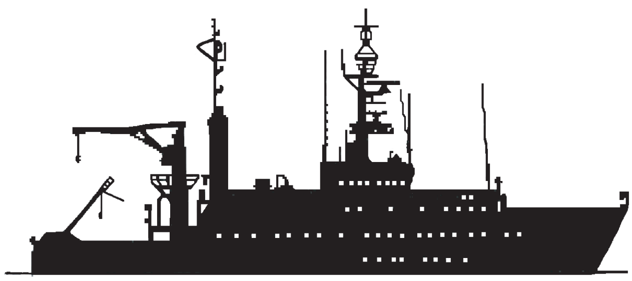
IFM-GEOMAR REPORT

IFM-GEOMAR

Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

FS POSEIDON
Fahrtbericht / Cruise Report
POS403

Ponta Delgada (Azores) - Ponta Delgada (Azores)
14.08. - 30.08.2010



Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

Nr. 38
September 2010

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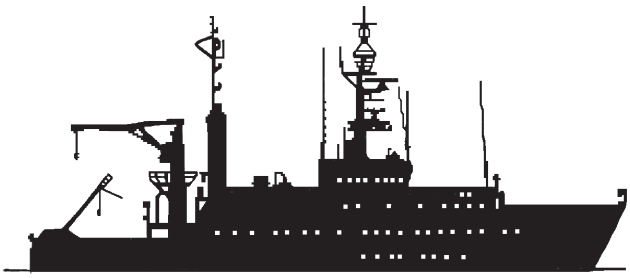

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Herausgeber / Editor:
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1. Science and ship crew

Name	Affiliation	Task
Torsten Kanzow	IFM-GEOMAR	Chief Scientist / Microstructure
Klas Lackschewitz	IFM-GEOMAR	Head of AUV Team
Andreas Thurnherr	LDEO (USA)	CTD / LADCP
Christopher Zappa	LDEO (USA)	CTD / LADCP
Uwe Koy	IFM-GEOMAR	Technician: Moorings, Sensors
Jan Sticklus	IFM-GEOMAR	Engineer: AUV Hardware
Marcel Rothenbeck	IFM-GEOMAR	Engineer: AUV Mission planning
Nico Augustin	IFM-GEOMAR	Marine Geologist; sea floor mapping
Andre Sodermans*	Rockland Scientific	Engineer: Microstructure technology

*Table 1.1: Scientific Crew during expedition P403. *Andre Sodermans joined the cruise on August 22 on the island of Flores.*

Name	Position
Klaus Ricke	Master
Bernhardt Windscheidt	First Officer
Alexander Hänsel	Second Officer
Heiko Hepping	First Engineer
Frank Tobolewski	Second Engineer
Dietmar Klare	Electrician
Rüdiger Engel	Engine Guard
Frank Schrage	Bosun
Pedro Barbosa	Seaman
Bernd Hänel	Seaman
Tim Stegmann	Ship mechanic
Ralf Peters	Ship mechanic
Benjamin Groenebaum	Ship mechanic
Volkhardt Falk	Chef
Bernd Gerischewski	Steward

Table 1.2: R/V Poseidon crew during the P403 campaign

2. Itinerary

Depart: Ponta Delgada (Sao Miguel, Azores), August 14, 2010
Arrive: Ponta Delgada (Sao Miguel, Azores), August 29, 2010

3. Acknowledgements

The Captain and crew of R/V Poseidon were professional and extremely helpful throughout. Regular liaison with the officers allowed a good working relationship between the science party and the ship. The permanent access to the internet and phone via satellite connection allowed us to get efficient shore-based support from the manufacturers of the AUV and the microstructure sensor, and from colleagues at our labs. The real-time display of bridge navigation data, and underway measurements in the labs prove very helpful in the timing of scientific work.

4. Introduction

by Torsten Kanzow

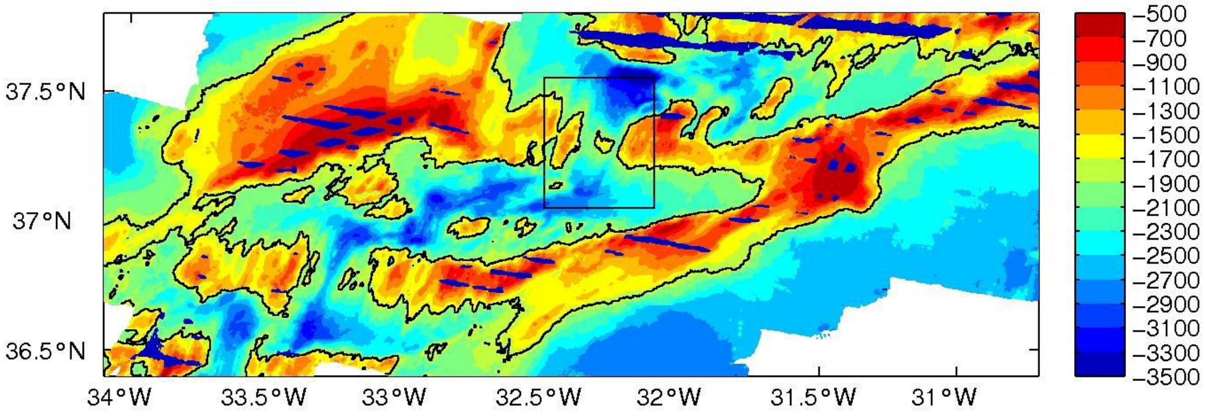


Fig. 4.1: The Lucky Strike area. Colour contours between 500 and 3500 m with an interval of 200 m are shown, the 1800m isobath is highlighted as black line. The box shows the working area around Lucky Strike. The bathymetry of the Lucky Strike area was mapped within the framework of the Monitoring the Mid-Atlantic Ridge (MOMAR) project. Data source: J. Escartin; www.ipgp.jussieu.fr/rech/lgm/ MOMAR/.

Dissipation and turbulent mixing are ubiquitous in the world ocean. As a direct consequence, even the deep ocean below 1000 m exhibits a notable stable stratification (Fig. 1; Munk, 1966; Munk and Wunsch, 1998; Kanzow and Visbeck, 2009). Vertical mixing associated with dissipation of turbulent kinetic energy sustains the circulation of the deep and abyssal ocean. However, the spatial distribution of diapycnal mixing in the oceans is clearly non-uniform. In the vicinity of rough bathymetry – as exhibited by mid-ocean ridges – values of $1 \cdot 10^{-4}$ m^2 s^{-1} are found (Toole et al., 1997; Polzin et al., 1997; Kunze et al., 2006), that exceed diffusivities found in the open ocean or above abyssal plains by one order of magnitude (Ledwell et al., 1993; Toole et al., 1994). The elevated mixing rates are commonly explained by topography-induced breaking of internal waves, with the latter being generated by (tidal) currents interacting with bathymetry.

Recent findings support the view that the largest mixing rates do not occur *above* rough bathymetry but *inside* deep canyons, such as the fracture zones and central valleys of the mid-oceanic ridge systems. In the Romanche Fracture Zone Ferron et al. (1998) found diapycnal diffusivities of 100 – 1000 * 10^{-4} m^2s^{-1} east of the main sill. Observations by St. Laurent et al. (2001) and Thurnherr et al. (2005) near 22°S in the Atlantic revealed three to five times larger turbulent dissipation within a valley on the western flank of the Mid-Atlantic Ridge than above the valley wall crests.

During the expedition aboard R/V Poseidon in August 2010 near-bottom oceanographic and marine-geologic measurements have been carried out in the central valley of the Mid-Atlantic Ridge near 37°N, using an autonomous underwater vehicle (AUV), complemented by “classical” lowered and mooring-based techniques. It is currently unclear, which physical mechanisms control the intense turbulent dissipation in deep ocean canyons. Recent studies point to a potential role of hydraulic jumps, which have been observed in shallow water studies. Overall, there is a growing body of evidence that the canyon bathymetry plays an important role. In particular, there are indications for a sill overflow in the Lucky Strike area being hydraulically controlled (St Laurent and Thurnherr, 2007; hereafter referred to as ST07), and this then might also true for mixing.

We chose to carry out a near-sea-floor circulation and mixing experiment in the Lucky Strike area (Fig. 4.1), because (i) good quality data for both targeted experiment planning and comparison purposes exist from the study by ST07 and (ii) at the same time ST07 left important questions about mixing dynamics unanswered. In this area, the hour-glass segment shape typical of many volcanically-active segments on slow spreading ridges (e.g. Sparks et al., 1993) results in a zonally-extending sill separating a northern from a southern basin within the central valley of the Mid-Atlantic Ridge (Fig. 4.1). The sill allows an inter-basin water exchange at depths in excess of 1800 m through a western and an eastern passage (Fig. 4.1, black box).

The measurements taken during the P403 campaign will be used to find out whether tidally varying hydraulic jumps can explain the observed large vertical mixing over a sill in the central valley (Fig. 4.1). To resolve the jumps AUV-based high-resolution horizontal fields of near-bottom turbulent kinetic energy dissipation and of flow velocities have been obtained. Further, the high-resolution AUV-based multi-beam echosounder mapping will allow us to study (i) the relationship between vertical mixing processes and the bathymetry, and (ii) the dynamic processes underlying the “mixing active” morphology.

Microstructure probes have already been used successfully aboard a range of AUVs (Levine and Lück, 1999; Lück, 2002; Thorpe et al., 2003; Goodman et al., 2006). Beside a large AUV of the US Navy (LDUUV) these measurements have been carried out aboard a REMUS 100, REMUS 600, AUTOSUB and an AUV built by the Woods Hole Oceanographic Institute. In all cases the measurement noise has been limited to values below $1 \cdot 10^{-9}$ W kg^{-1}. The AUV rotor and rudder constitute the two major sources of noise. Such AUV-generated vibrations are commonly found in the frequency band between 5 and 100 Hz, in which the dissipation measurements are partly carried out. However, the vibrations only cover a very narrow (platform specific) frequency range and they are well-resolved by the acceleration sensors of the microstructure probe. The contamination is usually found to very coherent (at the 0.99 to 0.999 significance level). Therefore the AUV-generated vibrations can very effectively be removed from the microstructure data by standard post-processing (Lück, 2002; Goodman et al., 2006).

Before the P403 campaign AUV-based microstructure measurements have been carried out in shallow waters of estuaries and in the upper ocean. We have widened the measurement range to the bottom boundary layer of the deep ocean, where free-falling and lowered measurements are inefficient and time-consuming.

5. Narrative

by Torsten Kanzow

12.8. Arrival of the scientist from IFM-GEOMAR in Ponta Delgada in the early afternoon. AUV container and freight from LARS (Launch and Recovery System) container are taken on board. All freight except for AUV batteries have arrived. Diplomatic clearance has not yet been received.

13.8. Andreas Thurnherr and Chris Zappa from Lamont Doherty Observatory arrive. Lab and deck preparations start. Diplomatic clearance is received. We will be able to work as planned, however, bottom sampling a tiny part of the Lucky Strike hydrothermal field is excluded. In the evening the power supply of the DATVIS computer breaks.

14.8. Departure at 12:00 with a 3 hour delay because a new power supply needs to be bought. A test CTD is carried out at 18:00. Preparations for the AUV operations and mooring deployments are under way.

15.8. Around midday a test of the DVL of the AUV takes place on a shallow (150 m deep) site following a 1x1 km track in dive depth of 10 m. A releaser test (lowered to 1000 m) took place in the afternoon (all 3 releaser works fine). Lab tests of the Microrider 6000 (MR) are carried out, to find the origin of the missing values of the AZ and T1 channels (see section 7.3 for details). Preparation for the mooring deployment scheduled for the following day are under way.

16.8. Arrival in the work area. Mooring M1 downstream of sill in the eastern passage near Lucky Strike is deployed anchor-first over the port side in calm conditions. The subsequent establishment acoustic communication between a modem connected to the ADCP in mooring M1 and a modem lowered from the vessel turns out to be difficult at first. We manage, however, to change the ensemble rate of the ADCP via the modem – modem connection from 20 s to 60 s. A subsequent test dive to 100 m depth with the MR attached to the AUV (but not connected to the AUV based power supply) is successful. After the dive, mooring M2 is deployed upstream of the sill in the same way as M1. However, the 1200 KHz ADCP that we had planned to integrate in M2, turns out to be out of order due to a previously undetected leakage. The instruments had been used by colleagues from MARUM (Bremen) and they had been sent it directly to the vessel, so there was no possibility for us to check the instrument prior to the cruise. We therefore decide integrate into M2 the upward looking 300 KHz ADCP from the CTD frame. In the evening the transponders T1 and T2 required for the AUV navigation were deployed and a triangulation survey was carried out.

During the night to **17.8.** a CTD survey (cast #2–6) is carried out between M2 and M1. Subsequently, the first deep AUV dive to 2000m covering the central and northern part of the eastern passage is carried out, with the MR connected to the AUV power supply (dive #1). The AUV performs well, however, the MR measurements shows serious problems soon after the start of the descend of the AUV. The Reson multibeam echosounder does not record data. The CTD system aboard the AUV works fine. After that, acoustic data telemetry from M1 is carried out. This time the vessel stays 3 cables away from the site and the communication works fine. From the ADCP data uploaded from M1 we are able to deduce the phase of the half daily tide. This is followed by a CTD survey over night in the passage and the northern basin. (#7-11). We contact Rockland Scientific about the problems with the MR to get assistance.

On **18.8**. an AUV dive is carried out (#2), which is aborted soon after the beginning of the descend in 120 m water depth. A leakage warning in the motor section initiates the drop of the ballast lead. On deck, an inspection of the AUV shows a tiny amount of salt water in the motor oil. The MR data during this short dive shows no obvious problems. The time before the next AUV dive is used to for another data upload from the ADCP in M1 via acoustic telemetry, this time with the vessel being 1 nm away from M1. Data transmission works fine, and the ADCP ensemble interval is set to 40 s via telemetry. Subsequently, an acoustic triangulation survey of mooring M1 is carried out. After that we attempt yet another acoustic data transmission, this at a distance of 3.5 nm from M1. At this long range the telemetry fails. In the afternoon (17:10) the AUV was is in operation again (#3), and returns on board around 22:20. This time we have had no data cable installed between the sensor unit und the data recording unit of the MR, to see if whether the "bad buffers" in the data in the deep ocean even occur without data acquisition. This is indeed the case, so the problem has to be either the due to the power supply or inside the data recording unit, but not inside the sensor unit.

In the night to **19.8.** we carry out 3 CTD casts (#12-14, upstream and downstream of the sill and in the southern basin). After that a CTD yo-yo (#15) is done for the duration of seven hours, during a phase, where the tidal current flows northward in the direction of the mean flow. In this part of the passage historical CTD data shows Froude number close to 1. Analyses of the MR data show that the instrument performs well at shallow depths, and that bad buffers start to occur at 500 – 700 m depth. This might point to either a pressure or temperature related problem. At 16:00 the AUV is launched again (#4), after a firmware update of the MR (as recommended by the manufacturer) has been carried out. The AUV accomplishes to fly 4 times along a 15-km-long along-channel track, before it returns to the surface at 07:00 on **20.8.** While the AUV is on its mission the vessel is positioned to the sill of the passage, where we carry out a CTD cast each time the AUV passes by (#16-18). It turns out that the MR firmware update has not been completed correctly. The MR data shows the same problems as during the previous deployments. Also, our attempts so far fail to modify the setting of the AUV-based 300 kHz ADCP (Navigator) such, that current profile measurements can obtained.

On **20.8.** at 09:00 the AUV departs on a deep dive for the duration of 2 hours (#5), after the MR firmware update had been completed correctly. The MR data, however, continue to show the same deficiencies. To be able to distinguish, whether the MR data recording unit has a pressure or temperature related problem, the device is operated in the fridge of the main lab of Poseidon at 4°C. After a short time the same bad buffers as in the deep ocean occur. After heating up again outside the fridge, the bad buffer messages disappear again. Rockland Scientific is subsequently able to reproduce this temperature flaw in their lab and locate the electronic components responsible for it. They agree to fly out an engineer with spare parts to the airport closest to us (island of Flores). Meanwhile the Reson multibeam still does not perform satisfactorily. Together with the manufacturer of the troubleshooting is ongoing. The CTD data measured aboard the AUV are of excellent quality – a bright spot among all the trouble.

Between 12:00 and 9:00 of the following day (**21.08.**) we obtained 11 CTD casts (#19-29) near M1 at three different sites that lie on an east-west axis, in order to describe the across-passage density and velocity gradients. The measurements reveal the mooring M1 is possibly located just downstream of the supercritical flow regime (in contrast to what historical observations showed). Therefore, mooring M1 is recovered in the morning.

Subsequently the AUV is launched for another test dive (#6). This time a shallow dive mission in 100 m depth is carried out to see if the MR gives good data at temperatures around 16°C. Indeed, the MR indeed records flawless data. After the dive, mooring M1 is redeployed about 4 cables upstream (south) of its original position (and is now referred to as M1_2). This is followed by acoustic triangulations of both the AUV navigation transponders and mooring M1_2. In the evening R/V Poseidon departs on a 16 hours steam towards Flores – the westernmost island of the Azores archipelago – to take Andre Sodermans from Rockland Scientific on board. The interruption of the measurement program is welcomed by cruise participants and crew members, as the cruise so far has been very demanding.

Fig. 5.1: Flores – the westernmost island of the Azores archipelago (Photo: Nico Augustin).

In the evening of **22.8.** R/V Poseidon steams back toward the work area. On the way, Andre Sodermans and Uwe Koy successfully modify the electronic boards of the MR and carry out further firmware updates for specific components. Two subsequent “fridge tests” with the reassembled MR are successful.

On **23.8.** around noon we arrive at Lucky Strike, and a deep AUV dive between 13:00 and 18:00 in the northern part of the eastern passage is carried out (#7). This time, both the MR and the Reson return good data. Our efforts thus have been worth while.

During the night leading to **24.8.** we accomplish 3 tow-yos on the 3.5 nm long track between M2 and the original position of M1(#30-32), to capture the spatial structure of bores propagating upstream through the passage. At 15:00 AUV Abyss sets off on a 19 hour long dive (#8), and returns on **25.8.** at 10:00. The AUV carries out 6 transects along the passage in 3 zonally staggered routes. During to the AUV mission the CTD was used near M1_2, to observed the east-west density and velocity gradient (casts #34-40). As the arrival of an atmospheric low pressure system in the work area was imminent, the captain Klaus Ricke advised us to recover both M1_2 and M2 while sea conditions would still allow us to carry out the operations. In the afternoon both moorings were thus successfully recovered. After another triangulation of the AUV navigation transponders no further measurements could be done before midnight due to insufficient availability of deck personnel. Immediately after the recovery of the AUV the process of recharging its batteries was initiated to attempt another dive the following day – provided the sea state would still allow us to launch / recovery operation.

From **26.8.** at 00:00 CTD repeat casts (#41-45) are carried out along the eastern passage in rather calm sea conditions. We therefore decide to launch the AUV again in the morning (#9). This dive marks the 50th scientific deployment of AUV Abyss. This time the AUV commenced its mission over the Lucky Strike hydrothermal field and then descended into the eastern passage again. In contrast to all earlier mission a terrain-following setting (rather than fixed depths) is chosen. Also, the protective frame around the microstructure probes was removed to test, if the measurement noise level is affected by the frame. During the dive one CTD cast (#46) is carried in the direct vicinity of the AUV. As a result of the steadily increasing winds and the developing wind sea, the dive is aborted around 16:00 – 3 hours before the scheduled termination. The recovery during force 7 winds is not without excitement, specifically when the recovery line winds round the mounting bracket of the MR. After recovery in steadily increasing wind sea and swell, we start a hydrographic section along the deep passage west of Lucky Strike, to find out whether southward oriented compensation transports for the northward flow in the eastern passage can be found. During the 5th cast (#51) we have to abort the measurements due to severe wind conditions.

On **27.7.** a short period of weaker winds is used to recover both AUV navigation transponders. This is a difficult task in the cross sea that has developed in the meantime associated with a change in wind direction. In these conditions further CTD and AUV work is impossible and as the wind prediction for the next day does not promise any improvement (quite the contrary), we terminate the scientific work program. With force 8 winds and swell from astern we start our eastward steam towards Ponta Delagada in the afternoon.

On **29.8.** at noon we arrive in Ponta Delgada.

6. AUV Operations

by Klas Lackschewitz, Marcel Rothenbeck Jan Sticklus, and Nico Augustin

6.1 Technical description

The Autonomous Underwater Vehicle (AUV) ABYSS (built by HYDROID) from IFM-GEOMAR can be operated in water depth of up to 6000 m. The ABYSS system comprises the AUV itself, a control and workshop container, and a mobile Launch and Recovery System (LARS) with a deployment frame that was installed on steel plates at the stern of R/V POSEIDON.

During P403, we have deployed and recovered the AUV at weather conditions with a swell of up to 2 m and wind speeds of up to 5-6 beaufort. For the recovery the nose float pops off when triggered through an acoustic command. The float and the 20 m long recovery line drift away from the vehicle so that a grappnel hook can snag the line (Fig. 6.1A). The line is then connected to the LARS winch, and the vehicle is pulled up (Fig. 6.1B). Finally, the AUV is brought up on deck and safely secured in the LARS (Fig. 6.1C). During P403 no problems were encountered during any deployment or recovery with the LARS system.

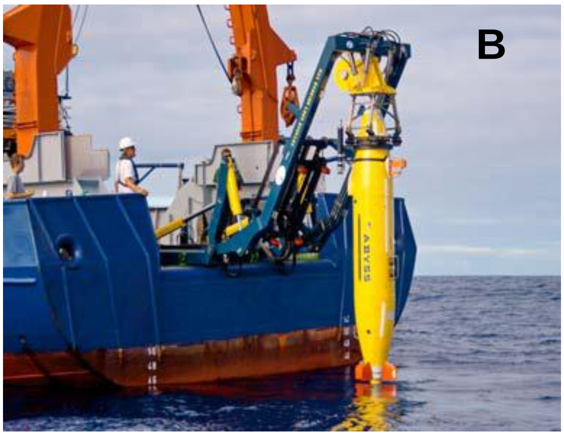


Fig. 6.1: A) A grappnel hook snags the recovery line of the AUV. B) The vehicle is pulled up in the LARS. C) The deployment frame of the LARS is brought in and the AUV is safely secured.

The vehicle has navigated autonomously using a combination of navigation methods:

• GPS - Works only on the surface, GPS determines the vehicle's location on

Earth. GPS determines the “initial position” before the vehicle submerges, and verifies or corrects the vehicle’s position when it surfaces during the mission. GPS also plays a critical role during INS alignment.

• Inertial Navigation System (INS) - After alignment on the surface, INS continuously integrates acceleration in 3 axes to calculate the vehicle’s position. It uses input from the DVL and the GPS to maintain its alignment.

• Doppler Velocity Log (DVL) - Continuously measures altitude and speed over ground whenever the vehicle can maintain bottom-lock. The DVL receives temperature and salinity data from the CTD Probe to calculate sound speed. The DVL must be within range of the bottom to measure altitude and provide bottom-lock for the INS.

• Long Baseline Acoustic Navigation (LBL) - The vehicle has also used the LBL navigation by computing its range to two moored acoustic transponders.

The vehicle has collected data using the following sensors:

- SEABIRD Fastcat SBE49
- WETLABS ECO FLNTU optical backscatter / fluorometer
- RESON Seabat 7125 multibeam echosounder system.

In addition, a MicroRider 6000 (MR) horizontal microstructure profiler from Rockland Scientific was mounted on the AUV Abyss. (Fig. 6.2)

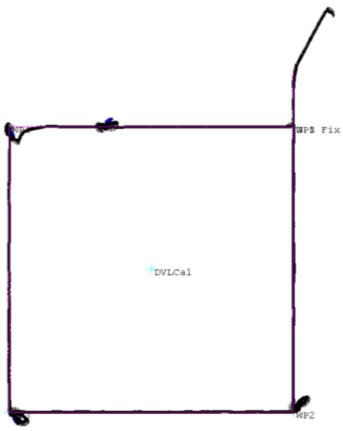
Fig. 6.2: AUV with microstructure profiler attached.

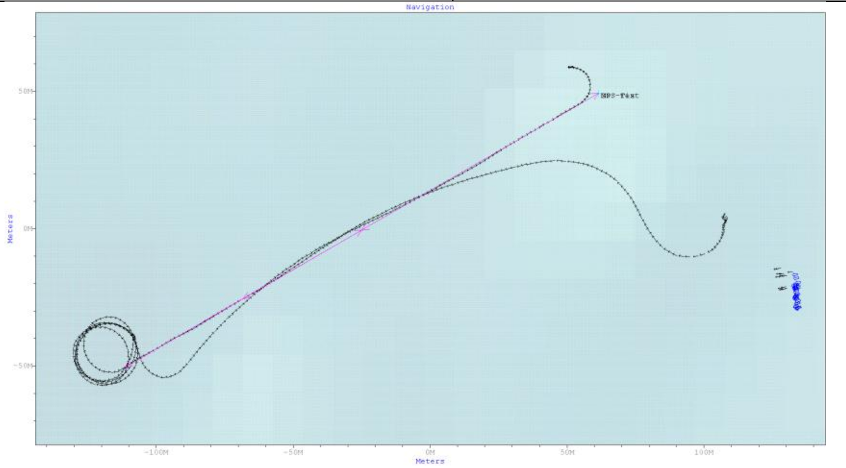
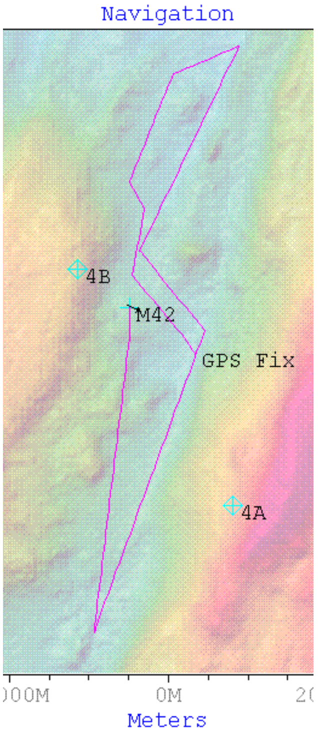
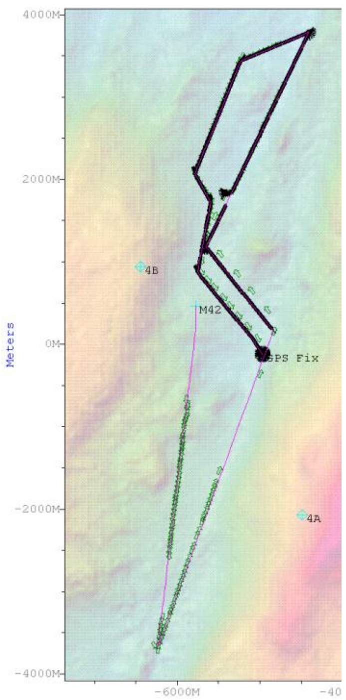
The MR is specifically adapted for the use on the AUV, and the mounting brackets and were designed such, that the instrument would fit inside the LARS for launch and recovery purposes. The MR consists of two pressure cases, with one housing the sensor electronics and the other the data recording unit. Power (24V) is supplied by the AUV, but data is stored internally in the MR.

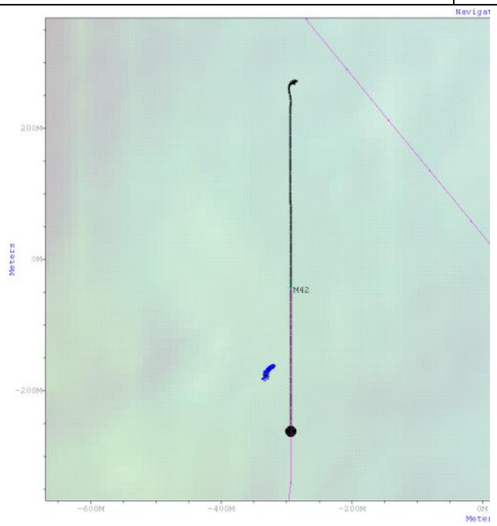
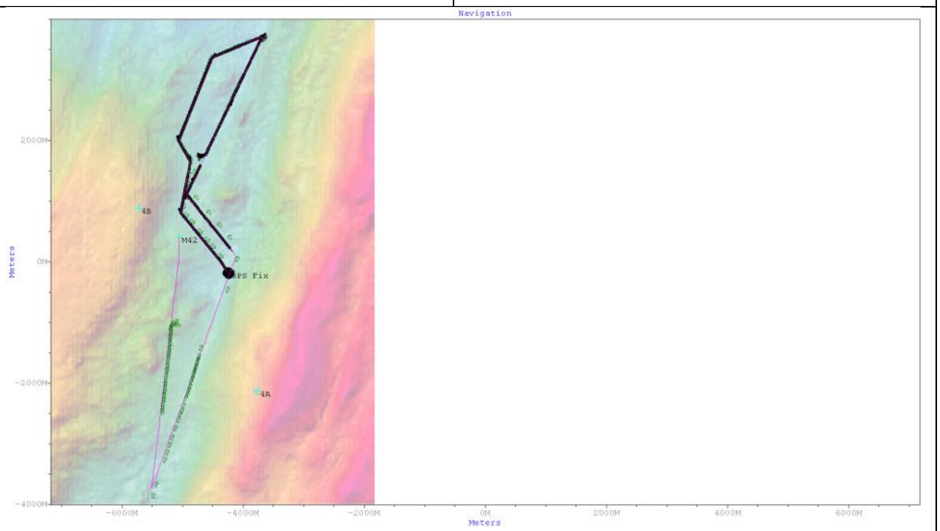
The MR is used to estimate the rate of dissipation of turbulent kinetic energy. This parameter is required to derive diapyncal mixing in the ocean. For this the MR is equipped with 2 velocity microstructure shear probes and 2 fast response temperature probes. It also accommodates a 3-axis accelerometer (to remove platform vibration contamination from the shear measurements) and a pressure sensor.

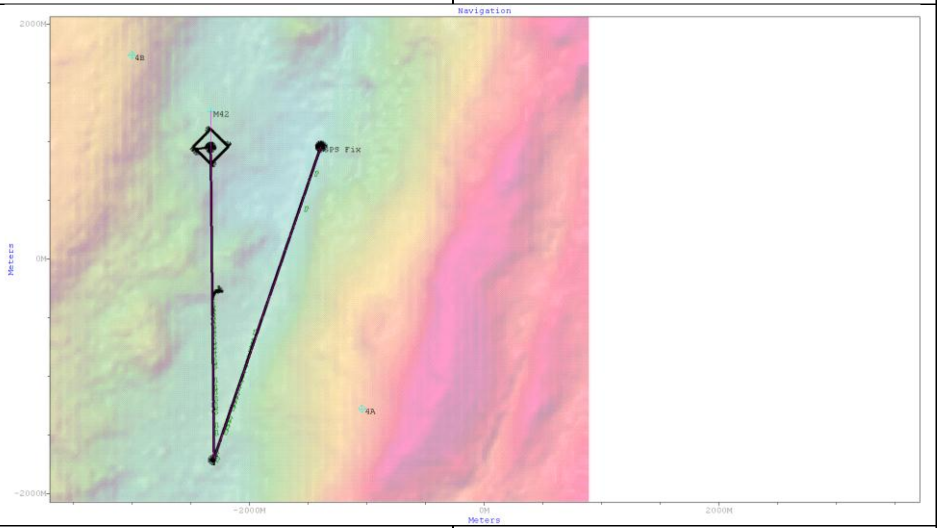
In total, 11 dives were completed in the central Atlantic south of the Azores (38°N, 32°W). ABYSS dives 40-50 were dedicated to oceanographic measurements and high-resolution seafloor mapping.

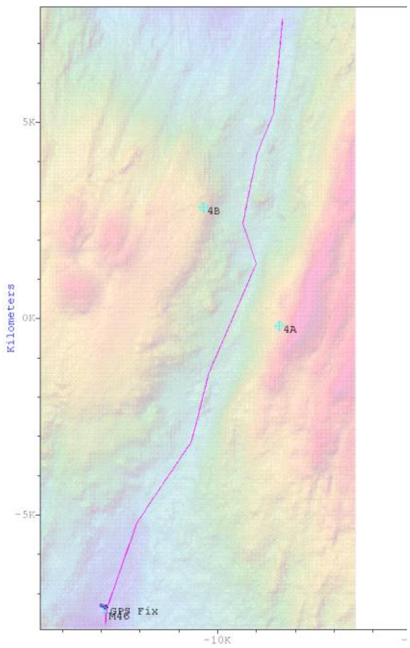
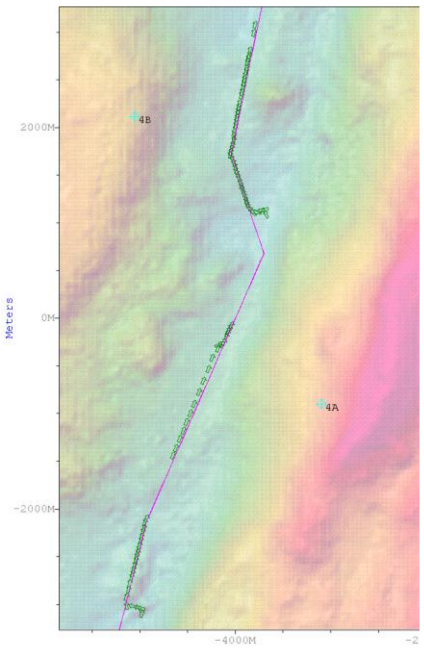
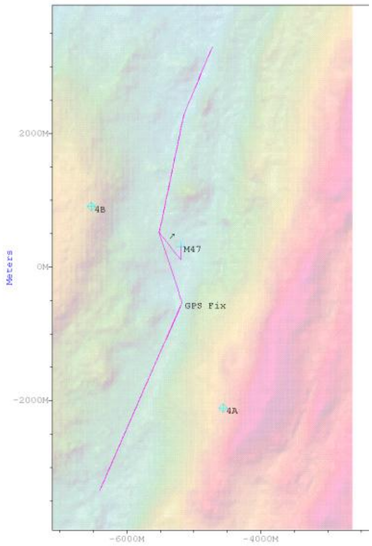
6.2 Timetable of events

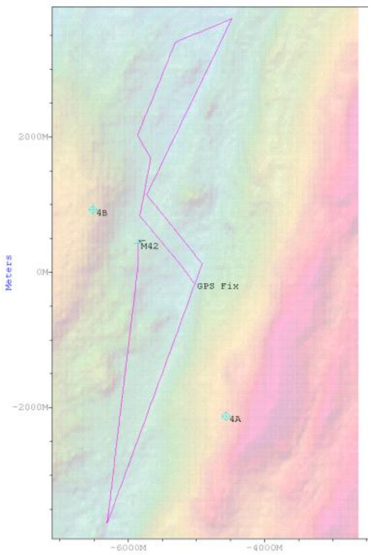
Day	Time (LT)	Plan	Result
15.08.10	12:36	*Mission: 040* DVL Calibration (Alignment between INS and DVL was required after maintenance of the DVL); Position south-west of the islands Faial and Pico (38° 00,195' N / 29° 19,088' W) <u>Instruments used:</u> RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	Results of the calibration got probably lost inside the RAM (no fatal influences but Keafott accepted less ADCP data than usual); a repetition is necessary
		 Vehicle positions	
15.08.10	15:43	Vehcile recovered	
16.08.10	14:05	Mission: 041 4 short dives to test the floatability of the AUV with micro-structure probe installed on the beams; AUV was escorted by zodiac. <u>Instruments used:</u> RDI ADCP Seabird Fastcat SBE49 CTD	Micro-structure probe doesn't cause obvious cutbacks for floatability, speed etc.; Ascent weight decreased to 12.5 kg

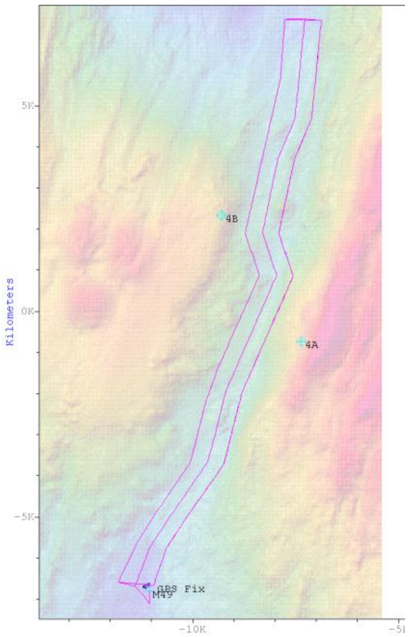
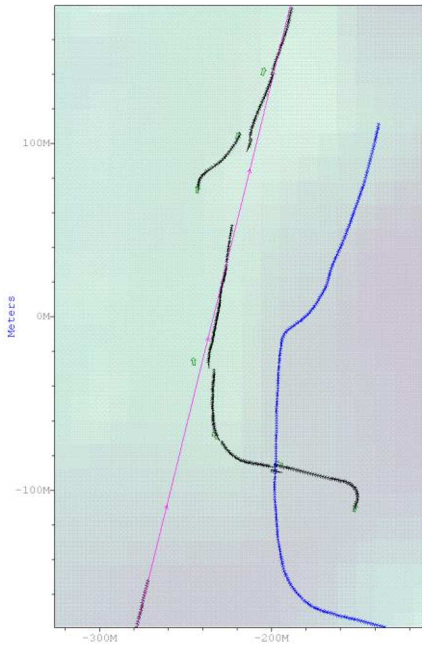
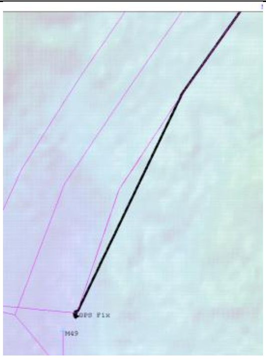
Day	Time (LT)	Plan	Result
		Wetlabs ECO FLNTU backscatter Rockland Micro-Structure Probe	
		 Mission 041: Fourth of four runs with max. depth of 100m	
16.08.10	15:21	Vehicle recovered	
17.08.10	12:58	***Mission: 042*** Mission to determine turbulent dissipation inside the channel and map bathymetry simultaneously; <u>Instruments used:</u> Micro-Structure Probe (MR) Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	Good mission; MR data is corrupted; Reson multibeam recorded files without vehicle attitude records
		 Planned mission	 Vehicle positions with transponder fixes
17.08.10	17:53	Vehicle recovered	

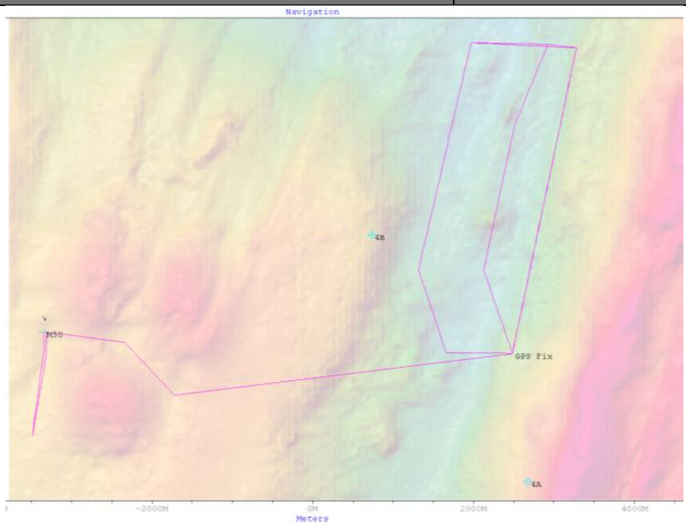
Day	Time (LT)	Plan	Result
18.08.10	09:52	***Mission: 043*** Mission was rerun of 42; <u>Instruments used:</u> Micro-Structure Probe (MR) Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	Mission aborted due to leak in vehicle tail section (small water drops inside oil). MR data is clean.
		 Mission 043 with ascent position after abort	
18.08.10	10:47	Vehicle recovered	
18.08.10	17:40	***Mission: 044*** Mission was rerun of 42; <u>Instruments used:</u> Micro-Structure Probe (MR) Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	Good mission; MR data is corrupted; Reson multibeam recorded files without vehicle attitude records
		 Last phase of mission	
18.08.10	22:26	Vehicle recovered	
19.08.10	15:50	***Mission: 045*** Short term mission to test the	Good mission; MR data is corrupted;

Day	Time (LT)	Plan	Result
		MR <u>Instruments used:</u> Micro-Structure Probe (MR) RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	
			
19.08.10	18:50	Vehicle recovered	
19.08.10	21:20	***Mission: 046*** Long term mission to determine turbulent dissipation during different tide phases; Sidescan was enabled to get a acoustical images of the deepest trench of the channel <u>Instruments used:</u> Micro-Structure Probe (MR) Edgetech 2200M Sidescan sonar RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	MR is corrupted (probably due to temperature); Sidescan didn't log due to comms failure; Misalignment between transponder pos and INS navigation

Day	Time (LT)	Plan	Result
		 Planned mission	 Transponder fixes (green arrows)
20.08.10	11:02	Vehicle recovered	
21.08.10	12:15	***Mission: 047*** Shallow water mission (depth 100m) to determine cause of MR failure <u>Instruments used:</u> Micro-Structure Probe (MR) RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	MR recorded good quality data.
		 Planned mission	
21.08.10	15:13	Vehicle recovered	
23.08.10	13:15	***Mission: 048*** Mission was a rerun of Mission 42 and 44; MR temperature problem was	MR recorded good-quality data; Reson multibeam recorded good data; Improved vehicle navigation after

Day	Time (LT)	Plan	Result
		fixed by Rockland technician; Reson multibeam: Vehicle attitude filter were added to the s7k file; Transponder positions were recalculated <u>Instruments used:</u> Micro-Structure Probe (MR) Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	revised transponder navigation;
			
23.08.10	18:10	Vehicle recovered	
24.08.10	14:50	***Mission: 049*** Long term mission to determine turbulent dissipation during different tide phases inside the Lucky Strike channel; Reson multibeam was enabled during the first three legs to map the channel <u>Instruments used:</u> Micro-Structure Probe (MR) Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	MR recorded good data; Reson Multibeam recorded good data; Mission aborted due to battery capacity of 10% (capa decreased to 5% abruptly)

Day	Time (LT)	Plan	Result
		 Planned Mission	 Vehicle navigation after the first transponder fixes
		 Mission aborted on the last part of the sixth leg due to battery capacity	
25.08.10	10:02	Vehicle recovered	
26.08.10	11:27	***Mission: 050*** Mission is split in a fix altitude and a fix depth part to figure out the difference in noise compensation caused by vehicle attitude (short side trip above the hydrothermal field of Lucky Strike at the beginning of the mission) <u>Instruments used:</u> Micro-Structure Probe (MR) Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter	MR recorded good data; Mission had to be aborted after 3 hours bottom time due to rough sea; Because of a failure the Sidescan was disabled and the Reson multibeam was used.

Day	Time (LT)	Plan	Result
		 Planned mission	
	16:02	Vehicle recovered	

7. Microstructure measurements aboard AUV Abyss

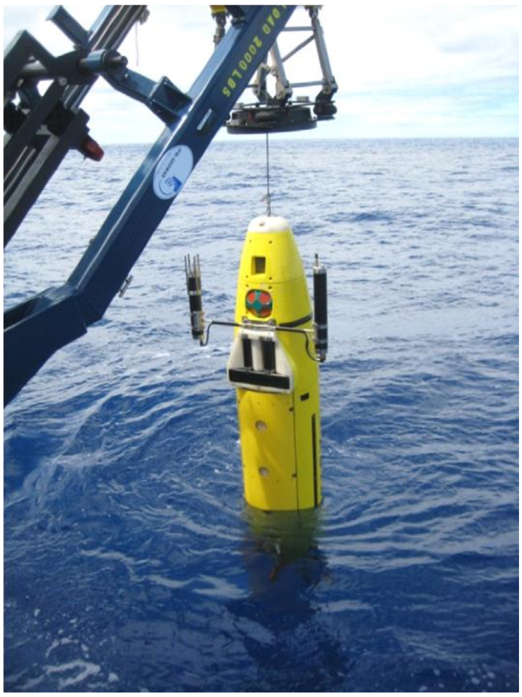
by Torsten Kanzow and Uwe Koy

7.1 Introduction

A MicroRider 6000 (MR) horizontal microstructure profiler from Rockland Scientific was mounted on the Remus 6000 AUV Abyss (Fig. 7.1, left). Our MR (S/N #045) is specifically adapted for the use on the AUV, and the mounting brackets and were designed such, that the instrument would fit inside the LARS for launch and recovery purposes. Our custom made MR consists of two pressure cases, with one housing the sensor electronics and the other the data recording unit. Power is supplied by the AUV, but data is stored internally in the MR. In addition to the mounting bracket the sensor pressure had been attached to the AUV by two extra rods in order to suppress vibration (Fig. 7.1, right).

The MR is used to estimate the rate of dissipation of turbulent kinetic energy. This parameter is required to derive diapyncal mixing in the ocean. For this the MR is equipped with 2 velocity microstructure shear probes and 2 fast response temperature probes. It also accommodates a 3-axis accelerometer (to remove platform vibration contamination from the shear measurements) and a pressure sensor.

The MR is operated with a sampling rate is 512 Hz. We found vibrations in the accelerometer measurements at well-define frequencies near 5, 10 and 25 Hz, originating from AUV motor and rudder. During the early deep dives (#1, 3, 4, 5) the MR data from the deep ocean is corrupted due to a temperature sensitivity in the data recording unit. The shallow dives (#2, 6) show good quality data. After fixing the temperature problem (section 7.3) good quality data was also recorded during the deep dives (#7, 8, 9).



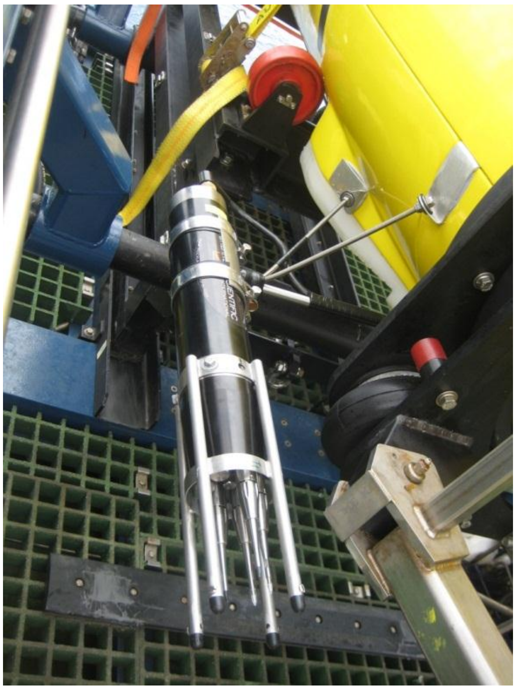


Fig. 7.1: Left: AUV with Microrider attached to its bow is launched over the stern of R/V Poseidon using the Launch and Recovery System (LARS). Right: The MR attached to AUV Abyss. To reduce contamination from vehicle vibrations, 3 mechanical connections between the sensor pressure case and the AUV were used from dive 7 onwards.

7.2. Deployments

This section details the MR deployments on AUV Abyss. Table 1 gives times, mission durations, sensor IDs and data file names. Table 7.2 specifies the calibration coefficients for the shear probes.

Cruise Dive ID AUV Dive ID	Launch date	Launch time	Duration [hh:mm]	Lat [N] / Lon [W]	S1 S2	T1 T2	Data file name [*.P]
01 / 42	17/08/10	12:54	04:56	37°17.8’ 32°14.1’	689 690	506 474	DAT19
02 / 43	18/08/10	09:33	00:54	37°17.8’ 32°14.1’	689 690	506 474	DAT024
03 / 44	18/08/10	17:53	04:47	37°17.8’ 32°14.2’	689 690	506 474	DAT027
04 / 45	19/08/10	15:52	15:17		689 690	506 474	DAT001
05 / 46	20/08/10	09:16	01:46	37°12.7’ 32°16.4’	689 690	506 474	DAT003
06 / 47	21/08/10	12:18	2:52		689 690	506 474	DAT019
07 / 48	23/08/10	13:14	04:56	37°17.9 32°14.3	689 690	506 474	DAT026
08 / 49	24/08/10	14:50	19:08	37°13.2 32°15.9	689 710	500 474	DAT026
09 / 50	26/08/10	11:27	4:34	37°17.6 32°17.5	686 710	500 474	DAT027

Table 7.1: Overview over the Microrider configuration during the different AUV dives.

Specific comments to the different dives:

Dive 1: Northern part of canyon. MR data corrupted soon after begin of diving operation. Step diving pattern. One bracket to hold sensor pressure case (as in Fig. 7.1).

Dive 2: Mission aborted at 120 m depth due to leakage warning. MR data looks clean.

Dive 3: Data cable between sensor pressure case and data recording case had not been installed to isolate if problem seen in dive 1 was due to power supply.

Dive 4: Long dive covering the entire canyon. Step diving pattern used (rather than terrain-following mode) to have less contamination of shear data from rudder motions. Data corrupted soon after start of diving operation.

Dive 5: Short deep dive to test new firmware and autoexec.bat. Data of MR corrupted. We found out during the deployment that new firmware was not properly installed.

Dive 6: Shallow dive to 100 m to check if MR works at high temperatures without producing bad buffers. This time new firmware installed. Second download provides data set with only very few bad buffers. First download (using Uwe's laptop) has majority of value as bad buffers.

Dive 7: Deep dive in step pattern to aprox. 2000 m in northern part of canyon. This was the first dive after Andre Sodermans and Uwe had replaced the electronics boards. MR provides good data from deep ocean for the first time! This is also the first time we had used 2 mechanical connections between the sensor pressure case and the AUV to reduce vibration.

Dive 8: Deep dive over 19 hours over 3 parallel 9 nm long courses along canyon. Data does not show bad buffers. MR appears to operate stable. From this dive onwards we used 3 Mechanical connections between sensor pressure case and AUV to further reduce vibration contamination of the shear data (as shown in Fig. 7.2). On one of the lines, the vehicle velocity was reduced from 3 kn to 2.7 kn to test the effect of vehicle velocity on noise in the shear measurements.

Dive 9: Deep dive starting at lucky Strike hydrothermal field (west of canyon), then descending into the valley and covering the northern part in 3 parallel lines. Good data returned from MR. Dive had to be aborted 3 hours before its scheduled termination because of steadily increasing wind gusts. Recovery at wind force 6. Terrain-following diving pattern chosen. No protection frame for the microstructure probes used, to test its effect on measurement noise levels.

Shear Sensor	**689**	**690**	**707**	**709**	**710**	**711**
Sensitivity V / $(m/s)^2$	0.0757	0.0674	0.0565	0.0617	0.0807	0.0793
Total Gain	1	1	1	1	1	1

Table 7.2: Calibration coefficients of the microrider shear probes.

7.3 Technical problems of the Microrider 6000: An experience report

Back in the lab in Kiel we had noticed that the newly delivered MR only showed reasonable data on both horizontal acceleration channels (Ax and Ay), but not on the vertical one (Az). Also, one temperature channel (T1) was missing. There was not time to do any more tests in the lab, as the MR had to be shipped soon after delivery.

On August 14 after departure from Ponta Delgada we started to test the MR. We had planned to replace the broken accelerometer by a new one that *Rockland Scientific* (the manufacturer of the MR) had delivered upon request free of charge. For this only the sensor pressure case was opened. The old accelerometer was disconnected and the new one connected instead. Subsequently the data acquisition was started, but Az was still not providing data! It became clear that the cause for the missing channel was not the accelerometer itself.

Switching on the MR with the lab power supply worked fine, but when we first tried to supply power from the AUV, the MR did not start the data acquisition. We found out that the plug MHDG-4-CCP of the power supply cable “Cable, Underwater AUV Power, Kanzow mR6000“ had been wired differently than the laboratory power cable. According to the drawing from Rockland Pin 1 is supposed to be Gnd and Pin 3 shoukd be +24 V. This is the case. However the plug the the lab cable has Pin 1 as Gnd and Pin2 as +24 V. After removing the connector in the data recording unit, a brigde was soldered between Pins 2 and 3. Now, both the AUV and the lab power cables work.

While reassembling the data recording pressure case after changing the power supply cable, a loose cable was spotted. It was cable 6 of the 10pol Molex that leads to the filter-ADC board. It turned out that this loose cable had caused the missing data on the T1 channel. After soldering the cable, T1 returned to supply data.

After this, however, the data streams of Ay and Az were gone! Inspection of the 10pol Molex connector to the filter ADC board with the ohmmeter revealed that no signal could be detected on pin 4. By very swiftly manually pulling the cables, the cable of pins 2, 3, and 4 came off without resistance. Most probably, the conductors had been broken already. The corresponding cables we subsequently soldered to the connectors. Subsequently, all sensor showed flawless data.

During dive #1 the instrument started giving good values in the beginning, but soon after starting its descending toward the sea floor, more and more "bad buffers" (bad data) occurred. At depth, most values were corrupted! We called Rockland to report to them the poor quality of the instrument, and we insisted to get wiring diagrams of the instrument. Diagrams plus new setup file arrived shortly afterward by email. The new setup file was supposed to give better results for long acquisition periods. A subsequent shallow dive (#2) gave good values (see section 7.2). This lead us to conclude that the MR might either have a malfunction at high pressures or at low temperatures.

To find out whether the problem was caused by the sensor electronics or by the power supply / data recording, we carried out another test dive where the data cable between the sensor pressure case and the data recording case was disconnected. Again, bad buffers occurred between 440 – 700 m and depths larger than 1100m the data was completely corrupted. Thus, the bad buffers did not originate from the sensor electronics.

To distinguish between a pressure and a temperature related problem, the data recording unit (without the sensor unit) was placed in the lab fridge at 4°C and was subsequently put in operation. After some time, bad buffers started to occur. The MR thus had a temperature related malfunction that did not depend on the power supply, but had to be internal to the data recording unit. At first, only sporadic bad buffers occurred, but after some time all data were recorded as bad buffers. In Motocross, bad buffers can be noticed by the following signature

L1 N0 **B**
L1 N0 **B**

Inspired by another email from Rockland - to further isolated the cause of the problem - a follow-up fridge test (August 20, 22:36) with new setup.txt and filter ADC board disconnected was carried out. In this configuration the MR does not report any bad buffers (23:36). This test had been conducted without pressure housing, to allow for a faster cooling of the electronics. When subsequently using the old setup in a fridge test, the bad buffers re-occurred.

To help Rockland diagnose the problem we measured the voltages at given test points, which were in agreement with the specifications. Power supply inside of the data recording unit thus was not the origin of the bad buffers. Data recorded by MR still contained bad buffers immediately after removing the instrument from the fridge. Warming the memory card by hand leads to good data being recorded. In the meantime Rockland was able to reproduce the temperature problem with one of their instruments in the lab. They found when exchanging the CF2 Interface board and the persistor and by changing a resistor on the Filter ADC board the problems were gone. We were able to convince Rockland to send one of their Software engineers, Andre Sodermans, to Flores, the island closest to our working area (the westernmost island of the Azores).

We had a 17 hour steam to Flores, and Andre arrived in the evening of August 22. Having taking him an board, we immediately steamed back to the working area and started working on the MR during the transit.

1) Change of CF2 Interface Board, including soldering of 4 interface cables and exchange of persistor

2) Change of resistor R9 at filter ADC board to one that had 60,4 Ohm.

3) Partial disassembly of power supply board and uploading of new firmware (P041R01-2010-07-02)

4) Re-assembly of electronic boards and upload of new firmware (P038R01-2010-06-28) of the Filter-ADC board. One of the column of the power supply boards broke, which however does not have any consequences for the operation.

5) A first test of the re-assemble MR (without pressure housing and without sensor unit connected) in the fridge gave no bad buffers for the duration of one hour.

6) In the morning the August 23, the data pressure case was closed, followed by a subsequent successful fridge test over three hours. On August 23 we conducted the first deep ocean AUV dive with the re-assembled MR for the duration of 5 hours. For the first time, the Microrider came back from the deep ocean without any bad buffers.

7) The next dive (#7) from August 24 in the afternoon until the following morning was conducted with success again

Things desired for the future:

a) a second DATA cable
b) a second PowerOn plug
c) a protective case covering all sensors
d) Schutzhauben für Sensoren im eingebautem Zustand
e) Tools: the ratchet with 3/8“drive is too big. A ¼“ ratchet would be ideal
f) Wiring diagrams of the electronic boards

The collaboration with Andre Sodermans was very constructive, efficient and successful.

8. Mooring Operations

by Uwe Koy, Torsten Kanzow, Chris Zappa

8.1 Introduction

On August 16, two moorings were deployed in the western canyon, M1 upstream and M2 downstream of the sill. The distance between M1 and M2 was approx. 3 nm. M1 was placed were historical measurements indicated the existence of a hydraulic jump, and M2 was located at a site of weaker mean flow. Together M1 and M2 were established to test the existence of upstream propagating bores during weakening tides. On August 21, after analyses of the LADCP data close to M1 implied, that this site was already in the subcritical domain, we recovered and immediately redeployed it (as M1_2) about 4 cables south of its original position. In M1_2 the upper Microcat and the ADCP are 20 m more distant from the seabed than was the case in M1, as a 10 m long wire got damaged upon recovery and had to be replaced by a 30 m long wire. M2 and M1_2 were recovered already on August 25 (i.e., 2 days earlier than scheduled) to avoid recovery during high-wind conditions.

8.2 Mooring operations

The aim was to position the moorings precisely on the desired locations. Therefore all moorings were deployed anchor-first. The work was carried out over the port side using the hydraulic boom and winches W3 and W4. When all mooring components were in the water, the deep-sea wire of W3 was connected to the top float of the mooring with an acoustic release, so that the mooring could be lowered very close to the sea bed. At a distance of 50 m between anchor and seabed, and with the vessel being precisely at the planned deployment site, the upper release was opened, thus allowing the mooring to sink to the sea bed. Subsequently, the actual mooring location was determined precisely by acoustic triangulation. Mooring recoveries were carried out over the port side, using the boom and winches 3 and 4.

ID	Latitude [N]	Longitude [W]	Water depth	Date deployed	Time depl.	Date released	Time rel.
M1	37°17.82‘	32°13.88‘	2140	16/08/2010	11:00	21/08/2010	10:00
M2	37°14.98’	32°25.00‘	2165	16/08/2010	18:10	25/08/2010	10:48
M1_2	37°17.40‘	32°13.89	2120	21/08/2010	17:40	25/08/2010	12:24

Table 8.1: Moorings deployed and recovered during the P403 campaign.

Mooring	Position		Water Depth	Mooring Length
M 1	37° 17.82‘ N	032° 13.88‘ W	2140 m	170 m
Senor Depth	Instruments	Type	Identification	
1970 m	Argos WatchDog		ID: 12620	
2015 m	DevilLogic – Modem			
2017 m	RDI WorkHorse	300 kHz	Ser # 1972	
2029 m	SeaBird MicroCat # 2262	IMP	Ser # 2262	
2082 m	HRCDS			
2116 m	SeaBird	IMP	Ser # 3757	

	MicroCat			
2126 m	Oceano Releaser	RT661	Ser# 107	

Table 8.2: Sensor distribution on mooring M1

Mooring	Position		Water Depth	Mooring Length
M 1_2	37°17.40‘ N	032°13.89‘ W	2120 m	170 m
Senor Depth	Instruments	Type	Identification	
1931 m	Argos WatchDog		ID: 12620	
1975 m	DevilLogic – Modem			
1977 m	RDI WorkHorse	300 kHz	Ser # 1972	
1989 m	SeaBird MicroCat # 2262	IMP	Ser # 2262	
2042 m	HRCDS			
2096 m	SeaBird MicroCat	IMP	Ser # 3757	
2106 m	Oceano Releaser	RT661	Ser# 107	

Table 8.3: Sensor distribution on mooring M1_2

Mooring	Position		Water depth	Mooring length
M 2	37°14.98’ N	32°25.00‘W	2165 m	170 m
Sensor Depth	Instruments	Type	Identification	
1966 m	Argos WatchDog		ID:	
2030 m	RDI WorkHorse	300 kHz	Ser # 680	
2036 m	SeaBird MicroCat # 2262	IMP	Ser # 3753	
2104 m	HRCDS		Ser #	
2139 m	RCM 8		Ser #10504	
2141 m	SeaBird MicroCat	IM	Ser # 2260	
2151 m	Oceano Releaser	RT661	Ser# 107	

Table 8.4: Sensor distribution on mooring M2

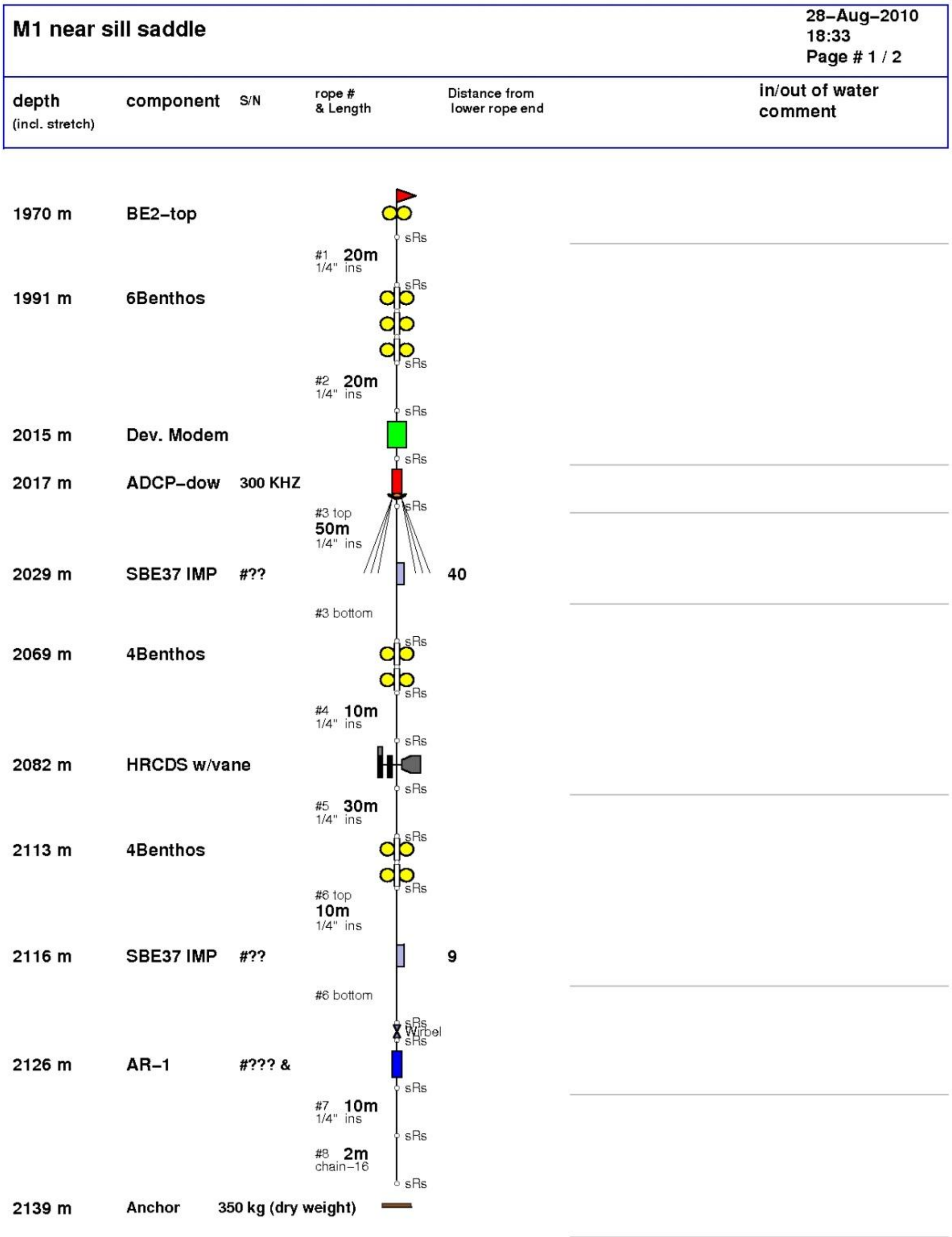


Fig 8.1: Schematic of mooring M1 downstream of the sill.

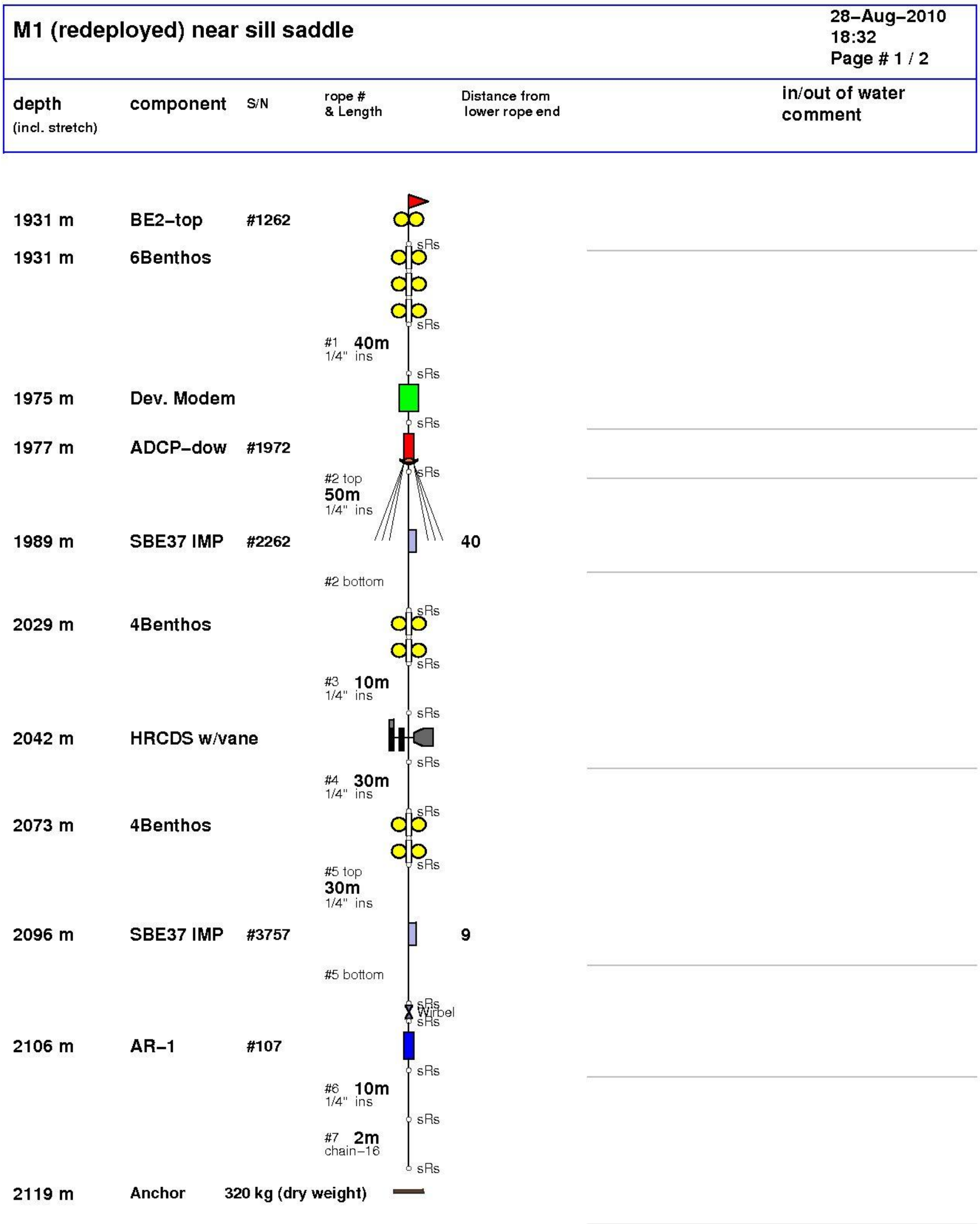


Fig. 8.2: Schematic of mooring M1_2. It contains the instrumentation of mooring M1, however differs slightly with M1 in terms of wire lengths. M1 was recovered and redeployed (under the name M1_2) about 4 cables upstream of the original M1 site on August 21, to move the mooring into a regime of higher flow speeds.

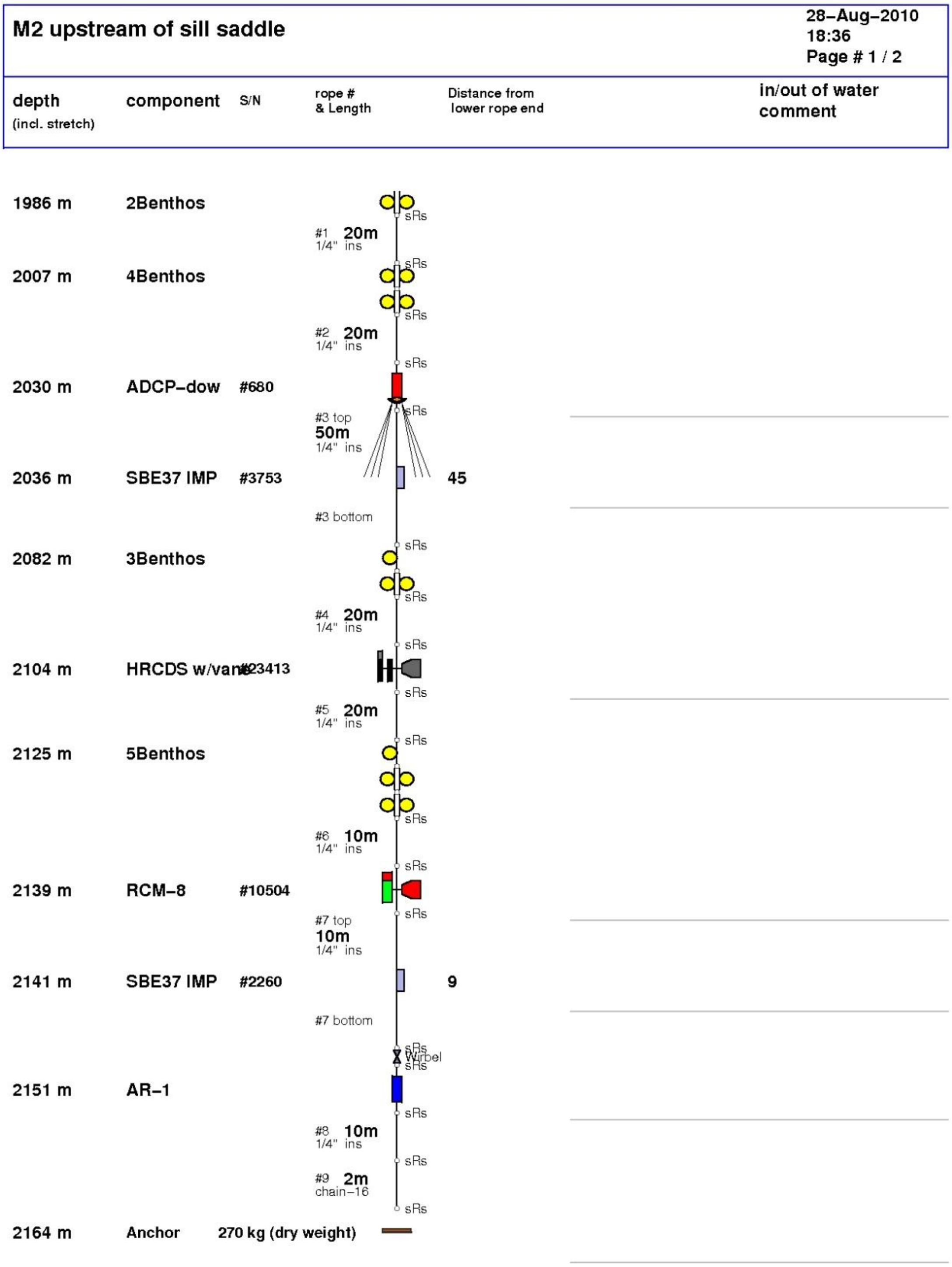


Fig. 8.3: Schematic of mooring M2 upstream of the sill.

8.3 Instrument settings

8.3.1 Mooring M1

IFM-GEOMAR Watchog ID:

HamNode Modem mit WH-ADCP 300kHz

WH-ADCP 300 kHz # 1972

CR1 CF11111 EA0 EB0 ED20000 ES35 EX11111 EZ1111101 WA50 WB0 WD111100000 WF0 WN25 WP10 WS800 WV175 TE00:00:20.00 TP00:00.56 CK CS	;Instrument = Workhorse Monitor ;Frequency = 307200 ;Water Profile = YES ;Bottom Track = NO ;High Res. Modes = NO ;High Rate Pinging = NO ;Shallow Bottom Mode= NO ;Wave Gauge = NO ;Lowered ADCP = YES ;Ice Track = NO ;Surface Track = NO ;Beam angle = 20 ;Temperature = 5.00 ;Deployment hours = 312.00 ;Battery packs = 1 ;Automatic TP = NO ;Memory size [MB] = 256 ;Saved Screen = 1 ; ;Consequences generated by PlanADCP version 2.05: ;First cell range = 8.36 m ;Last cell range = 200.36 m ;Max range = 130.97 m ;Standard deviation = 0.55 cm/s ;Ensemble size = 654 bytes ;Storage required = 35.03 MB (36728640 bytes) ;Power usage = 412.33 Wh ;Battery usage = 0.9 ; ; WARNINGS AND CAUTIONS: ; Advanced settings have been changed. ; Expert settings have been changed.

The ensemble interval (TE) of the 300 KHz ADCP had been twice during the deployment via acoustic telemetry (see section 8.4).

SeaBird Microcat # 2262
Setup:
SBE37-IM V 2.1 SERIAL NO. 2262 15 Aug 2010 22:43:58
not logging: received stop command
sample interval = 5 seconds
samplenumber = 1724, free = 188926
store time with each sample
do not transmit sample number

A/D cycles to average = 4
temperature = 28.79 deg C

Nortek AQD Aquadop HR Profiler von Chris Zappa
Ser# 6524 ; 512 samples at 4Hz, Burst 600s
Start: 16.08.2010 / 09:14 UTC
Stop: 25.08.2010 / 12:32 UTC

Nobska MAVS Modular Acustic Velocity System von Andreas Thurnherr
Ser# 10138 ; 8200 Samples; 10 HZ; 3600s Burst
Start: 16.08.2010 / 09:14 UTC
Stop: 25.08.2010 / 21:46 UTC

SeaBird Microcat # 3757
Setup:
SBE37-IM V 2.3 SERIAL NO. 3753 15 Aug 2010 23:02:49
not logging: received stop command
sample interval = 5 seconds
samplenumber = 1737, free = 188913
store time with each sample
do not transmit sample number
A/D cycles to average = 4
internal pump not installed
temperature = 28.00 deg C
Oceano Releaser Ser# 107

8.3.2 Mooring M2

IFM-GEOMAR Watchog ID:

TRDI WH-ADCP 300 kHz # 0680

CR1 CF11101 EA0 EB0 ED20000 ES35 EX11111 EZ1111101 WA50 WB0 WD111100000 WF0 WN25 WP10 WS800 WV175 TE00:00:20.00 TP00:00.56 CK CS	;Instrument = Workhorse Monitor ;Frequency = 307200 ;Water Profile = YES ;Bottom Track = NO ;High Res. Modes = NO ;High Rate Pinging = NO ;Shallow Bottom Mode= NO ;Wave Gauge = NO ;Lowered ADCP = NO ;Ice Track = NO ;Surface Track = NO ;Beam angle = 20 ;Temperature = 5.00 ;Deployment hours = 312.00 ;Battery packs = 1 ;Automatic TP = NO ;Memory size [MB] = 41 ;Saved Screen = 1 ; ;Consequences generated by PlanADCP version 2.05: ;First cell range = 8.36 m

	;Last cell range = 200.36 m ;Max range = 130.97 m ;Standard deviation = 0.55 cm/s ;Ensemble size = 654 bytes ;Storage required = 35.03 MB (36728640 bytes) ;Power usage = 410.38 Wh ;Battery usage = 0.9 ; ; WARNINGS AND CAUTIONS: ; Advanced settings have been changed. ; Expert settings have been changed.

SeaBird MicroCat ser: #3753
Setup:
SBE37-IM V 2.3 SERIAL NO. 3753 15 Aug 2010 23:02:49
not logging: received stop command
sample interval = 5 seconds
samplenumber = 1737, free = 188913
store time with each sample
do not transmit sample number
A/D cycles to average = 4
internal pump not installed
temperature = 28.00 deg C

Aanderaa Strömungsmesser RCM8 ser# 10504
Interval 5 min
Temperaturrange:
Gestarted: 16.08.2010 / 16:00 UTC Records : ? nicht 0!
Gestoppt: 28.08.2010 / 07:20 UTC Records : 20215

Nortek AQD Aquadop HR Profiler von Chris Zappa
Ser# 3132 ; 256 samples at 2 Hz, Burst 600s
Start: 16.08.2010 / 16:35 UTC
Stop: 25.08.2010 / 15:52 UTC

SeaBird MicroCat ser: #2260
Setup:
SBE37-IM V 2.1 SERIAL NO. 2260 15 Aug 2010 22:56:43
not logging: received stop command
sample interval = 5 seconds
samplenumber = 1856, free = 231160
store time with each sample
do not transmit sample number
A/D cycles to average = 4
reference pressure = 0.0 db
temperature = 28.26 deg C

Oceano Releaser Ser# 173

8.4 High-Resolution Pulse-to-Pulse Coherent Doppler Sonars

As part of the M1 and M2 moorings deployed during the P403 cruise, pulse-to-pulse coherent Doppler sonars were added to the instrumentation of the mooring for measurements of the turbulence and mixing near the ocean bottom due to flows over bottom topography (i.e., sills) within two channels of a larger ridge valley near Lucky Strike. The coherent Doppler sonars are Nortek model Aquadopp HR profilers and measure the current velocity. The Aquadopp HR profilers operate at a transmit frequency of 2 MHz and have a firmware upgrade that allows for a high-resolution mode with bin sizes capable of 13 mm to capture the inertial-dissipation range for turbulent kinetic energy (TKE) dissipation rate estimates. The Aquadopp HR profilers have a custom sensor head with 3 beams; two orthogonal beams in a plane that is orthogonal to the cylindrical axis and a third beam that is directed upward 45° to this plane and 45° between the two horizontal orthogonal beams.

For the moorings M1 and M2, one coherent Doppler sonar was placed on each mooring nominally at 60m from the bottom of the ocean. An Aquadopp HR profiler was placed on a vane system as shown in Figure 1. The sonar was placed forward with Beam 1 directed forward in-stream with the vane.

For the vane system on mooring M1, the Aquadopp HR profiler was paired with a Nobska Modular Acoustic Velocity System (MAVS) as shown in Figure 1. The MAVS transmits at 1.77 MHz and was mounted behind the Aquadopp HR profiler. The MAVS (Modular Acoustic Velocity Sensor) measures 3-axis velocity at a single point (1000 cm^3). The MAVS employs a differential travel-time measurement technique. The MAVS has a custom multi-transducer/receiver probe array and the probe volume is roughly 20 cm above the Aquadopp HR forward-looking Beam 1. The objective of the MAVS paired with the coherent Doppler sonar is to test the efficacy of the Taylor frozen field hypothesis in deep-ocean environments.

For the Aquadopp HR profiler on mooring M1, the system was set to sample one (Beam 1) of the three possible beams to maximize the sample rate at 4 Hz. The system sampled the along-beam velocity in 53 bins each with a size of 26 mm with a profile range of 1.38 m. The first 5 cm is considered the blanking distance and are not useful data. The nominal velocity range in each bin is ±10.5 cm s^{-1}. 512 pings were sampled every 10 minutes for the Aquadopp HR profiler on M1. The Aquadopp HR profiler on M1 was configured to last for roughly 12 days of operation.

For the Aquadopp HR profiler on mooring M2, the system was set to sample two (Beams 1 & 2) of the three possible beams to get the in-line and cross-line flow. The sample rate was 2 Hz. The system sampled the along-beam velocity in 53 bins each with a size of 26 mm with a profile range of 1.38 m. The first 10 cm is considered the blanking distance and are not useful data. The nominal velocity range in each bin is ±25.0 cm s^{-1}. 256 pings were sampled every 10 minutes for the Aquadopp HR profiler on M2. The Aquadopp HR profiler on M2 was configured to last for roughly 12 days of operation.

For the Nobska MAVS on mooring M1, the system was set to sample at 10 Hz. The system sampled the 3-dimensional velocity in the sample volume with a size of 1000 cm^3. The nominal velocity range is ±200 cm s^{-1} with an accuracy and resolution of ±0.3 cm s^{-1} and ±0.03 cm s^{-1}, respectively. 8200 samples (13.7 minutes) were made every hour on the hour. The Nobska MAVS was configured to last for roughly 5 days of operation. MAVS started on

22 August 2010 at noon and stopped at 21:46 pm 25 August 2010 UTC which gives 82 bursts.

Figure 8.4: Picture of the vane system for mooring M1 with one Aquadopp HR profiler and one MAVS.

Instrument	Serial	Depth (m)	Orientation	Samples	Sample Rate (Hz)	Burst Interval (s)	Start Date	Start Time (UTC)	Deploy Date	In-Water Time (UTC)
Nortek AQD	6524	2042	M1: One In-Line	512	4	600	16-Aug-10	0800	16-Aug-10	0914
Nobska MAVS	10138	2042	M1: All	8200	10	3600	22-Aug-10	1200	16-Aug-10	0914
Nortek AQD	3132	2039	M2: One In-Line	256	2	600	16-Aug-10	0800	16-Aug-10	1635
			M2: One Cross-Line							

Table 8.5: Cruise P403 M1 and M2 Deployment setup for the pulse-to-pulse coherent Doppler sonars and MAVS.

Instrument	Serial	Depth (m)	Orientation	Samples	Sample Rate (Hz)	Burst Interval (s)	Recover Date	Recover Time (UTC)	Re-Deploy Date	In-Water Time (UTC)
Nortek AQD	6524	2042	M1: One In-Line	512	4	600	21-Aug-10	1057	21-Aug-10	1554
Nobska MAVS	10138	2042	M1: All	8200	10	3600	21-Aug-10	1057	21-Aug-10	1554

Table 8.6: Cruise P403 M1 Re-Positioning.

Instrument	Serial	Depth (m)	Orientation	Samples	Sample Rate (Hz)	Burst Interval (s)	Recover Date	Release Time (UTC)	Stop Date	Stop Time (UTC)
Nortek AQD	6524	2042	M1: One In-Line	512	4	600	25-Aug-10	1224*	25-Aug-10	1232
Nobska MAVS	10138	2042	M1: All	8200	10	3600	25-Aug-10	1224*	25-Aug-10	2146
Nortek AQD	3132	2039	M2: One In-Line	256	2	600	25-Aug-10	1224*	25-Aug-10	1552
			M2: One Cross-Line							

*Table 3. Cruise P403 M1 and M2 Recovery for the pulse-to-pulse coherent Doppler sonars and MAVS. * Acoustic release time noted since no out of water times were given because the instruments were tangled. 1330 is the estimated time when the final piece of the mooring came on deck.*

8.5 The Ham.node hydroacoustic modem

Mooring M1 downstream of the sill contained a frame housing a 300 KHz downward looking ADCP connected via serial port to the HAM.NODE hydroacoustic modem (Fig. 8.5), at roughly 130 m above the sea bed (Fig. 8.1). Initially the ADCP had an ensemble rate (TE) of 20 s.

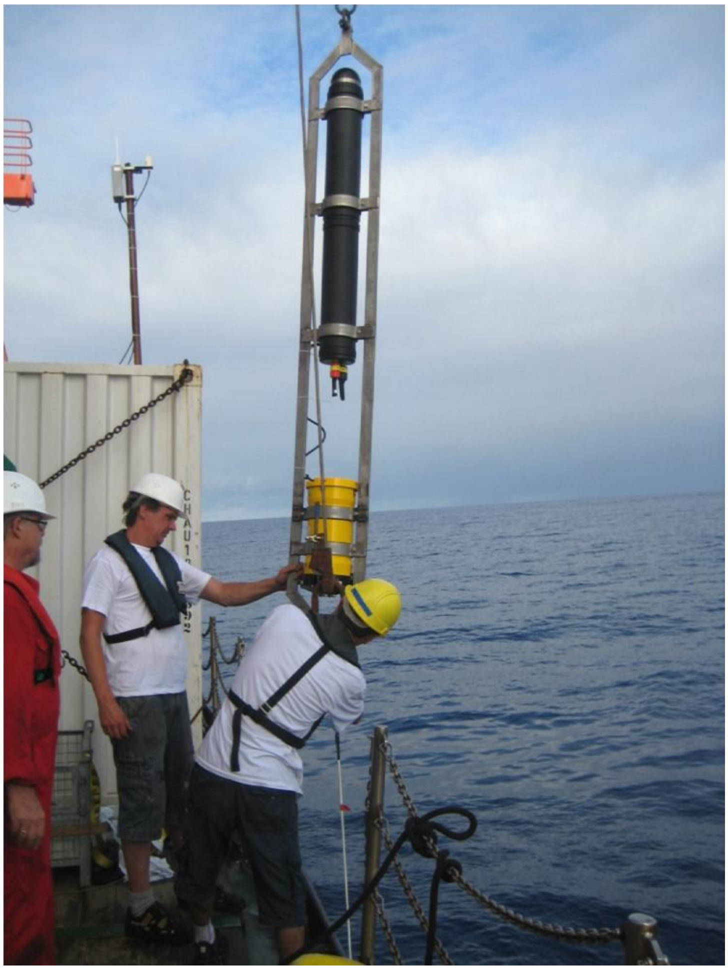


Fig. 8.5: Upward looking HAMNODE modem connected to 300 KHz ADCP in a frame used in mooring M1. Also shown (left to right) are Uwe Koy, Frank Schrage (basun) and Bernd Hänel (seaman).

Laboratory preparations and tests

Both surface and mooring modems were tested in the lab. For this the Hamnode interrogation software was started using hamnode.bat. Several problems occurred. Setting the time to UTC (via *local system →set system time*) in the modems was only possible by setting the time of the computer (to which the modems were connected via serial interface) one hour off, as the modem time was always offset by one hour to the computer time. The communication settings were an issue, too. Under *settings → port settings* the following was selected (Baud rate: 57600; Data bits: 8; Parity: none; Stop bits: 1; and flow control: none). In *local system ➔serial interface setup* the following was set …..TO BE COMPLETED

In *remote system → serial interface setup* the settings were ….TO BE COMPLETED

Then we connected the mooring modem to the ADCP serial port and tested the communication. The initial settings of the ADCP were 20 s for the ensemble interval (TE). When starting the interrogation with the ADCP via the ship modem ←→mooring modem connection, we were surprised that the number of records shown in the remote modem did only increase at a very low rater (2-3 per hour rather than the expected 1 every 20 sec). In a phone call the manufacturer (Markus Motz from Develogic) told us that TE should at least be 40 s in order for the modem to interrogate properly with the ADCP.

It was a major difficulty to close the mooring modem end caps. There is hardly enough space for the interior connectors und wiring to fit in, and it seems easy to break connectors when trying to close the pressure case. This is a design flaw.

Communication after mooring deployment

The mooring was deployed on 16/08/2010 at 10:55 (UTC). A **first attempt** to communicate with the mooring modem was carried out at 11:40. At this point the vessel held position right on top of the mooring drop point.

11:41 The communication to the ship modem (local modem) was excellent,

11:44 Communication to the remote modem prove difficult. We managed to have the remote modem report its directory structure by selecting *remote file browser →refresh root* in the hamnode software. However, when clicking on the data directory, the data file list from the remote from was not transmitted. We attempted this several times, though without success.

12:15 Repeated communication to remote modem. Same result as before (directory structure shown but file list not).

12:28 Shut down and restarted hamnode software.

12:31 Managed to get number of records (#765) in remote modem (remote system → DataLogger Setup →Remote Record ID)

12:33 Successfully increased TE in the ADCP to 60 sec using the following command (in the *command* window of the *console*):

set r.smm.adcp_interval=60

Second attempt to communicate to the mooring modem was carried out the same evening. This time the vessel held position **3 cables away from the mooring**, to avoid possible shadow effects from mooring components. Communication was indeed much improved compared to the first test.

18:22 Connect to local modem excellent

18:24 Remote modem reported 2552 ADCP records. The increase in records compared to 12:31 agrees with TE=60 sec.

18:25 Directory and file list on remote modem received

18:21 Download of file 775.PI (took 2 minutes)

18:25 Request started to download all files from remote modem

20:55 Pressed *cancel* bottom (below console) after connection got bad ➔10 of 20 files were transmitted successfully. The connection probably got bad because the modem did not point down vertically due to the vessel trying to hold position in strong surface currents. Told brigde to drift with current. Consequently, the connection improved drastically - and several more files were downloaded without errors

The **third data retrieval** was carried out on 18.8.2010. This time the distance to M1 was 1 nm, corresponding to a slant range of 2800 m.

12:12 received ADCP record ID: 3620

12:14 remote modem directory structure received

12:16 requested remote modem file list

12:17 file list receive

12:21 file retrieval requested. It takes about 2:40 (mm:ss) per 17 kB file.

12:44 download stopped

12:59 ADCP record ID on remote modem: 3672. This means that 1 file per minute is generated (which makes sense for TE=1min).

Conclusion: The Hamnode underwater modem prove to be rather reliable in transferring data, reporting the ADCP status and changing ADCP settings. We strongly recommend that a slightly larger pressure housing should be used to allow the user to close the housing with less effort.

9. CTD

by Andreas Thurnherr and Christopher Zappa

9.1 Introduction

The CTD system used on P403 consisted of a SeaBird SBE 9-plus CTD mounted on a rosette with 5 or 6 Niskin bottles and connected to a SeaBird SBE 11 deck unit. In addition to the single pressure sensor, the CTD was equipped with dual pumped sensors for conductivity, temperature and oxygen. Auxiliary instruments included a Fluorometer [Dr. Haardt Chlorophyll a], a Chelsea Instruments Mk.III Aqua Tracka configured as a nephelometer, as well as high-sensitivity (5NTU range) SeaPoint Turbidity Sensor (STS), the last of which was used from cast 7 onward, as well as one or two ADCPs (see section 10). Shipboard GPS data was merged into the CTD data stream in the SBE 11 deck unit. For safety, the rosette was also equipped with a bottom-contact switch triggered by a cylindrical steel weight suspended 20m (cast 1), 13.5m (casts 2-8), and 10.0m (remaining casts) below the rosette. The short length of the bottom-switch-line ensured that only the first LADCP bin was affected by sideline interference from the suspended weight.

The following protocol was used for standard (not to-yo and yo-yo) CTD/LADCP casts:

1. Deploy instrument and lower to depth of ~20m (10m wire-out display)
2. Wait until pumps turn on and both oxygen readings stabilize
3. Return CTD to the surface
4. Lower to 200m with a winch speed of 0.5 m s^{-1}
5. Increase wind speed to 1.0 m s^{-1}
6. Lower to 20-50m above the seabed (as determined from the echosounder) at 1.0 m s^{-1}, slowing down the winch speed to 0.5 m s^{-1} shortly before the bottom stop
7. Carry out the upcast at 1.0 m s^{-1}, stopping for bottle samples
8. Bottle samples were taken at the bottom and, for most casts, at 1700m, 1000m, 500m, and at 20m; bottles were triggered 30s after the winch was stopped; for casts starting with 29, water was collected only at the bottom and at 20m
9. After the final bottle stop at 20m, raise the CTD to the surface, stop, and bring it on deck
10. Collect water samples from non-leaking Niskins for post-cruise salinity analysis and calibration
11. Rinse the entire CTD system (except for the deck box), paying particular attention to the pump paths and the optical instruments

Standard CTD/LADCP casts were collected at the stations shown in Fig. 9.1. Additionally, a 7-hour yo-yo (station 15) was carried out at 37° 17.22'N 32° 14.19'W and three tow-yos (stations 30-32) were carried out between mooring M2 and the original location of the M1 mooring. Preliminary data processing was carried out using SeaBird software with standard IfM-Geomar CTD-processing scripts, resulting in 1dbar and 1second-averaged files.

Important Notes:

1) The automated program that sets the CTD to the GPS clock had a bug and assigned random non-UTC times (off by up to several hours). Turned off program at cast 16 and

time was manually set for the rest of the casts.
2) STS cable was homemade by Uwe Koy
3) See separate list of CTD Notes for individual casts

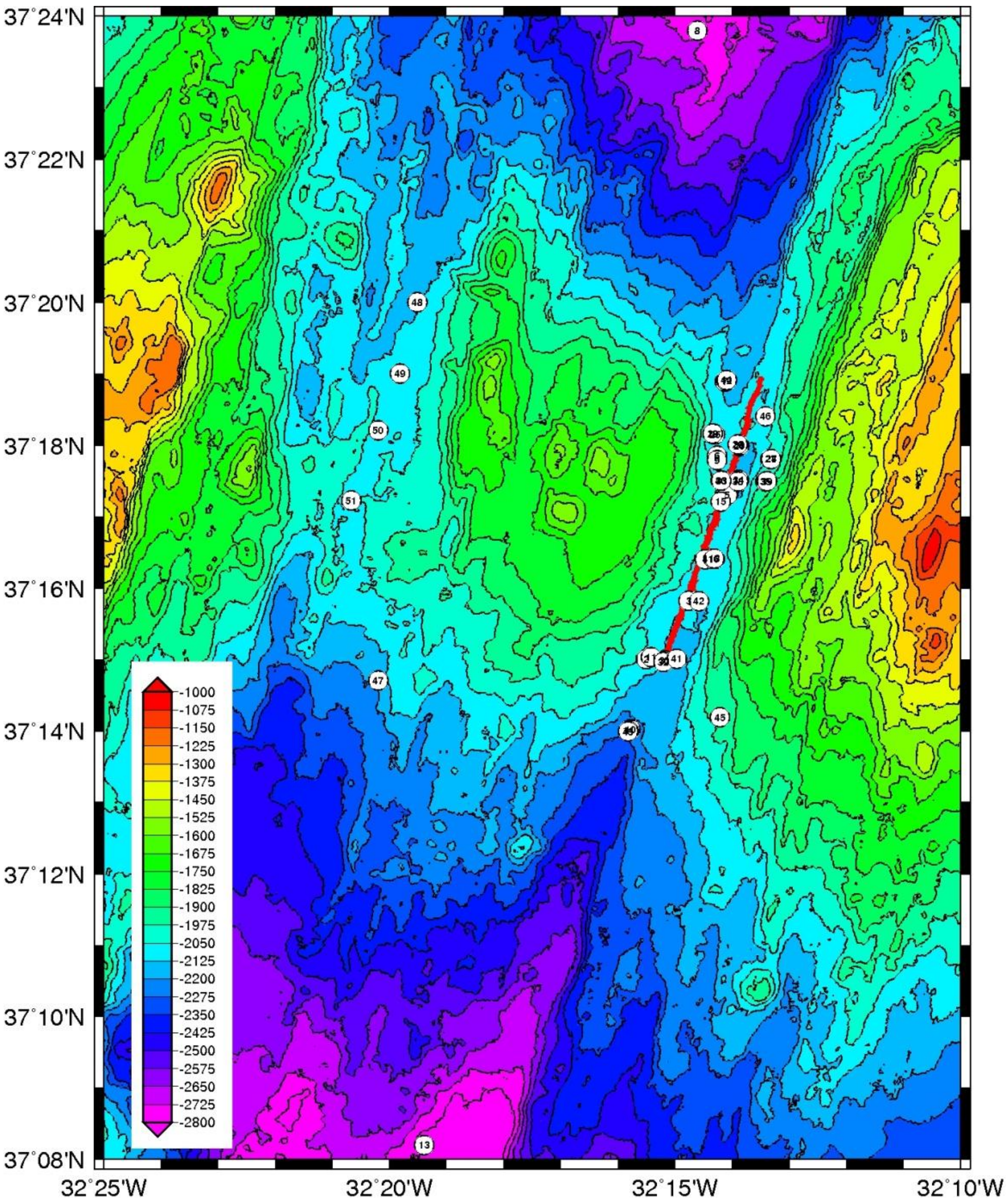


Fig. 9.1: Topography of the Lucky Strike segment center and CTD / LADCP stations. The red line shows the tow-yo track occupied three times (stations 30-32).

9.2 Station Logsheet

Cast	Date	Time [UTC]	Lat	Lon	Depth CTD [m]	Depth Water [m]	Notes
1	14.08.2010	18:15	37°41.0N	26°42.0W	--	2346	1
2	17.08.2010	00:47	37°15.0N	32°15.5W	2040	2065	1

3	17.08.2010	02:28	37°15.8N	32°14.8W	2081	2109	1
4	17.08.2010	04:27	37°16.4N	32°14.5W	2029	2063	1
5	17.08.2010	06:23	37°17.3N	32°14.1W	2040	2098	1,2
6	17.08.2010	08:09	37°17.9N	32°14.3W	2020	2050	1,2
7	17.08.2010	21:56	37°18.9N	32°14.1W	2086	2118	2
8	18.08.2010	00:13	37°23.8N	32°14.6W	2716	2758	
9	18.08.2010	02:40	37°17.8N	32°14.3W	2022	2046	
10	18.08.2010	04:58	37°14.0N	32°15.8W	2201	2218	
11	18.08.2010	06:54	37°15.0N	32°15.4W	2051	2072	
12	18.08.2010	23:17	37°18.9N	32°14.1W	--	2112	
13	19.08.2010	02:07	37°08.2N	32°19.4W	2774	2788	
14	19.08.2010	04:50	37°14.0N	32°15.8W	2195	2220	
15	19.08.2010	07:00	37°17.2N	32°14.2W	1993	2042	3
16	19.08.2010	23:04	37°16.4N	32°14.3W	2030	2075	
17	20.08.2010	02:19	37°16.4N	32°14.3W	2032	2068	
18	20.08.2010	05:15	37°16.4N	32°14.3W	2025	2068	
19	20.08.2010	12:20	37°18.2N	32°14.3W	2060	2085	
20	20.08.2010	13:54	37°18.0N	32°13.9W	2080	2110	
21	20.08.2010	15:26	37°17.8N	32°13.3W	1982	2013	
22	20.08.2010	20:25	37°18.1N	32°14.3W	2042	2092	
23	20.08.2010	22:00	37°18.0N	32°13.9W	2071	2110	
24	20.08.2010	23:33	37°17.8N	32°13.3W	1972	2013	
25	21.08.2010	01:07	37°18.2N	32°14.3W	2044	2087	
26	21.08.2010	03:02	37°18.0N	32°13.9W	2070	2110	
27	21.08.2010	04:50	37°17.8N	32°13.3W	1980	2010	
28	21.08.2010	06:47	37°18.2N	32°14.3W	2041	2091	
29	21.08.2010	08:26	37°18.0N	32°13.9W	2079	2118	
30	23.08.2010	19:26	37°15.0N	32°15.2W	2111	2120	4
31	24.08.2010	01:16	37°15.0N	32°15.2W	2096	2116	4,5
32	24.08.2010	07:26	37°15.0N	32°15.2W	1985	2117	4,5
33	24.08.2010	16:40	37°17.5N	32°14.2W	2066	2139	
34	24.08.2010	18:17	37°17.5N	32°13.9W	2104	2141	
35	24.08.2010	20:06	37°17.5N	32°13.4W	1909	1959	
36	24.08.2010	21:53	37°17.5N	32°14.2W	2089	2100 ± 60	
37	24.08.2010	23:29	37°17.5N	32°13.9W	abort	2146	6
38	25.08.2010	02:26	37°17.5N	32°13.9W	2100	2142	
39	25.08.2010	04:26	37°17.5N	32°13.4W	1896	1972	
40	25.08.2010	06:01	37°17.5N	32°14.2W	2010	2035	
41	26.08.2010	00:04	37°15.0N	32°15.0W	2116	2165	7
42	26.08.2010	01:43	37°15.8N	32°14.6W	2083	2122	
43	26.08.2010	03:22	37°14.0N	32°15.8W	2175	2216	
44	26.08.2010	05:46	37°18.9N	32°14.1W	2075	2106	
45	26.08.2010	07:57	37°14.2N	32°14.2W	1904	1955	
46	26.08.2010	13:13	37°18.4N	32°13.4W	1977	2108	
47	26.08.2010	17:59	37°14.7N	32°20.2W	2160	2199	
48	26.08.2010	20:37	37°20.0N	32°19.5W	2084	2121	
49	26.08.2010	22:24	37°19.0N	32°19.8W	2025	2080	
50	27.08.2010	00:47	37°18.2N	32°20.2W	2040	2055	
51	27.08.2010	03:39	37°17.2N	32°20.7W	abort	2068	6

NOTES:

1) no Seapoint turbidity sensor installed

2) CTD computer time 3 hours behind correct time

3) yo-yo

4) tow-yo

5) CTD made bottom contact

6) cast aborted
7) CTD turned on 3 hours before profile

9.3 Station notes

1. Cast 001
    a. Temp1 has spikes on downcast at 1610m and 1667m
    b. Temp1 craps out from downcast at 1809m through upcast at 402m
    c. Cond1 has spikes on downcast at 1610m and 1667m
    d. Cond1 has spike on downcast at 1810m with gradual response back to normal
    e. Cond1 has spike on upcast at 400m with gradual response back to normal
    f. Sal11 has spikes on downcast at 1610m and 1667m with gradual response back to normal
    g. Sal11 craps out from downcast at 1809m through upcast at 402m with gradual response back to normal
    h. Both oxygen bad
2. Cast 002
    a. Uplooking ADCP moved to downlooking; old downlooker moved to mooring.
    b. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 300m - 370m
    c. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 300m - 370m
    d. NOTE that the UP-cast shows preferentially lower salinity spikes
3. Cast 003
    a. CLEAN
4. Cast 004
    a. CLEAN
5. Cast 005
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 280m - 340m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 280m - 340m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
    d. CTD computer time was (automatically) set to wrong time (three hoursearlier than true time)
    e. see NMEA header info
6. Cast 006
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 480m - 500m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 480m - 500m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
    d. CTD computer time was (automatically) set to wrong time (three hours earlier than true time)
    e. see NMEA header info
7. Cast 007
    a. CLEAN

b. first cast with STS
c. CTD computer time was (automatically) set to wrong time (three hoursearlier than true time)
d. see NMEA header info

8. Cast 008
    a. Lost bottom switch wire & weight during bottom bottle stop at 6m above bottom
    b. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 300m - 340m and 450m - 500m
    c. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 300m - 340m and 450m - 500m
    d. NOTE that the UP-cast shows preferentially lower salinity spikes
9. Cast 009
    a. New bottom-switch line at 10m (instead of 13m as before)
    b. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 350m - 550m
    c. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 350m - 550m
    d. NOTE that the UP-cast shows preferentially lower salinity spikes
    e. Bad data during upcast near 500m; affected: both temp, salin, O2
10. Cast 010
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 450m - 500m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 450m - 500m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
11. Cast 011
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 400m - 500m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 400m - 500m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
12. Cast 012
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 300m - 370m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 300m - 370m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
13. Cast 013
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 250m - 600m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 250m - 600m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
14. Cast 014
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 300m - 550m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 300m - 550m

c. NOTE that the UP-cast shows preferentially lower salinity spikes

15. Cast 015
    a. Yoyo
    b. No SADCP data collected
    c. Temp1, Cond1, and Sal11 go bad during middle of tow-yo at record number 11867
    d. Salinity spikes -Selapsed:11000..13000
    e. Afterwards, primary salinities are much more spikey
16. Cast 016
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 450m - 500m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 450m - 500m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
    d. Automatic GPS clock correction disabled because time was off by 10min
    e. Clock set manually
    f. AUV nearby at 2000m when CTD was at 1800m during downcast
    g. STS anomalies in upcast above 1800m; connectors cleaned and re-connected after cast; no problems in following station
17. Cast 017
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 300m - 500m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 300m - 500m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
    d. Up-cast data problems above 600m as during earlier stations
18. Cast 018
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 300m - 500m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 300m - 500m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
    d. Up-cast data problems above 600m as during earlier stations
19. Cast 019
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 250m - 450m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 250m - 450m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
20. Cast 020
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 380m - 440m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 380m - 440m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
21. Cast 021
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 350m - 450m

   b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 350m - 450m
   c. NOTE that the UP-cast shows preferentially lower salinity spikes

22. Cast 022
    a. CLEAN
    b. Profile aborted due to connection problem, eventually traced to connector in wall behind deck box
    c. Earlier up-cast data problems not repeated after this repair
    d. Profile re-run after repair
23. Cast 023
    a. CLEAN
24. Cast 024
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 400m - 600m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 400m - 600m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
25. Cast 025
    a. CLEAN
    b. SADCP turned on late at 02:01
26. Cast 026
    a. CLEAN
    b. Cast had to be re-started because pump did not turn on; problem disappeared after pumps were filled with fresh water
27. Cast 027
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 300m - 700m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 300m - 700m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
28. Cast 028
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 500m - 650m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 500m - 650m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
29. Cast 029
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 440m - 480m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 440m - 480m
    c. NOTE that the UP-cast shows preferentially lower salinity spikes
    d. Data anomalies during upcast near 500m; both salinities affected
30. Cast 030
    a. Tow-yo
    b. CLEAN
31. Cast 031
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-casts between 1800m - 2150m
    b. NOTE that the DOWN-cast shows preferentially higher salinity spikes

c. Grounded on Sea Bed so final UP-cast is NO good
d. Tow-yo
e. SADCP stopped when ship was already steaming
f. Salinity spikes in primary sensor pair near end of several downcasts, beginning with first one; both temperature and conductivity affected
g. We hit the seabed pretty badly at the final bottom turning
h. Based on T/S, the secondary sensors were off afterwards
i. The primary sensor pair was apparently not affected but there are other (pump-related?) problems
j. With effort, it should be possible to construct a full data set
k. Also, the T/S data from later casts are consistent with the earlier ones; therefore, the problem was probably just some dirt in the water path of the secondary (main) sensor pair

32. Cast 032
    a. STS data problems
    b. Bottom-contact later during tow-yo
    c. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-casts between 1600m - 2100m
    d. NOTE that the DOWN-cast shows preferentially higher salinity spikes
    e. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 250m - 450m
    f. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 250m - 450m
    g. NOTE that the UP-cast shows preferentially lower salinity spikes
33. Cast 033
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-cast between 1950m - 2100m
    b. NOTE that the DOWN-cast shows preferentially higher salinity spikes
    c. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 250m - 600m
    d. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 250m - 600m
    e. NOTE that the UP-cast shows preferentially lower salinity spikes
34. Cast 034
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-cast between 1900m - 2150m
    b. NOTE that the DOWN-cast shows preferentially higher salinity spikes
    c. 1st O_2 bad from 1872m
35. Cast 035
    a. CLEAN
    b. No SADCP data collected during cast
    c. 10 min of SADCP data collected after cast while remaining on station
36. Cast 036
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-cast between 1720m - 1800m
    b. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-cast and UP-cast between 1950m - 2150m
    c. NOTE that the DOWN-cast shows preferentially higher salinity spikes
    d. NOTE that the UP-cast shows preferentially lower salinity spikes
37. Cast 037
    a. CLEAN, but aborted during DOWN-cast

   b. Aborted near 1000m because termination failed
   c. Down-cast to 1000m may be salvageable

38. Cast 038
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-cast between 1700m - 2000m
    b. Profile at same location as aborted station 037
39. Cast 039
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 400m - 700m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 400m - 700m
40. Cast 040
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 380m - 820m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 380m - 820m
41. Cast 041
    a. CLEAN
    b. CTD turned on at 21:13 to see whether pre-warming nephelmometer improves down-/up-cast consistency => resulting profile worse than ever
42. Cast 042
    a. Temp1, Cond1, and Sal11 all have artifacts on the UP-cast at 1430m - 1390m
    b. STS data problems during DOWN-cast; connectors cleaned and re-connected after cast
43. Cast 043
    a. CLEAN
    b. STS data problems during DOWN-cast
44. Cast 044
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 900m - 1250m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 900m - 1250m
    c. STS Problem during DOWN-cast
45. Cast 045
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-cast between 1200m - 1300m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the DOWN-cast between 1200m - 1300m
    c. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 1050m - 1400m
    d. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 1050m - 1400m
46. Cast 046
    a. Temp1, Cond1, and Sal11 all have artifacts at various depths on the DOWN-cast between 950m - 1000m
    b. Temp2, Cond2, and Sal22 all have artifacts at various depths on the DOWN-cast between 950m - 1000m
    c. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 900m - 1200m

d. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 900m - 1200m
e. 2 LADCPs from this Cast forward
f. Stopped to wait for AUV

47. Cast 047
    a. Temp2, Cond2, and Sal22 all have artifacts at various depths on the DOWN-cast between 200m - 450m
    b. Temp1, Cond1, and Sal11 all have artifacts at various depths on the UP-cast between 700m - 1250m
    c. Temp2, Cond2, and Sal22 all have artifacts at various depths on the UP-cast between 700m - 1250m
    d. No SADCP collected
    e. Y-Cable on for the Seabird pumps was changed after cast to fix spikiness observed throughout cruise.
48. Cast 048
    a. CLEAN
49. Cast 049
    a. CLEAN
50. Cast 050
    a. CLEAN
51. Cast 051
    a. CLEAN
    b. Alternate STS (#11290) on rosette; Original was STS (#11289); Problem not with instrument, but likely with cable (which was made by Uwe)
    c. CTD aborted at 1400m because of weather.

9.4 Performance of the Chelsea Instruments model Aqua Tracka III

The Chelsea Instruments model Aqua Tracka III is an optically-based fluorimeter that can be used to determine chlorophyll a, dye tracers, and turbidity. The instrument features two signal paths including a reference light path and a signal light path. The dual-path system allows for an expanded 4-decade dynamic range for the determination of turbidity with a manufacturer's stated accuracy of ±0.2 FTU.

The instrument was deployed on the CTD rosette of the *FS Poseiden* for routine measurements of turbidity during the P403 cruise from 14-30 August, 2010 roughly due west of the Azores at roughly 37^0 14' N and 32^0 14' W. Figure 1 shows turbidity and temperature for a typical cast of CTD. The temperature shows a well-defined thermocline, a distinct sub-thermocline, and a slowly-varying bottom 1300-2200 m. Both the down- and up-casts are identical except for at mid-depth between 600-800m and near the thermocline. While the instrument remains within stated accuracy throughout the cast, the optical backscatter, however, shows a significant difference between down- and up-casts. From experience working with optical sensors, instrument temperature is critical for a robust and accurate calibration. The difference between down- and up-casts is most likely due to a slowly varying internal instrument temperature. Just before the cast, the instrument is turned on and has not been allowed to come to equilibrium internal instrument temperature. The surface water is close to the ambient air temperature at roughly 24^{0}C. As the CTD is lowered, the temperature of the Aqua is a function of the output heat of the electronics and the ocean temperature that changes significantly with depth. At the bottom of the ocean, the temperature is significantly colder than at the surface at roughly 4-5^{0}C. The constant attempt to equilibrate causes the Aqua internal temperature to continually change and therefore the apparent drift of the instrument signal. Rather than a drift in the instrument calibration, it is a repeatable feature of the instrument than can be accounted for with knowledge of the internal instrument temperature.

The feature is further demonstrated during the “yo-yo” casts, or the repeated down- and up-casts on station at depths between 1300 m and 2200 m as shown in Figure 2. As in Figure 1, the temperature shows the same structure with depth and the optical backscatter shows the same behavior for the downcast and the initial up-cast of the yo-yo. However, the 2nd and 3rd down- and up-casts of the yo-yo show that the instrument is equilibrating with the surrounding water. Eventually, the Aqua instrument temperature has stabilized and the down- and up-casts are coincident in optical backscatter.

For any given cast, neither the down- or up-cast is preferable. The Aqua takes time to reach equilibrium as evident by the yo-yo cast. Thus, at any given depth, the Aqua does not have time to equilibrate to the surrounding temperature and will not give an accurate repeatable reading. Even when in equilibrium, the accuracy of the instrument is determined by the calibration at that specific internal instrument temperature. For this experiment, the best one can expect is to compare the relative signals (though not absolute accurate) during individual “yo-yo” casts after they have come to equilibrium at relatively the same ocean temperature. Figure 3 shows the three yo-yo’s after the Aqua has come to equilibrium. The optical backscatter for Casts 31 and 32 match nearly perfectly. However, the optical backscatter in Cast 30 is still slightly higher than the other two casts. The absolute accuracy would need to be determined by a new user-defined calibration using knowledge of the internal equilibrium temperature. The recommendation of the user is for the company to supply an output for the internal instrument temperature so that the user can determine the appropriate calibration for the instrument.

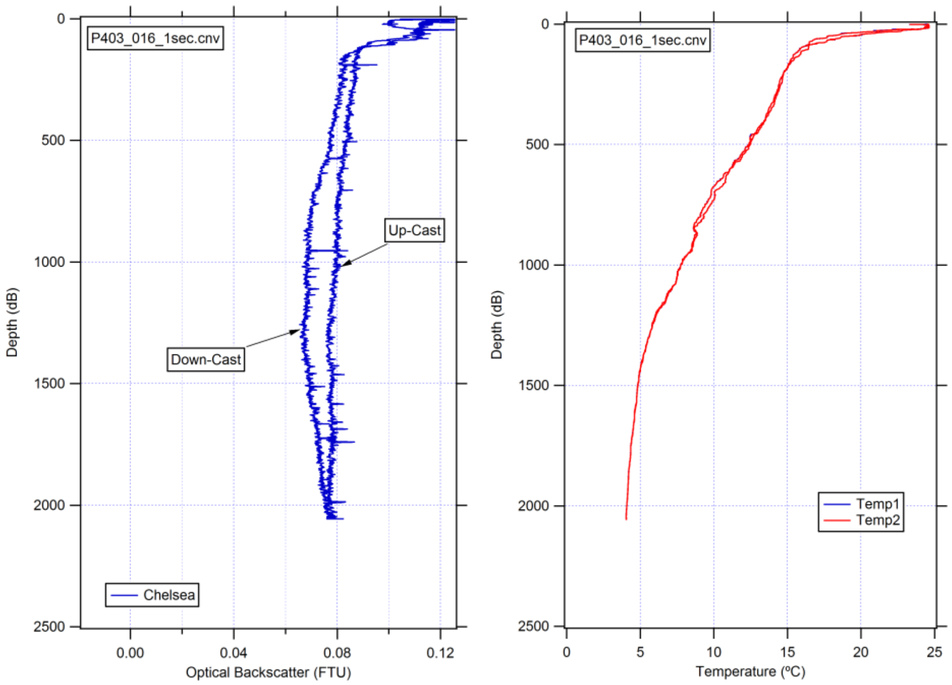


Fig. 9.2. Optical backscatter from the Chelsea Instruments model Aqua Tracka III and temperature for CTD cast #16 during cruise P403 on the FS Poseiden.

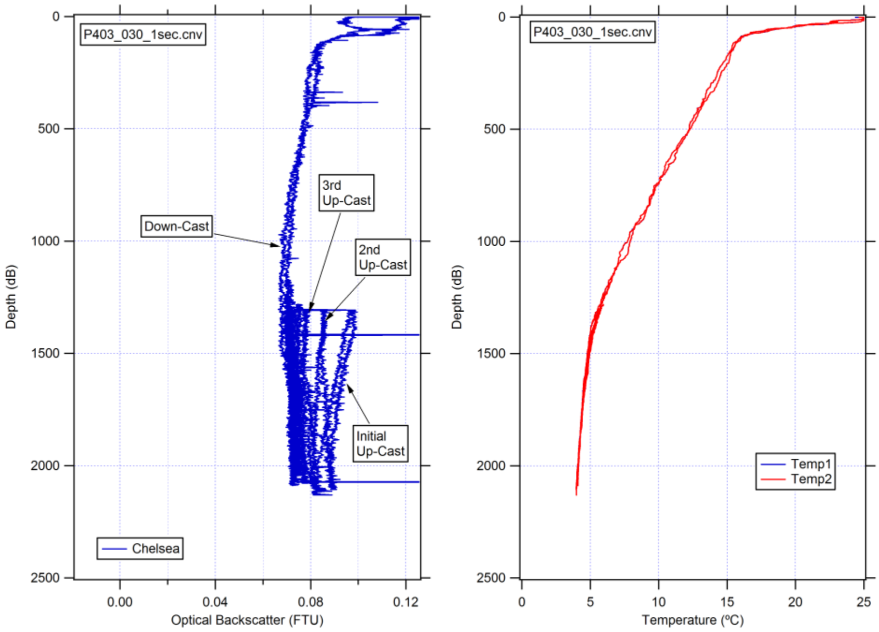


Fig. 9.3. Optical backscatter from the Chelsea Instruments model Aqua Tracka III and temperature for CTD cast #30 during cruise P403 on the FS Poseiden.

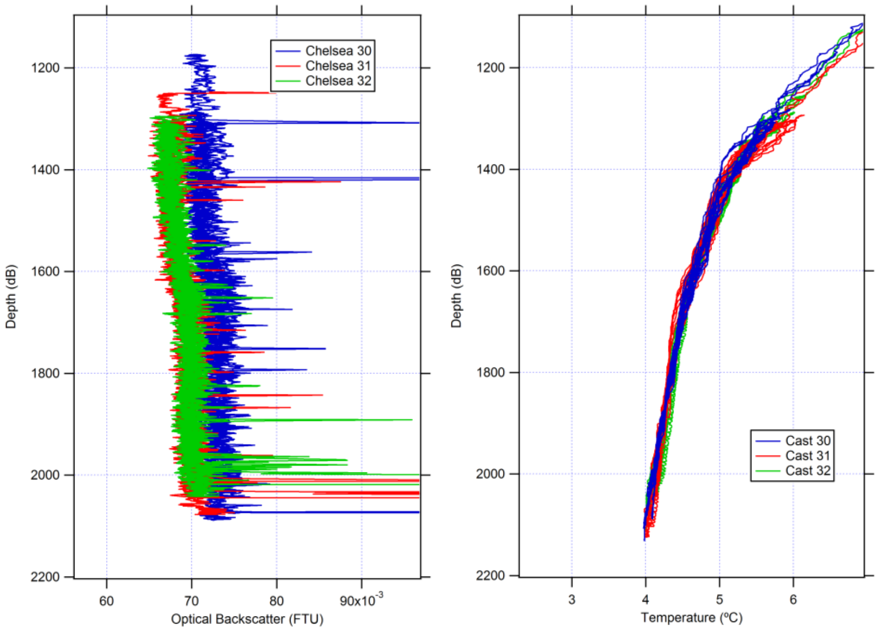


Figure 9.4: Optical backscatter from the Chelsea Instruments model Aqua Tracka III and temperature for CTD casts #30, #31, and #32 during yo-yo's after the instrument has come to equilibrium during cruise P403 on the FS Poseiden.

10. Lowered Acoustic Doppler Profiler

by Andreas Thurnherr and Christopher Zappa

10.1 Narrative

Velocity data were collected on all CTD stations (Fig. 9.1, Tab. 9.2) using one or two Teledyne/RDI Workhorse 300kHz ADCPs mounted on the CTD rosette. For the first cast (station 1), instruments with serial numbers 680 and 11436 were installed as down- and uplookers, respectively. After station 1, it was decided to deploy instrument 680 on mooring M2 (because the 1200kHz ADCP originally intended for that purpose was not working properly) and instrument 11436, which had better range during cast 1, was switch to the downward-looking position. Casts 2-45 were carried out with this configuration. After mooring M2 was recovered, instrument 680 was put back on the CTD rosette, this time as the uplooker. The remaining casts (stations 46-51) were again carried out with a dual-headed setup, although no uplooker data were collected on station 48 because of an operator error. Both ADCPs used on the CTD rosette performed flawlessly without indications for serious instrument problems, although beam 3 of instrument 680 is somewhat weak.

Both in the water and on deck, the LADCP system was powered with non-rechargeable alkaline batteries installed in a custom pressure case. Battery voltage was logged during data download (i.e. when under load) after every cast. Initial post-cast voltage was >43V, dropping to 37.5V after cast 29. For tow-yo station 30, the batteries were replaced in order to ensure full data coverage. Post-cast battery voltage after station 30 was 51.3V, dropping to 44V at the end of the cruise.

The LADCP data were collected with the standard IfM-Geomar instrument setup (wh300ma.cmd & wh300sl.cmd): with 25x10m bins, earth coordinates, single-ping ensembles, zero blanking distance (data from bin 1 are discarded during processing), and regular pinging every 1.5s. On the casts carried out with a dual-head setup, pinging was synchronized with the downlooker serving as the master. None of the instruments, both with firmware version 16.3, returned bottom-track data from water-track pings. (No bottom-tracking pings were used.)

Data acquisition was carried out using the LDEO "acquire" software, versions 1.3 and, later, 1.4beta. The software was installed on an OpenSuse 10.1 Linux system running inside a Sun Microsystems Virtual Box version 2.2.2 on a Windows XP laptop. The system clock was synchronized automatically once a minute with the system time of the CTD acquisitions computer. Due to problems with the system time on the CTD acquisitions computer (software bug), the time information in the raw LADCP data from stations 5-7 is offset by -3hr with respect to the correct UTZ time; the offset was corrected for during shipboard processing. Communications between the acquisition computer and the instruments took place across two parallel RS485 connections and a 2-port FTDI USB-to-RS422/485 converter to the battery case, where a RS-485 to RS-232 converter was used to interface the ADCP heads via RS-232. This setup resulted in an unusually large number of minor communications glitches that usually manifested themselves as wrong station numbers detected by the recover scripts (endladcp1 and endladcp2). The problems could always be solved by re-running the same scripts again --- in some instances, the scripts had to be restarted twice. Given the fact that the communications glitches only occurred in the recover scripts, it seems likely that they are related to timing issues, perhaps caused by Linux controlling the USB-to-serial converter in the Sun virtual box. No attempt was made to investigate this any further. In addition to those communications glitches, twice, the downloads resulted in data files with lowercase, instead of uppercase, filenames. This required operator intervention to rename the files and manually transfer them to the backup share. Because of this problem, changes were incorporated into the acquisition software version 1.4beta, which was used for the final 10 stations or so (setups for both single- and dual-head systems were tested). The changes to the software include using the -u option in the rb ymodem-receive program. More testing is required, however, to ensure that the upper/lower case problem does not re-occur. If it does, the updated acquire software now allows a work-around, using the master_download_glob and slave_download_glob variables set in CRUISE_SETUP.expect.

During each CTD/LADCP station, shipboard-ADCP (SADCP) data were collected with an RDI OS75 system set up in narrow-band mode. SADCP data logging was usually enabled just after deployment of the rosette and turned off just before the rosette was put back on deck. Exceptions are yoyo station 15, during which no SADCP data were collected; station 25, when the SADCP was turned on late (at 02:01); tow-yo station 31, when the SADCP was turned off after the ship had already left station; station 35 when no SADCP data were collected during the CTD/LADCP cast but 10 minutes of data were collected after the cast while the ship remained on station; and station 47, when no data were collected. The SADCP collected data with single-ping ensembles once every second in 8m bins with a 4m blanking distance.
60 pings were combined into 1-minute "short-term averages" (STAs) by the RDI VMDAS software and all available short-term averages were averaged into cast-averaged velocity profiles before loading into the LADCP processing software. The corresponding standard errors were estimated assuming that the errors in the individual 1-minute short-term averages are independent.

Preliminary shipboard processing of the LADCP data from the standard (non-yoyo and tow-yo casts) was carried out with the LDEO IX_6 LADCP-processing software using 1-s averaged CTD time series for depth- and sound-speed correction, as well as post-processed bottom-track data and GPS information in the CTD time series files to reference the relative velocities. The SADCP data were loaded in the processing software but not used to constrain the velocities --- this allowed visual monitoring of the LADCP performance by comparing the LADCP and SADCP velocities near the sea surface.

11. Preliminary findings from CTD/LADCP data collected during P403

by Andreas M. Thurnherr

11.1 Rift-Valley Hydrography and Circulation

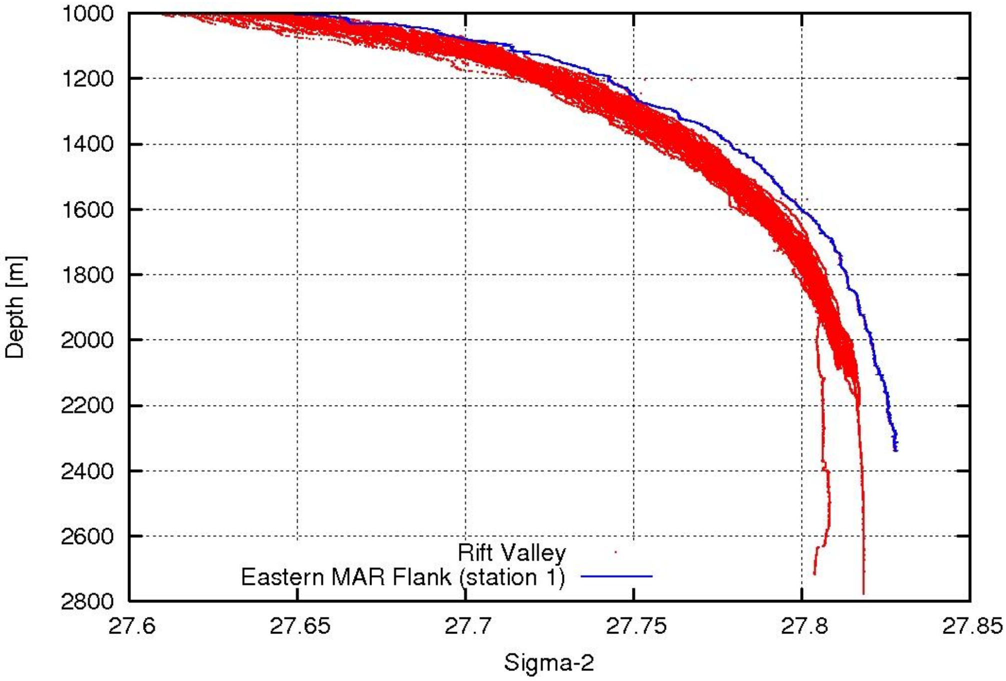


Fig. 11.1: Potential-density profiles below 1000m, for comparison with Fig. 3 of Thurnherr et al. (JMR 2008). Note that the apparent large-scale static instability in the northern-basin profile below 2600m has to be confirmed in the post-cruise re-processed CTD data.

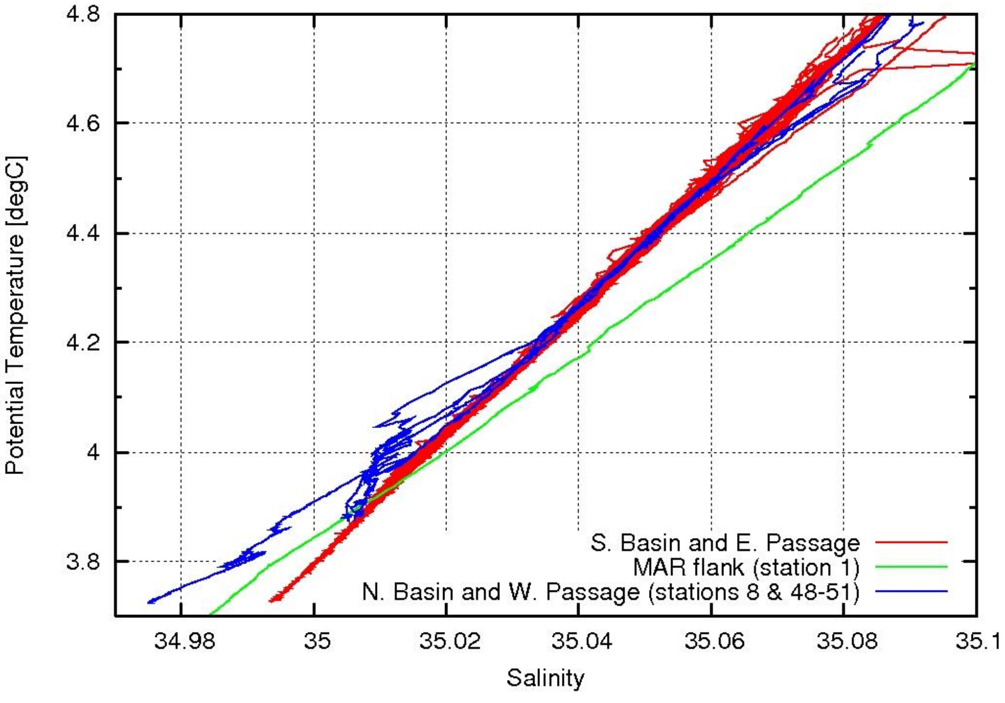


Fig. 11.2: T/S properties below 1500m from the second C/T sensor pair. Note that all western-passage stations show influence of northern-basin water, whereas no such influence is seen in the profiles from the eastern passage.

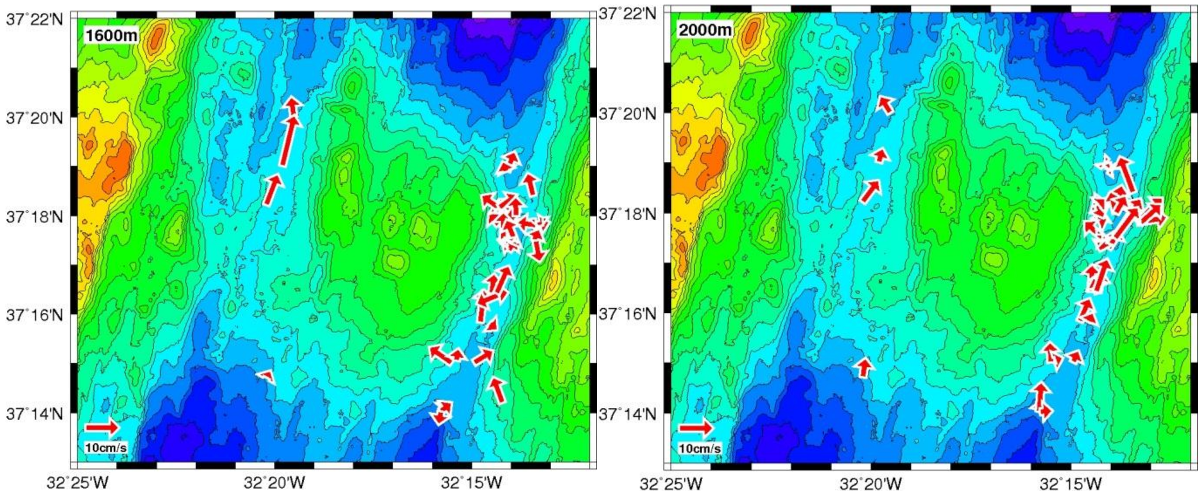


Fig. 11.3: LADCP-derived velocities at 1600 and 2000m, for comparison with Fig. 7 of Thurnherr et al. (JMR 2008). Note that while these figures show (strong) northward flow in the western passage, the hydrography there (previous figure) indicates that the mean flow must be southward.

11.2 Eastern-Passage Overflow

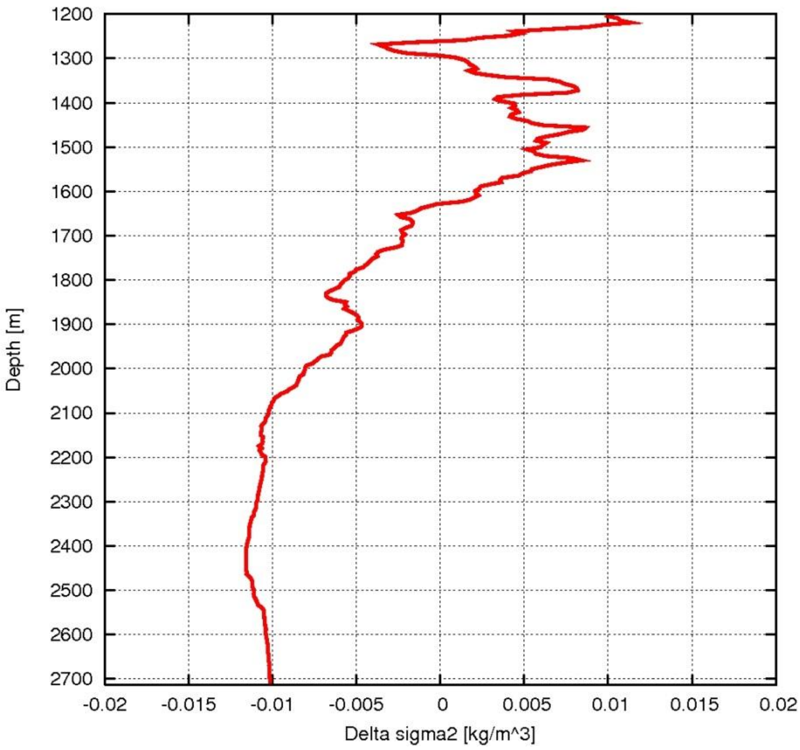


Fig. 11.4: Potential-density differences between the northern and southern basins, for comparison with Fig. 3 of Thurnherr et al. (JMR 2008). Compared to the 2006 data, the density drop in the lower layer is smaller and the "interface" is higher up in the water column, consistent with the weaker flow observed during P403.

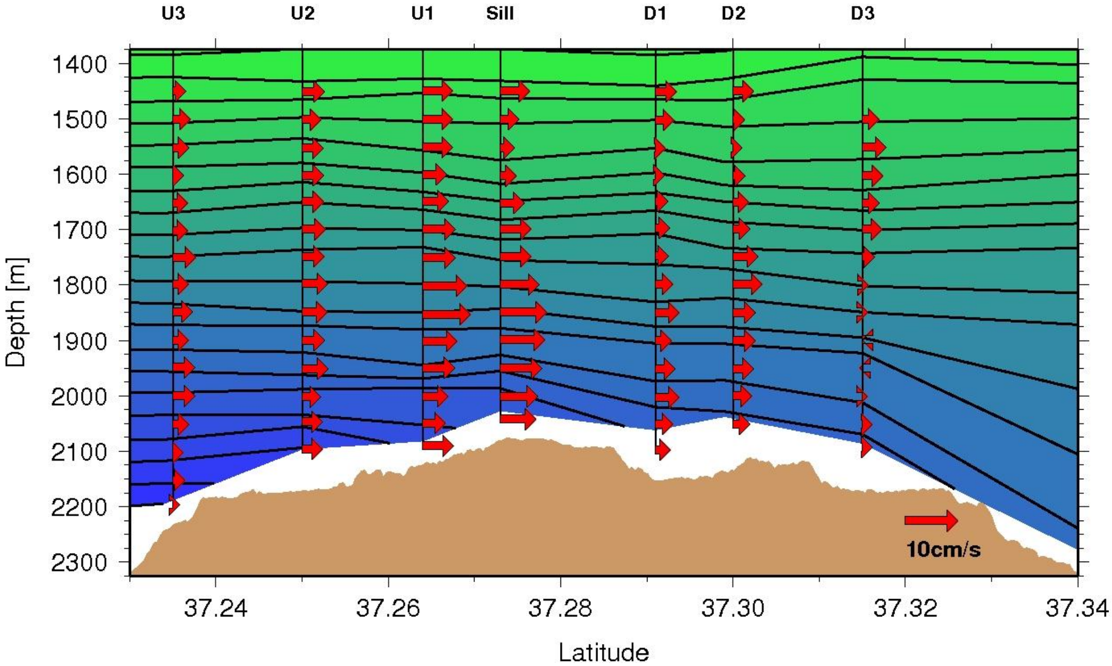


Fig. 11.5: Along-channel section of potential density and velocity in the eastern passage, for comparison with Fig. 2 of St. Laurent and Thurnherr (Nature 2007). Note that the profiles are all ensemble averaged without taking the cross-channel location of the underlying profiles into account, which may be one of the reasons the velocities during P403 were apparently smaller than in 2006.

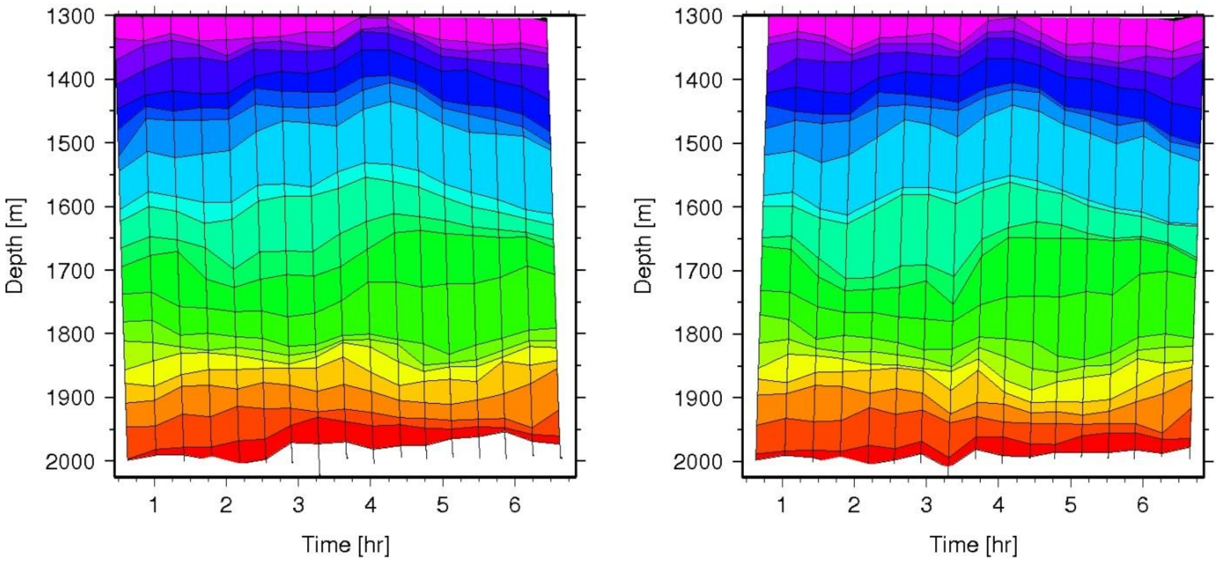


Fig. 11.6: Potential-density time series from the CTD yoyo (station 15). The down- and upcast-data are shown separately in order to avoid hysteresis-related artifacts remaining in the preliminarily processed CTD data. Note the prominent high-frequency (faster than semi-diurnal) variability.

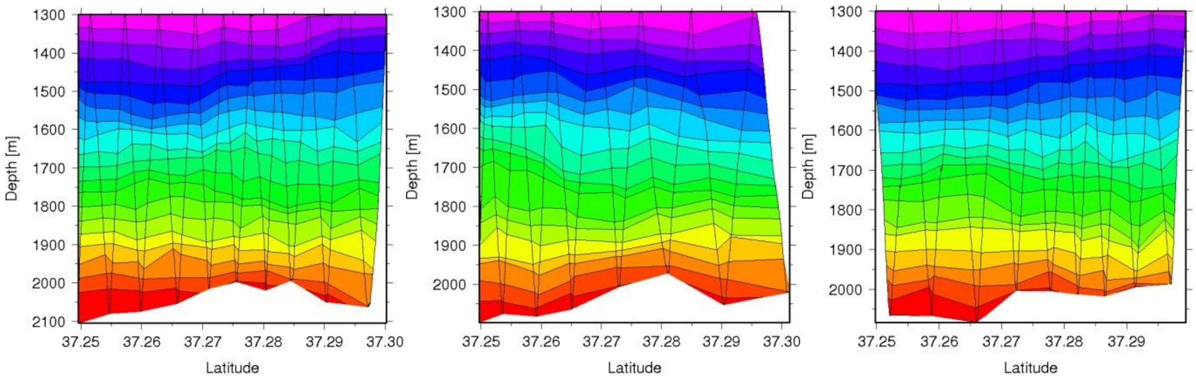


Fig. 11.7: Potential-density sections from the three tow-yos carried out in the eastern passage (stations 30-32). The "zig-zagging" is caused by hysteresis-related artifacts remaining in the preliminarily processed CTD data. Note the striking differences between the different occupations.

11.3 Light Scattering

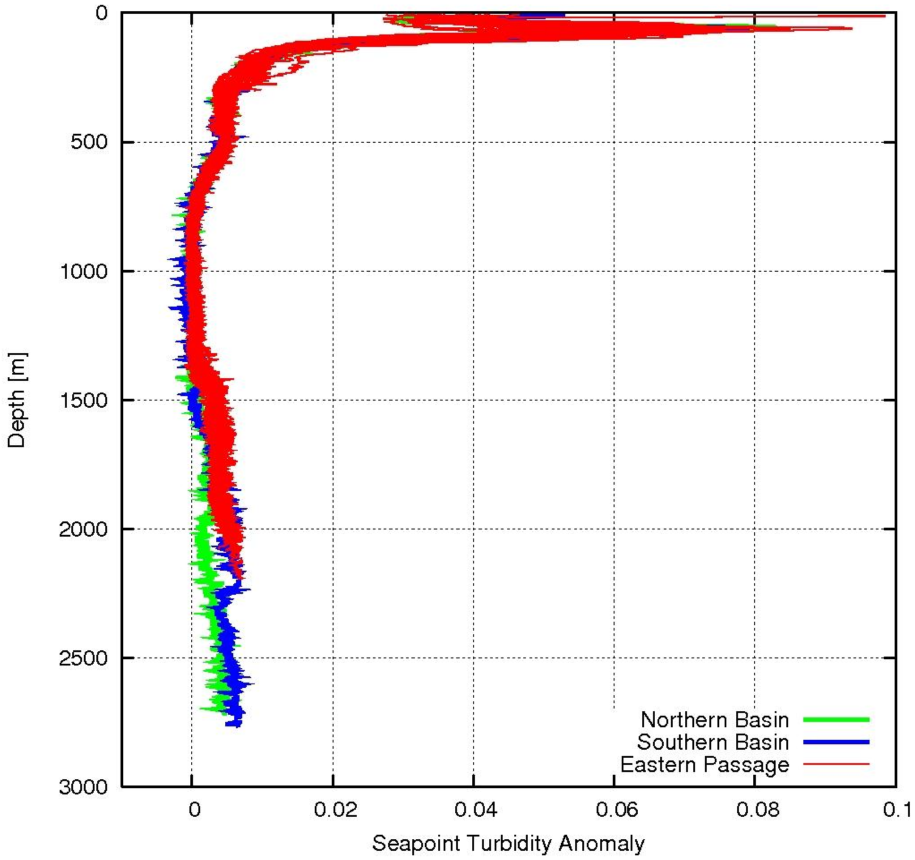


Fig. 11.8: Profiles of Seapoints light-scattering anomalies from stations 7-29. (Earlier stations did not have an STS installed while later ones need significant cleanup due to cable problems). Note the lack of clear indications for hydrothermal plumes, although the step in light scattering near 2300m in the Southern Basin may be related to hydrothermal particles.

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No.	Title
1	RV Sonne Fahrtbericht / Cruise Report SO 176 & 179 MERAMEX I & II (Merapi Amphibious Experiment) 18.05.-01.06.04 & 16.09.-07.10.04. Ed. by Heidrun Kopp & Ernst R. Flueh, 2004, 206 pp. In English
2	RV Sonne Fahrtbericht / Cruise Report SO 181 TIPTEQ (from The Incoming Plate to mega Thrust EarthQuakes) 06.12.2004.-26.02.2005. Ed. by Ernst R. Flueh & Ingo Grevemeyer, 2005, 533 pp. In English
3	RV Poseidon Fahrtbericht / Cruise Report POS 316 Carbonate Mounds and Aphotic Corals in the NE-Atlantic 03.08.–17.08.2004. Ed. by Olaf Pfannkuche & Christine Utecht, 2005, 64 pp. In English
4	RV Sonne Fahrtbericht / Cruise Report SO 177 - (Sino-German Cooperative Project, South China Sea: Distribution, Formation and Effect of Methane & Gas Hydrate on the Environment) 02.06.-20.07.2004. Ed. by Erwin Suess, Yongyang Huang, Nengyou Wu, Xiqiu Han & Xin Su, 2005, 154 pp. In English and Chinese
5	RV Sonne Fahrtbericht / Cruise Report SO 186 – GITEWS (German Indonesian Tsunami Early Warning System 28.10.-13.1.2005 & 15.11.-28.11.2005 & 07.01.-20.01.2006. Ed. by Ernst R. Flueh, Tilo Schoene & Wilhelm Weinrebe, 2006, 169 pp. In English
6	RV Sonne Fahrtbericht / Cruise Report SO 186 -3 – SeaCause II, 26.02.-16.03.2006. Ed. by Heidrun Kopp & Ernst R. Flueh, 2006, 174 pp. In English
7	RV Meteor, Fahrtbericht / Cruise Report M67/1 CHILE-MARGIN-SURVEY 20.02.-13.03.2006. Ed. by Wilhelm Weinrebe und Silke Schenk, 2006, 112 pp. In English
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