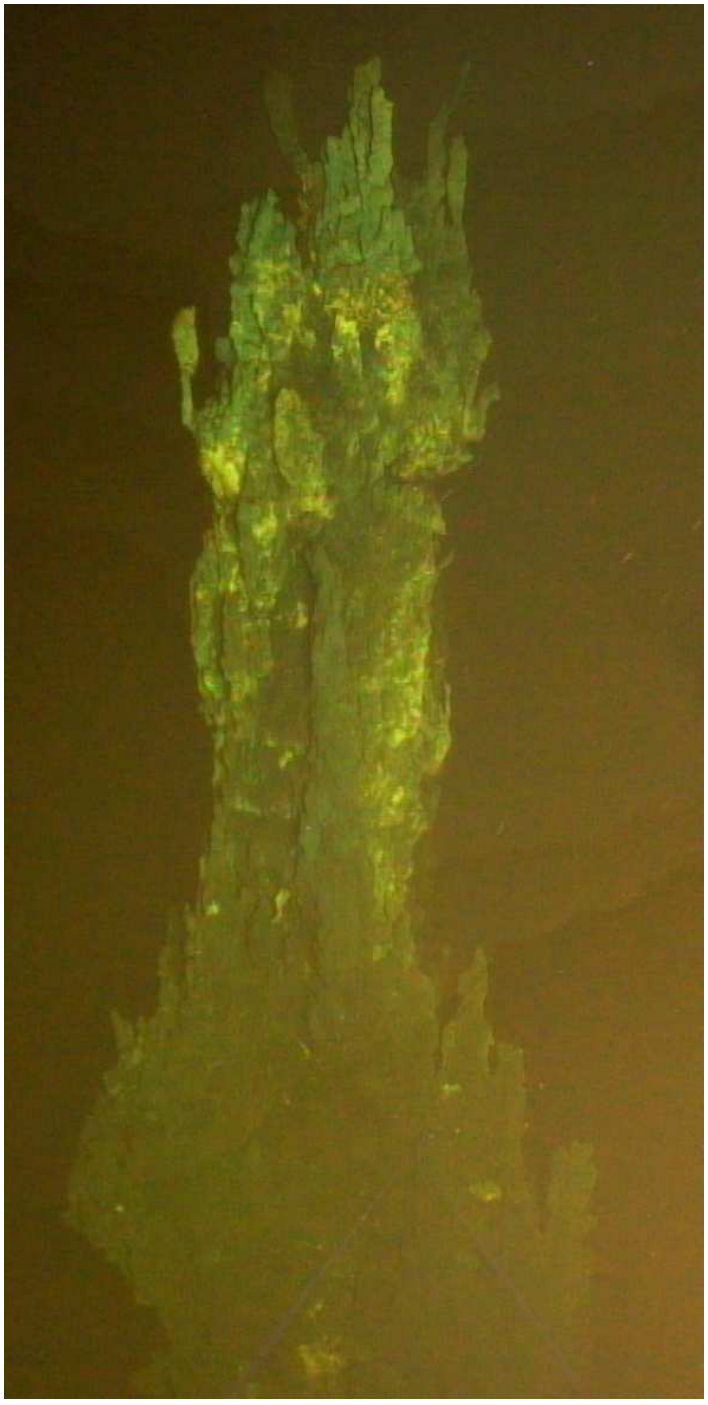

Figure 24: Panorama mosaic of newly discovered PBR600 vent (Dive 4271).

recorded DVL and LBL navigation data were re-processed to obtain a re-navigated dive track with 1-Hz resolution. This track constitutes one of the inputs for the ALVIMOS software. Working with Ryan Jackson (WHOI), we successfully re-navigated 10 of the 15 dive tracks. We automatically processed video mosaics from DVCAM tapes for 6 of these 10 dives. Only one of the dives, Dive 4264, had problems with the timecode in the DVCAM tapes, preventing our automated processing. Results for automated processing of entire 2-hr dive tapes ranged from 42–98% (median 68%) useful mosaics, with "bad" mosaics generally due to switching cameras while working at vent sites. For other dive tapes, we targeted specific time intervals noted in dive reports as video transects. This targeted automated processing yielded a range of 50–89% (median 76.5%) useful mosaics, with "bad" mosaics generally due to altitude and turbidity. As one of the main objectives for this cruise, we completed a version of the ALVIMOS User Manual and tested sections of the manual on 2 science users. We also were able to use ArcGIS to overlay the georeferenced mosaics on the dive tracks.

14.2 Details

After the duplication of DVCAM video tapes, first copies were used for extraction of video frames essential for creation of mosaics. These frames were then processed, sequentially registered, combined in mosaics and saved on a computer hard drive as images in TIFF format with geo-referenced tags (GeoTIFFs). All the above processing was performed automatically, and the operator's intervention was needed only for handling a DVCAM player and substituting file names in a prepared batch file (ALVIMOS is a collection of console programs).

Once the mosaics are built, the operator is needed to look through the TIFFs, identify featureless and garbled (due to e.g. improper camera positioning, sediment in water column, objects moving in the field of view, etc.) mosaics and delete them. Occasionally, the operator's intervention was needed for manual correction of registration records. Analysis of situations when automatic techniques failed to produce correct record shows that it happens under one of the following conditions:

1. Camera has been manually operated by Alvin pilot or an observer such that it stops showing seafloor, or has been zoomed in, so that overlap between the consecutive extracted frames drops below the threshold that guarantees robust registration. (Note that the frames for extraction are determined on the basis of vehicle altitude and speed, and we assume that the camera is fully zoomed out.)

2. Sudden change in distance from the camera to the scene forces overlap to drop below the robust threshold.

3. Motion in the field of view (Alvin manipulator, suspended particles in the water column, etc.) does not allow estimation of the change between the consecutive frames in terms of rigid affine transformation model.

4. Scenery has comparatively strong features that move with the vehicle (for example, laser beams used for scale estimates). Note that if the seafloor has pronounced texture, laser beams do not hinder the registration process, and although the beams are visible in a final mosaic, it appears to be of a reasonable quality.

Occasionally, the failure was indicated by the verification process, when registration results were compared to navigation data. It has been found that this occurs under the following circumstances:

1. Re-navigation processing oversmooths the vehicle track, while the vehicle was in fact following a more complex trajectory which was reflected in the captured frames.

2. The vehicle has been following the right turn, and the camera (which is mounted on the starboard side) did not reflect the actual translation, indication only rotation, thus showing the discrepancy between the DVL speed and the speed inferred from the imagery.

Most of the time the operator did not need to browse through the registration records to find a failure: these failures were self-evident from the observation of final mosaics. Mis-registrations were manually corrected, and these particular mosaics re-created.

Some of the interesting mosaics (with a rich complex texture) were re-created in full resolution. Detailed instructions for this procedure were compiled in the User Manual. Color was not helpful in most of the cases, because the imagery was essentially dark and required detrending, which distorted the palette. Different frames had different distortions, so that final mosaics had apparent seams separating contributions from frames.

Not all the dives were used for acquisition of video suitable for mosaicking — in some cases the altitude of the vehicle was too high for the adequate imagery (>3 meters); some dives were devoted to deployment and collection of sampling equipment. On average, each dive produced about 100 mosaics ($\approx$1500 m total transect), with 75% of them assessed as adequate, each mosaic covering approximately $2.5\,\mathrm{m} \times 15\,\mathrm{m} \approx 37.5\,\mathrm{m}^2$.

During the cruise we compiled a User Manual for ALVIMOS, which, in conjunction with the detailed Program Reference Guide, should constitute a good starting point for a complete novice wishing to process Alvin video imagery. These documents, the ALVIMOS program executables, and a number of computer packages from the public domain, which are useful for troubleshooting and visualization, have been compiled and written on a DVD for the next cruise.

Processing of a dive video consists of 4 stages, described in detail in the User's Manual. The first stage is a processing of a re-navigated data and takes $\approx$5 min on a PC (Pentium processor 3.4 GHz). The second stage is grabbing video frames from DVCAM player, which is done in real time, i.e. takes as much time as playing the video (2 hours per tape). The third stage is the pre-processing and pair-wise registration of consecutive frames in extracted segments. This stage is the most time-consuming, and most of this work was done automatically overnight. The fourth stage is building of mosaics from pre-processed imagery and registration records, which typically takes around one hour. After that, manual assessment of the results and removal of useless and garbled mosaics takes another thirty minutes.

14.3 Future Plans

Video mosaics in a GIS context provide researchers with a broader view of geological formations and mutual positioning of experimental sites. Although mosaics may not be aligned perfectly well between each other, when hundreds of them are positioned on a map, they assist in better understanding of large-scale inter-relationships. We propose to create and maintain a database of all constructed video mosaics which will be available for researchers for dive-planning.

Additionally, comparison of mosaics constructed from the imagery collected prior to and after cataclysmic events (like the eruption at 9N EPR in January 2006) will allow for better understanding of event consequences and interpretation of their scenarios.
Rough estimate of the database characteristics:
Assuming that:

- we would be able to re-process video acquired since 2002 (when re-navigation software was first introduced)
- around 100 dives per year

- 100 mosaics per dive
- each mosaic covers $\approx 35\,\mathrm{m}^2$
- each GeoTIFF representing a mosaic takes $\approx$ 2 Mb

The database will require $4 \times 100 \times 100 \times 2 = 80000\mathrm{Mb} = 80\mathrm{Gb}$ of storage, with 20 Gb being added every year. Total coverage of the seafloor will be $4 \times 100 \times 100 \times 35\mathrm{m}^2 = 1400000\mathrm{m}^2$, which is equivalent to a square $1.2 \times 1.2\mathrm{km}^2$, with $0.35\mathrm{km}^2$ being added every year. *Note: without review of past dive tracks and corresponding video it is difficult to estimate actual extent of coverage.*

15 Extreme4Kids

[*Monika Bright, Andreas Laschober.*]

extreme 4 kids is an Austria-wide program for students between 6 and 16 years of age, and classrooms of all types initiated by Monika Bright and funded by the Science Communication Award 2006 by the Austrian Science Foundation. *extreme 4 kids* is an interactive, multidisciplinary program designed to spark students' curiosity about science. This program uses multimedia techniques to educate students about the largest habitat on Earth: the deep sea and its fascinating hydrothermal vents. Teachers can adapt the program to meet the needs of their specific school grades, and to conduct the program during project weeks in class. A folder and a live webpage (`www.hydrothermalvent.com`) are offered. *extreme 4 kids* focuses on all aspects of marine biology, oceanography, volcanism, the Earth, and hydrothermal vents. Since hydrothermal vent communities are based on chemosynthesis and chemosynthetic symbiosis, especially prominent symbiosis such as the giant tubeworm, mussel, clam, and shrimp symbiosis are a strong part of this program. Also highlighted are: ship and submersible technology, descriptions of life on a ship, and an introduction of ocean-related careers such as seaman, captain, or steward. The program also includes an artistic component. The program ran successfully through the length of the entire cruise between 25 October and 15 November and included a daily log, experiments conducted during the cruise, an open invitation for questions that where answered and published online, a competition for science and art projects, and a phone call to the deep including 8 school from Austria and Germany being able to directly be in contact with Alvin while diving and the ship.

A Cruise Participants

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Andreas	Laschober	
Shannon	Williamson	SWilliamson@venterinstitute.org
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B Science Data DVDs

The LADDER-1 science data are stored on 3 DVDs, each of which has a file `Diskinfo.txt`, which contains additional information:

Alvin Data: One directory per dive with Alvin underway data (navigation, etc.), frame-grabber images, and top-lab data. Handheld still-camera images are found in a separate directory tree under `pictures`. Data directories of instruments that were not used are empty (e.g. `magnetometer`). The `CTD` subdirectories on this DVD are empty — Alvin CTD data (as well as Alvin renavigation) can be found on Science Data Disk 2.

Science Data Disk 1: Shipboard ADCP (OS75); Atlantis underway data (date, time, depth, heading, speed, GPS, meteorology, SST/SSS, fluorometer); cruise-participant photographs; SBE 911 (main CTD) raw data; documentation & scripts.

Science Data Disk 2: All data residing in the `science` subdirectory during the cruise: Alvin dive plans, dive reports & sampling procedures; dye-entrainment movie; GIS mooring maps; Alvin DVL navigation of mooring deployments; mooring slant-range surveys; SBE 911plus CTD processed; Alvin SBE19 CTD; LADCP; CTD & LADCP logsheets; Diane Adams' CM data; tidal prediction; misc. photographs; sediment traps; Imagenex renavigation processing.

Additionally, there are external-camera video DVDs (usually 6 per dive), 5 DVDs containing the images taken with the external still camera (3 dives per DVD), one DVD containing the videos taken with the handheld camera, and a CD containing the raw navigation data.

C Dives & Operations

Date	Dive	Dive Location	Divers	Day Ops	Night Ops
Oct 30		no dive		depl. nav. net, CTD 1	depl. WF mooring; CTD 2–3
Oct 31	4259	K vent	Thurnherr McCarthy (PIT)		depl. pumps L1 & L2; CTD 4
Nov 1	4260	Ty&Io, Mkr 8/11, Mkr 141	Bright Strasser	rcvr sed. trap R2	CTD 5–6
Nov 2	4261	P-vent, Tica, East Wall, Biovent	Beaulieu Kohli	rcvr pumps L1 & L2	CTD 7–9
Nov 3	4262	P-vent, Choo-Choo	Mullineaux Pflugfelder	rcvr sed. trap R1	depl. sed. trap L1 & NA mooring; CTD 10–11
Nov 4	4263	Ty&Io, Tica	Pradillon Jackson		depl. pumps L3 & L4; CTD 12
Nov 5	4264	Tica, off-axis	Göllner McCarthy (PIT)		CTD 13–15
Nov 6	4265	Q, M, Riftia Field, E. Wall & Tica	Bright Terenzi	depl. elevator; rcvr pumps L3 & L4	CTD 16–18
Nov 7	4266	Tica, Bio9, P vent & Ty&Io	Thurnherr García Berdeal	rcvr elevator	depl. pumps L5 & L6; CTD 19
Nov 8	4267	Riftia Field, Tica	Mullineaux Worrilow		depl. sed. trap L2 & CA mooring; CTD 20
Nov 9	4268	P vent, Bio9, Q and M vents, Biovents, 2in1	Bright Guan	depl. elevator; rcvr pumps L5 & L6	CTD 21–23
Nov 10	4269	Bio9, P vent, Marker 5, Ty&Io, off axis	Beaulieu Kelley (PIT)	rcvr elevator	depl. pumps L7 & L8; CTD 24
Nov 11	4270	K vent	Mullineaux Williamson		CTD 25–27
Nov 12	4271	tracer injection, K vent & PBR600	Jackson Guest	rcvr pumps L7 & L8	depl. W1/W2 moor.; depl. tracer float; CTD 28–29
Nov 13	4272	K vent	Pradillon Katz	depl. & rcvr elevator	depl. SA mooring; CTD 30–31
Nov 14	4273	Tica, East Wall, off axis	Beaulieu Hogue		CTD 32–34
Nov 15		no dive (weather)		CTD 35–36	steam to Manzanillo

D Meta Data

Note: The following are condensed versions of the metadata forms submitted to the Ridge2000 data office.

D.1 CTD Stations

Sta. No.	Date in 2006	Time (UTC)	Site	Lat deg	Lat min	Lon deg	Lon min	Max CTD depth (m) from file	HAB* (m)	No. of salinity samples
1	10/30	22:03	WF	9	26.5984	-104	32.3996	2881		8
2	10/31	04:09	WF	9	26.9964	-104	32.3891	2893		8
3	10/31	07:47	W3	9	27.7005	-104	28.0000	3009	15	8
4	11/1	10:08	NA	9	50.0074	-104	17.5312	2502	4	8
5	11/2	05:32	EF	9	33.5001	-103	52.3006	2988	10	8
6	11/2	11:20	NA	9	50.8382	-104	17.2924	2512	5	8
7	11/3	02:08	E3	9	32.5001	-103	58.0023	169		0
8	11/3	02:35	E3	9	32.5007	-103	58.0001	3018	9	8
9	11/3	07:17	E2	9	31.5004	-104	4.6998	3096	6	8
10	11/4	07:41	NW	9	53.0147	-104	20.4902	2833	13	6
11	11/4	10:56	NA	9	50.0172	-104	17.3326	2473		7
12	11/5	07:50	CA	9	29.9880	-104	14.4847	2535	30	8
13	11/6	01:29	W1	9	29.8012	-104	19.8363	2758	25	6
14	11/6	04:41	CA	9	30.0007	-104	14.5028	2540	30	6
15	11/6	07:30	E1	9	30.7997	-104	10.0021	2779	30	8
16	11/7	00:53	W1	9	29.8000	-104	19.7600	2766	25	8
17	11/7	03:56	W2	9	28.5000	-104	23.7000	3008	25	8
18	11/7	07:04	W3	9	27.6900	-104	27.9970	3000	30	8
19	11/8	03:44	N2	9	40.0400	-104	15.6600	2511	30	8
20	11/9	08:16	E1	9	30.7559	-104	10.0070	2782	30	8
21	11/10	01:10	W2	9	28.5045	-104	23.7009	2990	30	8
22	11/10	04:13	W3	9	27.7001	-104	28.0011	3002	30	8
23	11/10	06:16	N1	9	35.0011	-104	15.1002	2515	30	8
24	11/11	09:38	E2	9	31.4900	-104	4.7000	3094	20	8
25	11/12	01:55	E3	9	32.5000	-104	57.9990	3019	25	8
26	11/12	06:08	N1	9	34.9700	-104	15.1000	2515	30	8
27	11/12	09:17	N3	9	45.0000	-104	16.5100	2497	30	8
28	11/13	08:05	W1	9	30.0001	-104	19.7996	2748	50	0
29	11/13	10:32	CA	9	29.7213	-104	14.5091	2516	46	5
30	11/14	04:19	SA	9	9.0046	-104	12.6696	2567	24	8
31	11/14	09:50	N2	9	40.0084	-104	15.8824	2500	32	8
32	11/15	02:18	EF	9	33.4888	-104	52.2915	2974	35	8
33	11/15	07:25	N3	9	44.9623	-104	16.5078	2499	31	7
34	11/15	10:12	N2	9	40.0054	-104	15.6672	2499	42	8
35	11/15	14:23	S1	9	25.0011	-104	13.8008	2539	43	0
36	11/15	16:22	S1	9	25.0000	-104	13.8000	2534	50	8

CTD/LADCP casts. *HAB is the height above bottom from either the altimeter read on the fly or from the Knudsen Precision Depth Sounder, read from the graph. Neither is very accurate. In some cases the HAB is not recorded. The altimeter did not always work well due to interference from the LADCP. The HAB can always be determined to within a few m from the LADCP data.

D.2 Instrument Deployments

Note: The following table has been split in two. Use first column to correlate the data on pp. 52–53 with the data on pp. 54–55. Grid positions marked with asterisks are not re-navigated.

	Instrument Type	Mooring ID	Instrum. S/N	Action	Dive	Date	Time *(UTC)*	Location method
1	RDI ADCP		1804	Dep.	4259	2006-10-30	18:29	transponder
2	RCM-11	WF	345	Dep.	n/a	2006-10-30	02:00	surveyed-in
3	RCM-11		158	Dep.	n/a	2006-10-30	02:00	surveyed-in
4	RCM-11		369	Dep.	n/a	2006-10-30	02:00	surveyed-in
5	Sedim. Trap	EF	12055-02	Dep.	n/a	2006-11-01	04:00	surveyed-in
6	RCM-11		370	Dep.	n/a	2006-11-01	04:00	surveyed-in
7	RCM-11		150	Dep.	n/a	2006-11-01	04:00	surveyed-in
8	RCM-11		152	Dep.	n/a	2006-11-01	04:00	surveyed-in
9	RCM-11	NA	161	Dep.	n/a	2006-11-03	00:53	Alvin
10	Sedim. Trap		12055-03	Dep.	n/a	2006-11-03	00:53	Alvin
11	RCM-11		154	Dep.	n/a	2006-11-03	00:53	Alvin
12	RCM-11		366	Dep.	n/a	2006-11-03	00:53	Alvin
13	RCM-11	CA	155	Dep.	n/a	2006-11-08	04:12	transponder
14	Sedim. Trap		12055-01	Dep.	n/a	2006-11-08	04:12	transponder
15	RCM-11		339	Dep.	n/a	2006-11-08	04:12	transponder
16	RCM-11		371	Dep.	n/a	2006-11-08	04:12	transponder
17	RCM-11	SA	368	Dep.	n/a	2006-11-13	01:40	GPS
18	RCM-11		163	Dep.	n/a	2006-11-13	01:40	GPS
19	RCM-11		157	Dep.	n/a	2006-11-13	01:40	GPS
20	Profiler Moor.	P1	102	Dep.	n/a	2006-11-12	01:40	ranged
21	Profiler Moor.	P2	119	Dep.	n/a	2006-11-12	06:29	ranged
22	Sedim. Trap	R1	11649-07	Rec.	4262	2006-11-02	18:00	Alvin
23	RCM-11		373	Rec.	4262	2006-11-02	18:00	Alvin
24	Sedim. Trap	R2	11649-08	Rec.	4260	2006-10-31	18:10	Alvin
25	Sedim. Trap L1	L1	11649-08	Dep.	n/a	2006-11-03	05:55	Alvin
26	RCM-11		367	Dep.	n/a	2006-11-03	05:55	Alvin
27	Sedim. Trap L2	L2	11649-07	Dep.	n/a	2006-11-07	02:27	Alvin
28	RCM-11		373	Dep.	n/a	2006-11-07	02:27	Alvin
29	Pump	PumpL1	9660	Dep.	n/a	2006-10-31	04:15	Alvin
30	Pump		9660	Rec.	n/a	2006-11-01	19:23	Alvin
31	Pump		2114	Dep.	n/a	2006-10-31	04:15	Alvin
32	Pump		2114	Rec.	n/a	2006-11-01	19:23	Alvin
33	Pump	PumpL2	9664	Dep.	n/a	2006-10-31	08:37	transponder
34	Pump		9664	Rec.	n/a	2006-11-01	16:59	transponder
35	Pump		2115	Dep.	n/a	2006-10-31	08:37	transponder
36	Pump		2115	Rec.	n/a	2006-11-01	16:59	transponder
37	Pump	PumpL3	9660	Dep.	n/a	2006-11-03	22:57	Alvin
38	Pump		9660	Rec.	n/a	2006-11-05	19:00	Alvin
39	Pump		2115	Dep.	n/a	2006-11-03	22:57	Alvin
40	Pump		2115	Rec.	n/a	2006-11-05	19:00	Alvin
41	Pump	PumpL4	9664	Dep.	n/a	2006-11-04	02:49	surveyed-in
42	Pump		9664	Rec.	n/a	2006-11-05	16:55	surveyed-in

	Instrument Type	Mooring ID	Instrum. S/N	Action	Dive	Date	Time *(UTC)*	Location method
43	Pump		7452	Dep.	n/a	2006-11-04	02:49	surveyed-in
44	Pump		7452	Rec.	n/a	2006-11-05	16:55	surveyed-in
45	Pump	PumpL5	9660	Dep.	n/a	2006-11-07	03:00	Alvin
46	Pump		9660	Rec.	n/a	2006-11-08	18:34	Alvin
47	Pump		2114	Dep.	n/a	2006-11-07	03:00	Alvin
48	Pump		2114	Rec.	n/a	2006-11-08	18:34	Alvin
49	Pump	PumpL6	2115	Dep.	n/a	2006-11-07	07:27	transponder
50	Pump		2115	Rec.	n/a	2006-11-08	16:09	transponder
51	Pump		9664	Dep.	n/a	2006-11-07	07:27	transponder
52	Pump		9664	Rec.	n/a	2006-11-08	16:09	transponder
53	Pump	PumpL7	9660	Dep.	n/a	2006-11-10	04:10	Alvin
54	Pump		9660	Rec.	n/a	2006-11-11	18:38	Alvin
55	Pump		2114	Dep.	n/a	2006-11-10	04:10	Alvin
56	Pump		2114	Rec.	n/a	2006-11-11	18:38	Alvin
57	Pump	PumpL8	9664	Dep.	n/a	2006-11-10	07:37	transponder
58	Pump		9664	Rec.	n/a	2006-11-11	17:27	transponder
59	Pump		2115	Dep.	n/a	2006-11-10	07:37	transponder
60	Pump		2115	Rec.	n/a	2006-11-11	17:27	transponder
61	Elevator		n/a	Dep.	n/a	2006-11-05	12:30	Alvin
62	Elevator		n/a	Rec.	n/a	2006-11-06		Alvin
63	Elevator		n/a	Dep.	n/a	2006-11-08	12:30	Alvin
64	Elevator		n/a	Rec.	n/a	2006-11-09	21:18	Alvin
65	Elevator		n/a	Dep.	n/a	2006-11-12	12:30	Alvin
66	Elevator		n/a	Rec.	n/a	2006-11-12		Alvin
67	Benchmark		L1	Dep.	4259	2006-10-30	17:05	Alvin
68	Benchmark		L2	Dep.	4266	2006-11-06		Alvin
69	Benchmark		L-O	Dep.	4269	2006-11-09		Alvin
70	Benchmark		L-R	Dep.	4267	2006-11-07	18:16	Alvin
71	Benchmark		L-S	Dep.	4269	2006-11-09		Alvin
72	Benchmark		L-T	Dep.	4270	2006-11-10		Alvin
73	Hobo		L-01	Dep.	4269	2006-11-09		Alvin
74	Hobo		L-02	Dep.	4269	2006-11-09		Alvin
75	Hobo		L-03	Dep.	4261	2006-11-01		Alvin
76	Hobo		L-04	Dep.	4261	2006-11-01		Alvin
77	Hobo		L-05	Dep.	4261	2006-11-01		Alvin
78	Hobo		L-06	Dep.	4267	2006-11-07		Alvin
79	Hobo		L-07	Dep.	4267	2006-11-07		Alvin
80	Hobo		L-08	Dep.	4267	2006-11-07		Alvin
81	Hobo		L-09	Dep.	4272	2006-11-12		Alvin
82	Hobo		L-10	Dep.	4270	2006-11-10		Alvin
83	Hobo		L-11	Dep.	4270	2006-11-10		Alvin

	Grid X *(m)*	Grid Y *(m)*	Depth *(m)*	Water depth	Location description	Contact Person
1	10087	40498	2567		On-axis 9N30	AT
2	-22535	34322	2450	2915	West flank 9N30	AT
3	-22535	34322	2550	2915	West flank 9N30	AT
4	-22535	34322	2900	2915	West flank 9N30	AT
5	50800	46248	2000	2990	East flank 9N30	AT
6	50800	46248	2450	2990	East flank 9N30	AT
7	50800	46248	2550	2990	East flank 9N30	AT
8	50800	46248	2900	2990	East flank 9N30	AT
9	4695	77384	2450	2506	On-axis 9N50	AT
10	4695	77384	2475	2506	On-axis 9N50	AT
11	4695	77384	2500	2506	On-axis 9N50	AT
12	4695	77384	2518	2506	On-axis 9N50	AT
13	10097	40324	2450	2568	On-axis 9N30	AT
14	10097	40324	2475	2568	On-axis 9N30	AT
15	10097	40324	2555	2568	On-axis 9N30	AT
16	10096	40330	2573	2568	On-axis 9N30	AT
17	13738	1843	2450	2582	On-axis 9N10	AT
18	13738	1843	2570	2582	On-axis 9N10	AT
19	13738	1843	2588	2582	On-axis 9N10	AT
20	287	40100	2304 to 2804	2816	West flank 9N30	AT
21	-16490	37322	2259 to 3059	3071	West flank 9N30	AT
22	4608	77940	4mab	2508	Bio-9	LM
23	4608	77940	9 mab	2508	Bio-9	LM
24	4559	77596	4 mab	2505	BM82/MKR8	LM
25	4697	77469	5 mab	2500	70 m N of NA	LM
26	4697	77469	11 mab	2500	70 m N of NA	LM
27	10097	40254	7 mab	2570	70 m S of CA	LM
28	10097	40254	11 mab	2570	70 m S of CA	LM
29	4628	77541	2 mab	2502	On-axis, 100 m S of Ty/Io	LM
30	4628	77541	2 mab	2502	On-axis, 100 m S of Ty/Io	LM
31	4628	77541	74 mab	2502	On-axis, 100 m S of Ty/Io	LM
32	4628	77541	74 mab	2502	On-axis, 100 m S of Ty/Io	LM
33	4743	77667	2 mab	2515?	Off-axis, 100 m E of Ty/Io	LM
34	4743	77667	2 mab	2515?	Off-axis, 100 m E of Ty/Io	LM
35	4743	77667	74 mab	2515?	Off-axis, 100 m E of Ty/Io	LM
36	4743	77667	74 mab	2515?	Off-axis, 100 m E of Ty/Io	LM
37	4571	78180	2 mab	2512	On axis (Tica)	LM
38	4571	78180	2 mab	2512	On axis (Tica)	LM
39	4571	78180	74 mab	2512	On axis (Tica)	LM
40	4571	78180	74 mab	2512	On axis (Tica)	LM
41	4852	78177	2 mab	2505?	Off-axis, 272 m E of Tica	LM
42	4852	78177	2 mab	2505?	Off-axis, 272 m E of Tica	LM
43	4852	78177	74 mab	2505?	Off-axis, 272 m E of Tica	LM

	Grid X *(m)*	Grid Y *(m)*	Depth *(m)*	Water depth	Location description	Contact Person
44	4852	78177	74 mab	2505?	Off-axis, 272 m E of Tica	LM
45	4418	78743	2 mab	2506	On axis (Riftia Field)	LM
46	4418	78743	2 mab	2506	On axis (Riftia Field)	LM
47	4418	78743	74 mab	2506	On axis (Riftia Field)	LM
48	4418	78743	74 mab	2506	On axis (Riftia Field)	LM
49	4515	78744	2 mab	2505?	Off-axis, 100 m E of Riftia Field	LM
50	4515	78744	2 mab	2505?	Off-axis, 100 m E of Riftia Field	LM
51	4515	78744	74 mab	2505?	Off-axis, 100 m E of Riftia Field	LM
52	4515	78744	74 mab	2505?	Off-axis, 100 m E of Riftia Field	LM
53	10114*	40040*	2 mab	2568?	On axis (K-vent)	LM
54	10114*	40040*	2 mab	2568?	On axis (K-vent)	LM
55	10114*	40040*	74 mab	2568?	On axis (K-vent)	LM
56	10114*	40040*	74 mab	2568?	On axis (K-vent)	LM
57	10211	40093	2 mab	2568?	Off-axis, East 9N30	LM
58	10211	40093	2 mab	2568?	Off-axis, East 9N30	LM
59	10211	40093	74 mab	2568?	Off-axis, East 9N30	LM
60	10211	40093	74 mab	2568?	Off-axis, East 9N30	LM
61	4383	78262			Tica, 9N50	SW
62	4383	78262			Tica, 9N50	SW
63	4568	77968			Fish Hole, 9N50	SW
64	4568	77968			Fish Hole, 9N50	SW
65	10088	40067			Off-axis, outside K-vent	SW
66	10088	40067			Off-axis, outside K-vent	SW
67	10139	40031	2569		K-vent area	AT
68	4502*	78137*				AT
69	4627	77910			P-vent	LM
70	4579	78164			Tica	LM
71	4683	77523			S of Ty/Io	LM
72	10105	40051			K-vent, mussel patch	LM
73	4683	77523	2564		Ty/Io	LM
74	4683	77523	2564		Ty/Io	LM
75	4613	77912	2509		P-vent	LM
76	4626	77916	2509		P-vent	LM
77	4624	77916	2509		P-vent	LM
78	4595	78158	2513		Tica	LM
79	4560	78154	2512		Tica	LM
80	4588	78165	2510		Tica	LM
81	10107	40050	2561		K-vent area	LM
82	10083	40064	2561		K-vent area	LM
83	10095	39996	2564		K-vent area	LM

D.3 Biological Samples

Note: The following table has been split in two. Use first column to correlate the data on pp. 56–58 with the data on pp. 59–61. Grid positions marked with asterisks are not re-navigated.

	Sample Description	Dive no.	Device no.	Date	Time
1	*Alvinella* collection	4260		11/1/2006	19:43
2	*Alvinella* collection	4261		11/2/2006	18:35
3	*Alvinella* collection	4262		11/3/2006	17:33
4	Deployment TRAC 1	4263		11/4/2006	19:25
5	Deployment TRAC 2	4263		11/4/2006	19:39
6	Deployment TRAC 3	4263		11/4/2006	19:47
7	*Alvinella* collection	4266		11/7/2006	17:43
8	*Alvinella* collection	4266		11/7/2006	19:16
9	Recovery TRAC 3	4267		11/8/2006	18:33
10	Recovery TRAC 2	4267		11/8/2006	18:42
11	Recovery TRAC 1	4267		11/8/2006	18:48
12	*Alvinella* collection	4268		11/9/2006	17:16
13	Deployment TRAC 2	4269		11/10/2006	16:59
14	1 *Alvinella* collected	4271		11/12/2006	20:30
15	*Alvinella* collection	4272		11/13/2006	16:41
16	Deployment TRAC 1	4273		11/14/2006	16:07
17	Deployment TRAC 3	4273		11/14/2006	16:34
18	pelagic pump sample above *Tevnia*	4260		2006-10-31	
19	pelagic pump sample above basalt	4260		2006-10-31	
20	basalt with *Tevnia*	4260		2006-10-31	
21	pelagic pump sample above *Tevnia*	4261		2006-11-01	
22	pelagic pump sample above basalt	4261		2006-11-01	
23	basalt with *Tevnia*	4261		2006-11-01	
24	basalt periphery	4261		2006-11-01	
25	basalt with *Tevnia*	4264		2006-11-04	
26	new basalt	4264		2006-11-04	
27	old basalt	4264		2006-11-04	
28	pelagic pump new sediment	4264		2006-11-04	
29	pelagic pump old sediment	4264		2006-11-04	
30	basalt w/ dead tubeworms/mussels	4265		2006-11-05	
31	pelagic pump above dead tubes/mussels	4265		2006-11-05	
32	sulfide with dead *Alvinella*	4265		2006-11-05	
33	pelagic pump above sulfide/dead *Alvinella*	4265		2006-11-05	
34	sulfide with *Alvinella*	4266		2006-11-06	
35	basalt periphery	4266		2006-11-06	
36	pelagic pump above sulfide with *Alvinella*	4266		2006-11-06	
37	pelagic pump above basalt periphery	4266		2006-11-06	
38	sulfide chimney	4266		2006-11-06	
39	pelagic pump sample above *Tevnia*	4267		2006-11-07	
40	basalt periphery	4268		2006-11-08	
41	old sulfide	4268		2006-11-08	
42	pelagic pump above periphery	4268		2006-11-08	

	Sample Description	Dive no.	Device no.	Date	Time
43	pelagic pump at broken basalt	4268		2006-11-08	
44	basalt with *Tevnia/Riftia*	4268		2006-11-08	
45	basalt periphery	4269		2006-11-09	
46	basalt periphery	4273		2006-11-13	
47	pelagic pump sample above *Tevnia*	4273		2006-11-13	
48	pelagic pump sample above basalt	4273		2006-11-13	
49	Baby trap/sponge	4260	24, 25, 26	2006-10-31	
50	Baby trap/sponge	4260	43	2006-10-31	
51	Baby trap/sponge	4261	27, 28, 29	2006-11-01	
52	Baby trap/sponge	4261	45	2006-11-01	
53	Baby trap/sponge	4264	30, 31, 32	2006-11-04	
54	Baby trap/sponge	4264	49	2006-11-04	
55	Baby trap/sponge	4265	51	2006-11-05	
56	Baby trap/sponge	4265	52	2006-11-05	
57	Baby trap/sponge	4265	53	2006-11-05	
58	Baby trap/sponge	4265	55	2006-11-05	
59	Baby trap/sponge	4265	54	2006-11-05	
60	Baby trap/sponge	4266	56	2006-11-06	
61	Baby trap/sponge	4266	41	2006-11-06	
62	Baby trap/sponge	4273	36	2006-11-13	
63	Baby trap/sponge	4273	40	2006-11-13	
64	sandwich-Rec	4261	2	02-Nov-06	
65	sandwich-Rec	4261	3	02-Nov-06	
66	sandwich-Rec	4261	4	02-Nov-06	
67	sandwich-Rec	4260	19	01-Nov-06	
68	sandwich-Rec	4260	6	01-Nov-06	
69	sandwich-Rec	4260	7	01-Nov-06	
70	sandwich	4269	1	10-Nov-06	
71	sandwich	4269	5	10-Nov-06	
72	sandwich	4269	9	10-Nov-06	
73	sandwich	4269	10	10-Nov-06	
74	sandwich	4269	11	10-Nov-06	
75	sandwich	4269	8	10-Nov-06	
76	sandwich	4269	13	10-Nov-06	
77	sandwich	4269	14	10-Nov-06	
78	sandwich	4269	15	10-Nov-06	
79	sandwich	4269	12	10-Nov-06	
80	sandwich	4261	32	02-Nov-06	
81	sandwich	4261	29	02-Nov-06	
82	sandwich	4261	34	02-Nov-06	
83	sandwich	4261	30	02-Nov-06	
84	sandwich	4261	28	02-Nov-06	
85	sandwich	4261	22	02-Nov-06	
86	sandwich	4261	25	02-Nov-06	
87	sandwich	4261	31	02-Nov-06	
88	sandwich	4261	35	02-Nov-06	
89	sandwich	4261	27	02-Nov-06	

	Sample Description	Dive no.	Device no.	Date	Time
90	sandwich	4261	23	02-Nov-06	
91	sandwich	4261	26	02-Nov-06	
92	sandwich	4261	21	02-Nov-06	
93	sandwich	4261	24	02-Nov-06	
94	sandwich	4261	33	02-Nov-06	
95	sandwich	4267	36	08-Nov-06	
96	basalt	4267	36	08-Nov-06	
97	sandwich	4267	20	08-Nov-06	
98	basalt	4267	95	08-Nov-06	
99	sandwich	4267	37	08-Nov-06	
100	basalt	4267	126	08-Nov-06	
101	sandwich	4267	40	08-Nov-06	
102	sandwich	4267	41 or 42?	08-Nov-06	
103	sandwich	4267	18	08-Nov-06	
104	basalt	4267	1	08-Nov-06	
105	basalt	4267	163	08-Nov-06	
106	sandwich	4267	16	08-Nov-06	
107	sandwich	4267	17	08-Nov-06	
108	sandwich	4267	38	08-Nov-06	
109	basalt	4267	200	08-Nov-06	
110	sandwich	4267	41 or 42?	08-Nov-06	
111	basalt	4267	173	08-Nov-06	
112	sandwich	4267	43	08-Nov-06	
113	sandwich	4267	45	08-Nov-06	
114	basalt	4267	11	08-Nov-06	
115	basalt	4267	133	08-Nov-06	
116	sandwich	4267	49?	08-Nov-06	
117	sandwich	4267	47	08-Nov-06	
118	sandwich	4267	46	08-Nov-06	
119	sandwich	4270	55	11-Nov-06	
120	sandwich	4270	60	11-Nov-06	
121	sandwich	4270	53	11-Nov-06	
122	sandwich	4270	48	11-Nov-06	
123	sandwich	4270	56	11-Nov-06	
124	sandwich	4270	51	11-Nov-06	
125	sandwich	4270	59	11-Nov-06	
126	sandwich	4270	57	11-Nov-06	
127	sandwich	4270	54	11-Nov-06	
128	sandwich	4270	44	11-Nov-06	
129	sandwich	4272	49?	13-Nov-06	
130	sandwich	4272	52	13-Nov-06	
131	sandwich	4272	50	13-Nov-06	
132	sandwich	4272	58	13-Nov-06	
133	sandwich	4272	39	13-Nov-06	

	Location			Collection of sample			Collection	T max	Contact
	Mkr	Vent	Position on vent	Grid X *(m)*	Grid Y *(m)*	Depth *(m)*	method	*(degC)*	person
1		Ty&Io		4671	77616	2505	grab		FP
2		Bio9		4618	77982	2511	grab		FP
3		Ty&Io		4670	77616	2505	grab		FP
4		Tica		4588	78165	2507	incubation		FP
5		Tica		4588	78167	2510	incubation		FP
6		Tica		4583	78169	2510	incubation		FP
7		Bio9		4592*	77969*	2508	grab		FP
8		Bio9		4590*	77977*	2509	grab		FP
9		Tica		4586	78164	2510	incubation		FP
10		Tica		4586	78164	2510	incubation		FP
11		Tica		4586	78164	2507	incubation		FP
12		Bio9		4612	77987	2509	grab		FP
13		Bio9		4607	77981	2508	incubation		FP
14		PBR600		10286	39164	2553	grab		FP
15		K Vent		10109	40049	2558	grab		FP
16		Tica		4587*	78164*	2510	incubation		FP
17		Tica		4591*	78160*	2511	incubation		FP
18		Ty/Io		4682	77523	2507	pump		MB
19		Ty/Io		4682	77523	2507	pump		MB
20		Ty/Io		4682	77523	2507	grab		MB
21	M5	P-vent		4627	77910	2508	pump		MB
22	M5	P-vent		4627	77910	2508	pump		MB
23	M5	P-vent		4627	77910	2508	grab		MB
24	M5	P-vent		4627	77910	2508	grab		MB
25		Tica		4577	78163	2510	grab		MB
26		off-axis					grab		MB
27		off-axis					grab		MB
28		off-axis					pump		MB
29		off-axis					pump		MB
30		East-Wall		4557	78425	2500	grab		MB
31		East-Wall		4557	78425	2500	pump		MB
32		Q-Vent		4428	78783	2502	grab		MB
33		Q-Vent		4428	78783	2502	pump		MB
34		Bio9		4615	77968	2508	grab		MB
35		Bio9		4615	77968	2508	grab		MB
36		Bio9		4615	77968	2508	pump		MB
37		Bio9		4615	77968	2508	pump		MB
38		Bio9		4615	77968	2508	grab		MB
39		Tica		4577	78163	2510	pump		MB
40		Q-Vent		4428	78783	2502	grab		MB
41		Q-Vent		4428	78783	2502	grab		MB
42		Q-Vent		4428	78783	2502	pump		MB

	Location			Collection of sample			Collection	T max	Contact
	Mkr	Vent	Position on vent	Grid X *(m)*	Grid Y *(m)*	Depth *(m)*	method	*(degC)*	person
43		Q-Vent		4428	78783	2502	pump		MB
44		Fish-Hole?		4621	77958	2512	grab		MB
45		Ty/Io		4682	77523	2507	grab		MB
46		Tica		4577	78163	2510	grab		MB
47		Tica		4577	78163	2510	pump		MB
48		Tica		4577	78163	2510	pump		MB
49		Ty-Io	*Tevnia*	4682	77523	2507	coloniz.		MB
50		Ty-Io	peripheral basalt	4682	77523	2507	coloniz.		MB
51	M5	P-vent	*Tevnia*	4627	77910	2508	coloniz.		MB
52	M5	P-vent	peripheral basalt	4627	77910	2508	coloniz.		MB
53		Tica	*Tevnia*	4577	78163	2510	coloniz.		MB
54		Tica	peripheral basalt	4577	78163	2510	coloniz.		MB
55		Q-vent	dead *Alvinella*	4428	78783	2502	coloniz.		MB
56		Q-vent	peripheral basalt	4428	78783	2502	coloniz.		MB
57		East Wall	dead mussels shell	4557	78425	2500	coloniz.		MB
58		East Wall	dead *Riftia* tube	4557	78425	2500	coloniz.		MB
59		East Wall	peripheral basalt	4557	78425	2500	coloniz.		MB
60		Bio9	*Alvinella*	4615	77968	2508	coloniz.		MB
61		Bio9	peripheral basalt	4615	77968	2508	coloniz.		MB
62		Tica	*Alvinella/Tevnia*	4577	78163	2510	coloniz.		MB
63		Tica	peripheral basalt	4577	78163	2510	coloniz.		MB
64	5	P vent	tubeworm	4631	77930	2510	coloniz.	26.7	LM
65	5	P vent	tubeworm	4631	77930	2510	coloniz.	23.2	LM
66	5	P vent	tubeworm	4631	77930	2510	coloniz.	24.7	LM
67	8	Mkr 8/11	mussel?	4677	77599		coloniz.	6.5	LM
68	8	Mkr 8/11	mussel?	4677	77599		coloniz.	2.2	LM
69	8	Mkr 8/11	mussel?	4677	77599		coloniz.	2.2	LM
70	L-S	Ty/Io	*Tevnia*				coloniz.	4.5	LM
71	L-S	Ty/Io	*Tevnia*				coloniz.	14.4	LM
72	L-S	Ty/Io	*Tevnia*				coloniz.	15.1	LM
73	L-S	Ty/Io	*Tevnia*				coloniz.	17.0	LM
74	L-S	Ty/Io	*Tevnia*				coloniz.	3.7	LM
75	L-S	Ty/Io	2-4C				coloniz.	4.2	LM
76	L-S	Ty/Io	2-4C				coloniz.	2.2	LM
77	L-S	Ty/Io	2-4C				coloniz.	2.2	LM
78	L-S	Ty/Io	2-4C				coloniz.	2.2	LM
79	L-S	Ty/Io	2-4C				coloniz.	2.4	LM
80	L-O	P vent	tubeworm				coloniz.	21.5	LM
81	L-O	P vent	tubeworm				coloniz.	27.1	LM
82	L-O	P vent	tubeworm				coloniz.	15.9	LM
83	L-O	P vent	tubeworm				coloniz.	24.7	LM
84	L-O	P vent	tubeworm				coloniz.	18.5	LM
85	L-O	P vent	2-4C				coloniz.	2.8	LM
86	L-O	P vent	2-4C				coloniz.		LM
87	L-O	P vent	2-4C				coloniz.	2.4	LM
88	L-O	P vent	2-4C				coloniz.	3.2	LM
89	L-O	P vent	2-4C				coloniz.	2.3	LM

	Location			Collection of sample			Collection	T max	Contact
	Mkr	Vent	Position on vent	Grid X *(m)*	Grid Y *(m)*	Depth *(m)*	method	*(degC)*	person
90	L-O	P vent	4-10C				coloniz.	9.6	LM
91	L-O	P vent	4-10C				coloniz.	9.0	LM
92	L-O	P vent	4-10C				coloniz.	10.3	LM
93	L-O	P vent	4-10C				coloniz.	7.0	LM
94	L-O	P vent	4-10C				coloniz.	5.9	LM
95	L-R	Tica	2-4C				coloniz.	5.8	LM
96	L-R	Tica	2-4C				coloniz.	4.3	LM
97	L-R	Tica	2-4C				coloniz.	3.7	LM
98	L-R	Tica	2-4C				coloniz.	7.3	LM
99	L-R	Tica	2-4C				coloniz.	3.0	LM
100	L-R	Tica	2-4C				coloniz.	4.5	LM
101	L-R	Tica	2-4C				coloniz.	4.2	LM
102	L-R	Tica	2-4C				coloniz.	4.9	LM
103	L-R	Tica	tubeworm				coloniz.	17.0	LM
104	L-R	Tica	tubeworm				coloniz.	28.0	LM
105	L-R	Tica	tubeworm				coloniz.	18.8	LM
106	L-R	Tica	tubeworm				coloniz.	16.8	LM
107	L-R	Tica	tubeworm				coloniz.	26.0	LM
108	L-R	Tica	tubeworm				coloniz.	11.9	LM
109	L-R	Tica	tubeworm				coloniz.	17.4	LM
110	L-R	Tica	tubeworm				coloniz.	?	LM
111	L-R	Tica	4-10C				coloniz.	12.8	LM
112	L-R	Tica	4-10C				coloniz.	4.7	LM
113	L-R	Tica	4-10C				coloniz.	7.8	LM
114	L-R	Tica	4-10C				coloniz.	11.0	LM
115	L-R	Tica	4-10C				coloniz.	5.5	LM
116	L-R	Tica	4-10C				coloniz.	18.4	LM
117	L-R	Tica	4-10C				coloniz.	8.5	LM
118	L-R	Tica	4-10C				coloniz.	6.3	LM
119	L-T	K vent	mussel patch				coloniz.		LM
120	L-T	K vent	mussel patch				coloniz.	2.1	LM
121	L-T	K vent	mussel patch				coloniz.	2.0	LM
122	L-T	K vent	mussel patch				coloniz.	2.3	LM
123	L-T	K vent	mussel patch				coloniz.	2.1	LM
124	X-6	K vent	suspension				coloniz.	3.3	LM
125	X-6	K vent	suspension				coloniz.	9.9	LM
126	X-6	K vent	suspension				coloniz.	2.8	LM
127	X-6	K vent	suspension				coloniz.	27.0	LM
128	X-6	K vent	suspension				coloniz.	5.4	LM
129	X-6	K vent	sulfide top				coloniz.	10.0	LM
130	X-6	K vent	sulfide top				coloniz.	11.0	LM
131	X-6	K vent	sulfide top				coloniz.	27.0	LM
132	X-6	K vent	sulfide top				coloniz.	28.0	LM
133	X-6	K vent	sulfide top				coloniz.	27.0	LM

D.4 Transponder Deployments

Transp. ID	Net ID	Deployment of transponder Date	Lat *deg*	Lat *dec min*	Lon *deg*	Lon *decmin*	Depth (m)	Freq. *(kHz)*	Rel. code
S/N-35003	A	2006-10-30	9	30.438	-104	14.342	2360	9.0/10.5	D
S/N-48500	B	2006-10-30	9	29.72	-104	14.342	2342	9.0/11.0	E

Transponder deployments. Transponders are TR-6000's. Recovery planned for Jan. 2007

D.5 Float Deployment

Float ID	Float deployment Date	Time *(UTC)*	Lat *deg*	Lat *dec min*	Lon *deg*	Lon *dec min*	Drifting depth *(dbar)*	Cycle interval *(days)*
RF33	2006-11-12	02:53	9	29.95	-104	14.31	2450	31

Float deployment. The float was deployed one M_2 tidal period after the tracer injection and is intended to drift with the center of the tracer patch. It is programmed to surface early during the LADDER-2 cruise.

E Mooring Standoff Protocol

[*The following protocol was sent by email to Dan Fornari, the R2K EPR ISS site coordinator, during the cruise.*]

The one thing that we are trying to avoid is that our moorings get snagged by anything towed through the water. We would like to do so without unduly restricting the work of other groups, of course. We are particularly worried about snagging our axial moorings because they are ballasted very lightly — we had to do this in order to be able to re-position them with Alvin. (That does not mean that they can be moved from their current positions, though!) Therefore, it is likely that you might not even notice if you snag a mooring while towing an instrument.

After considerable additional discussions, in particular with Scott Worrilow, who is the head of our mooring operations and the owner of most of the mooring hardware, we have come up with the following requests, which we hope interferes as little as possible with planned operations, while ensure the safety of our moorings:

1. Instruments towed at or lowered to 2300 m or shallower: No restrictions.

2. Unnavigated instruments (i.e. no transponders on the lowered bodies) towed or lowered vertically to depths below 2300 m (including CTDs!): 500 m horizontal standoff distance between the ship and the moorings. (500 m is the maximum displacement distance for instruments lowered on the wire that we observed during our cruise while the ship was on DP.)

3. Acoustically navigated instruments towed or lowered vertically to depths below 2300 m:

   (a) Keep the ship and the towed body on the same side of all moorings in the area at all times when the ship is less than 500 m horizontally from any of the moorings. (I.e. Do not cross

the mooring location with the towing wire, regardless how high in the water you think the towing line is.)

(b) Keep at least 75 m horizontal standoff distance between the towed platform and all moorings. Please note that while the position of the towed body is known, the position of the towing wire is not. Wire-drag models show that when a body is towed through the water the wire can be deflected significantly from a straight line connecting the ship and the towed body, depending on the currents and the towing-track and -speed.

4. Alvin: Keep at least 30 m standoff distance to the moorings. We are aware of a single low-temperature hydrothermal area that is closer than 50 m to our sediment-trap mooring at 9°50′N (and none within 50 m of our current-meter mooring; biomarker 141 site is approximately 200 m south of the closest of our moorings). We would appreciate it if the sub could remain 50 m from our moorings unless work is to be done at the site that's 40 m from the sediment trap.

We cannot preclude that these restrictions will affect towed operations in the area while the moorings are deployed (until November 2007). We would like to point out, however, that the longer one of our moorings at 9°50′N is crucial for the success of our project, that our plan has been publicly available on the web since December 2004, and that it was presented to the EPR ISS community during the workshop held at Lamont earlier this year and that no protests were raised then.

We hope that this provides you with the information that you requested. Please let us know if you need further clarifications.

- Andreas Thurnherr (LADDER co-PI)
- Lauren Mullineaux (LADDER co-PI)
- Jim Ledwell (LADDER co-PI)
- Scott Worrilow (head, LADDER mooring operations)