IFM-GEOMAR REPORT

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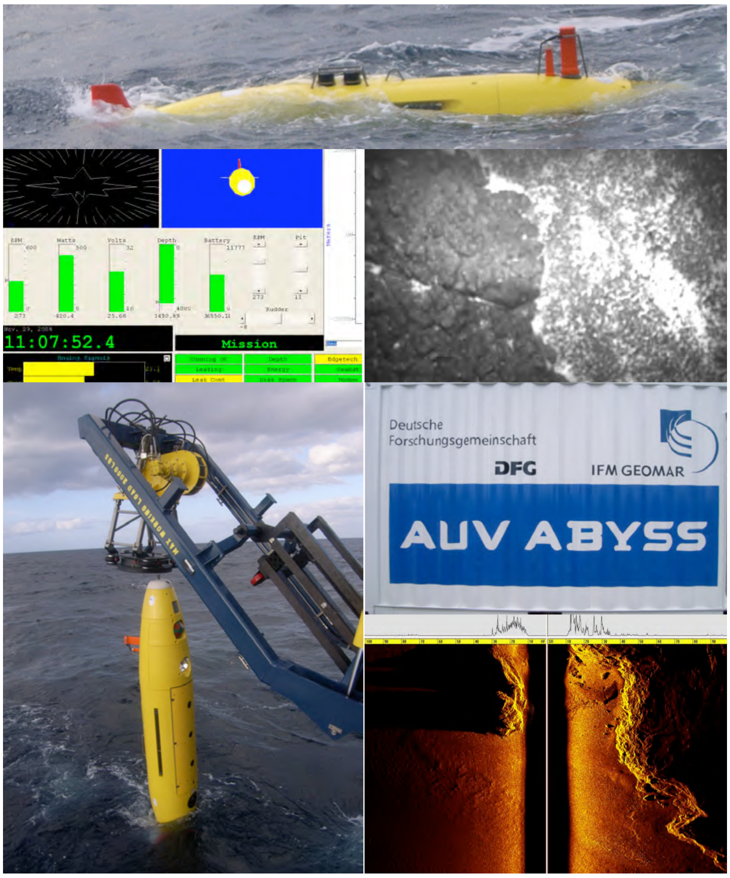
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

RV Poseidon
Fahrtbericht / Cruise Report
POS376 ABYSS Test

Las Palmas - Las Palmas
10.11. - 03.12.2008



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

Nr. 24
Dezember 2008

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Herausgeber / Editor:
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IFM-GEOMAR Report
ISSN Nr.: 1614-6298

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Mulrooney, Michael	Hydroid LL, Pocassett USA
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Rothenbeck, Marcel	IFM-GEOMAR, Kiel, Germany
Sticklus, Jan	IFM-GEOMAR, Kiel, Germany
Joergen Hansen	Reson, Denmark

<u>Crew</u>

Michael Schneider	Captain
Bernhard Windscheid	1st mate
Cornelia Dahlke	2nd mate
Hans-Otto Stange	First engineer
Günther Hagedorn	Second engineer
Dietmar Klare	Electrician
Volkhard Falk	Cook
Bernd Gerischewski	Steward
Joachim Mischker	Bosun
Ralf Meiling	Ship mechanic
Bernd Rauh	Ship mechanic
Jürgen Sauer	Ship mechanic
Pedro M. Barbosa	Seaman
Tim Schröder	Apprentice

2 Introduction

C. Devey, S. Petersen and K. Lackschewitz

The 376st cruise of the research vessel Poseidon had purely technical aims, testing the newly-acquired, 6000m-rated Autonomous Underwater Vehicle (AUV) "ABYSS" from IFM-GEOMAR. The vehicle was acquired by the German Science Foundation for use during the Special-Priority Program 1144 "From Mantle to Ocean: Energy, Material and Life Cycles at Spreading Centers".

Much of the work on seafloor hydrothermal systems needs to be carried out at the interface between the newly-created oceanic crust and the overlying water masses (effectively the lithosphere/hydrosphere boundary). It is at this interface that many of the biological, tectonic and mineralogical features which make the spreading axis systems so unique and important are concentrated. The processes occurring here happen at small scales, produce localised effects and vary rapidly – the interface is highly dynamic.

Studying this dynamic interface from a surface ship has several major disadvantages:

- The low resolution of ship-mounted geophysical systems (swath sonar, seismics, magnetics etc.) due to their large distance from the object being studied.
- The long transit times for equipment lowered for oceanographic, chemical or biological purposes on cables from a surface vessel (e.g. CTD). This makes imaging, sampling and analysing (Eh, CH_4, H_2 etc) both cumbersome and time-consuming, severe drawbacks in a highly dynamic system.
- The poor manoeuvrability, slow turning speed and lack of bottom-following ability of deep-towed operations aimed at bringing sensors closer to the seafloor. This makes deep-towed deployments in many ridge axes ineffective and/or hazardous to the equipment.

To address these significant problems, a system was needed which is capable of being present for significant amounts of time close to the seafloor, is capable of acquiring most types of geophysical seafloor data (bathymetry, magnetics, etc.) repeatedly on a raster and also has the ability to map gradients (compositional, physical, chemical) in the water column. It is for such automated, grid-like (but also gradient-following) work and for work in which tether-snagging is a concern that an AUV is uniquely suitable. The AUV "ABYSS" has a torpedo-like shape and can be run in three configurations: multibeam bathymetry, bottom photography or sediment profiling. A detailed description of the system is given in chapter 4. In all three configurations side-scan sonar, CTD, turbidity, ADCP and Eh data can be collected.

For testing purposes several working areas close to the Canary Islands (Spain) were chosen (Figs. 1 and 2) that span water depths between 50m and 5300m. Due to technical difficulties with the vehicle the planned deep-water tests to the west of the Canary Islands were not carried out. The maximum water depth attained by the vehicle during the course of the cruise was 3500m in offshore test box 1 (see figure 1).

Fig. 1: Location of the shallow-water test area south of Fuerteventura and the two proposed mid-water offshore test areas (depending on sea and weather conditions).

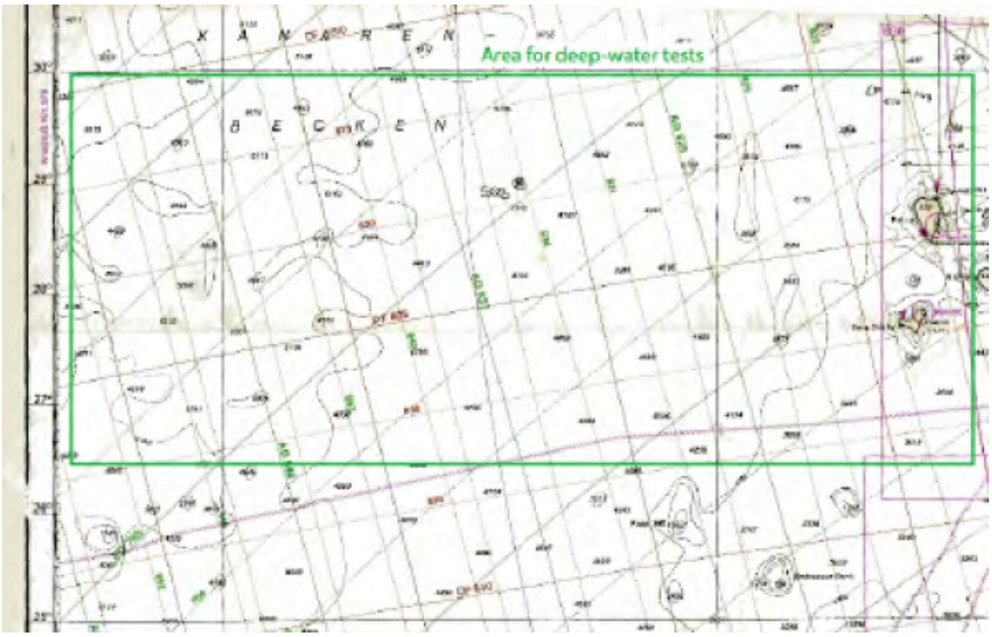


Fig. 2: Location of the deep-water test area west of the Canary Islands.

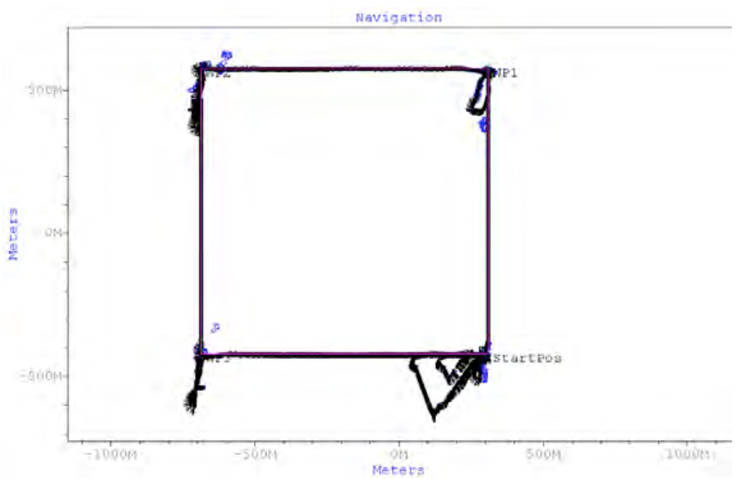
3 Cruise Narrative and Event List

C. Devey, and S. Petersen

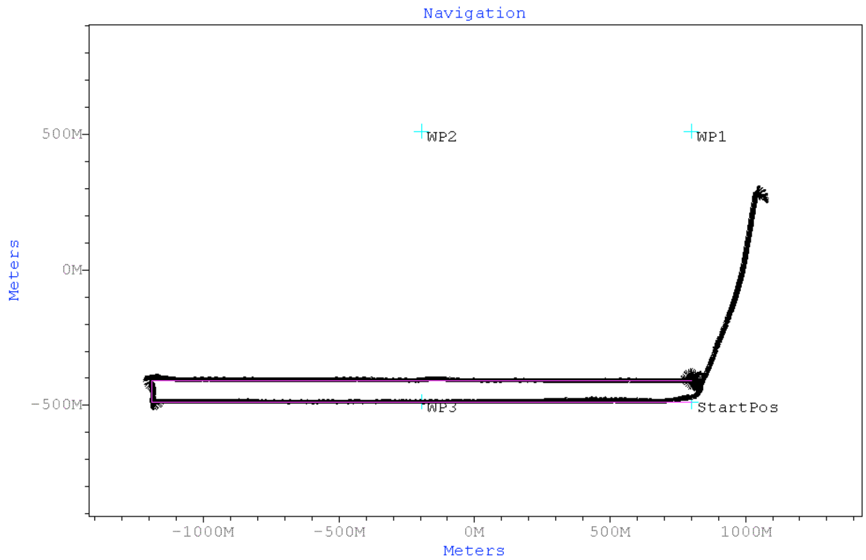
The *Poseidon* left Las Palmas at 10:00 on 10.11.2008 and took course to the working area, initially designated as being around 27°57´N/14°39´W. The area has about 80m water depth with some rocky areas rising to 50m. As the multibeam configuration is the main working configuration work was begun on testing this configuration. Several dives during the daylight hours were carried out as listed in the event table. On 17.11.08 a crew-change in Las Palmas took place and was followed by further shallow water testing in the same area, during which time the camera system was also checked. In the course of the cruise a technician from the manufacturer of the multibeam system (RESON) had to be flown in for repairs and to help with the integration of the system. Mid-water to deep-water tests (~3600m water depth) were carried out for the remainder of the cruise in order to test system integrity and sensor functionality. Poseidon left the deep-water working area on December 1st and sailed back to Las Palmas where she arrived in the late afternoon of December 2nd. The containers where unloaded on the 3rd and the scientists left Las Palmas in the afternoon of December 3rd.

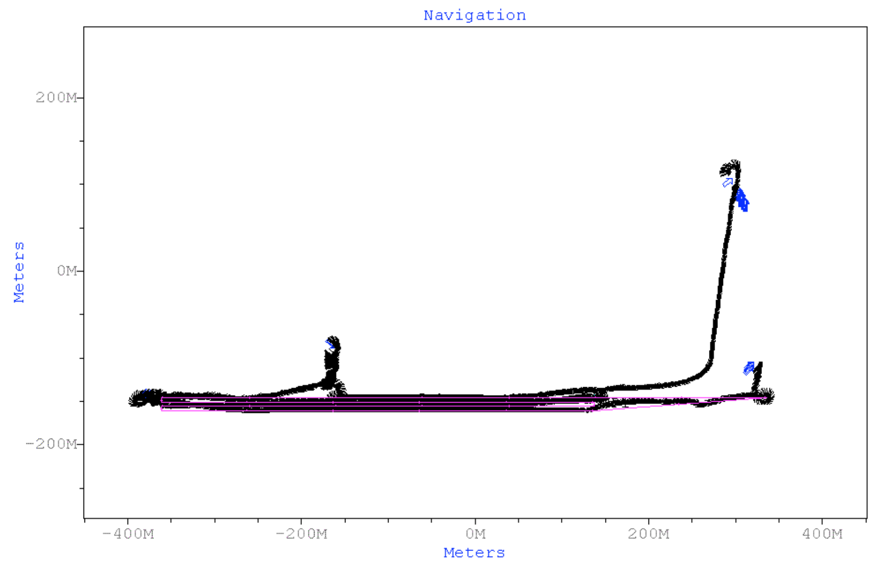
Event list for POS376

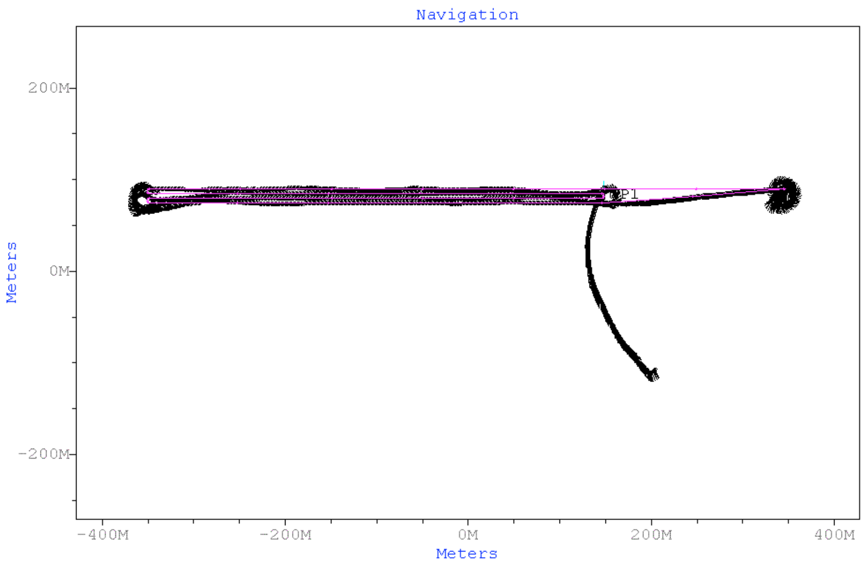
Day	Time (LT)	Plan	Result
10.11.08	10:00	Leave harbour of Las Palmas	
	16:00	Arrive in shallow water working area at 27°57´N/14°39´W	
11.11.08	all day	Practise deployments using dummy.	
12.11.08	08:00	**Test dives 01, 02, and 03**; make bathymetric survey of region 1x1 km; dive 02 is for INS calibration. Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	Vehicle completed survey, no multibeam data registered

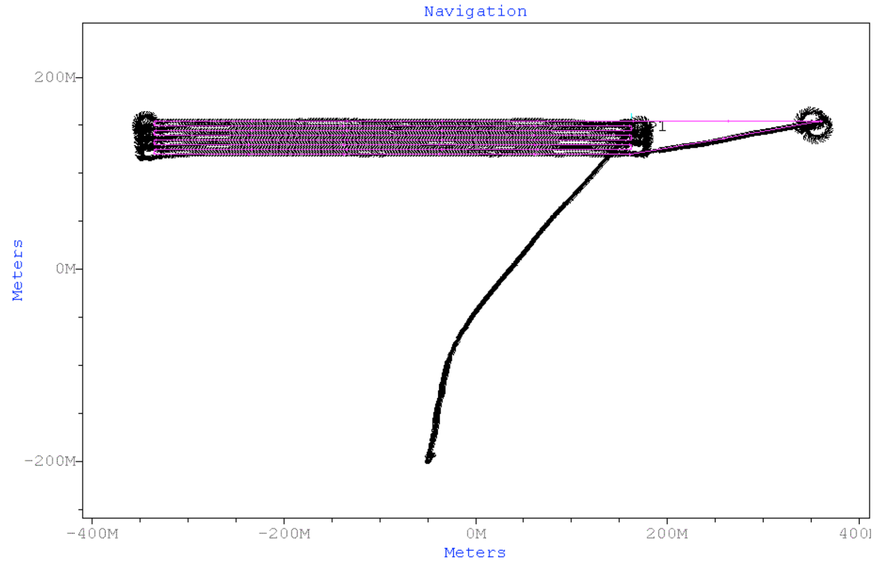
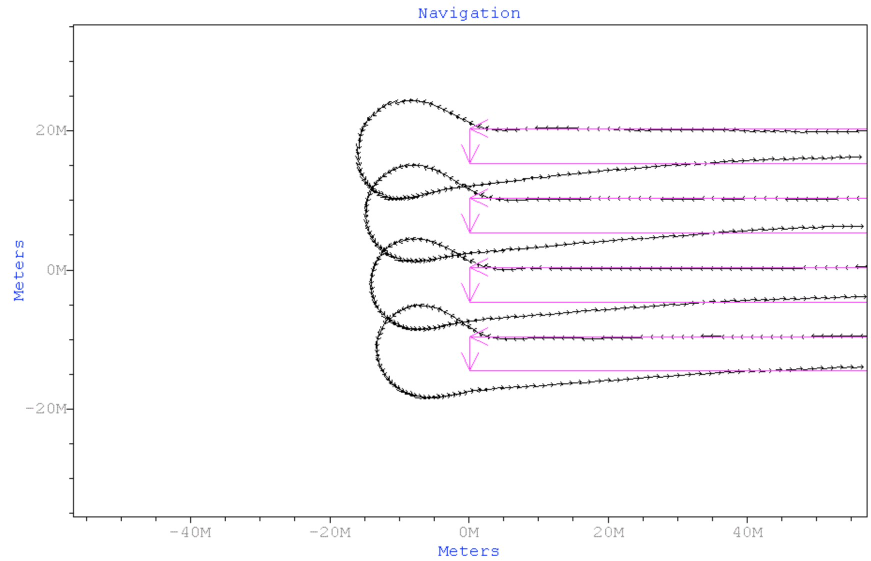


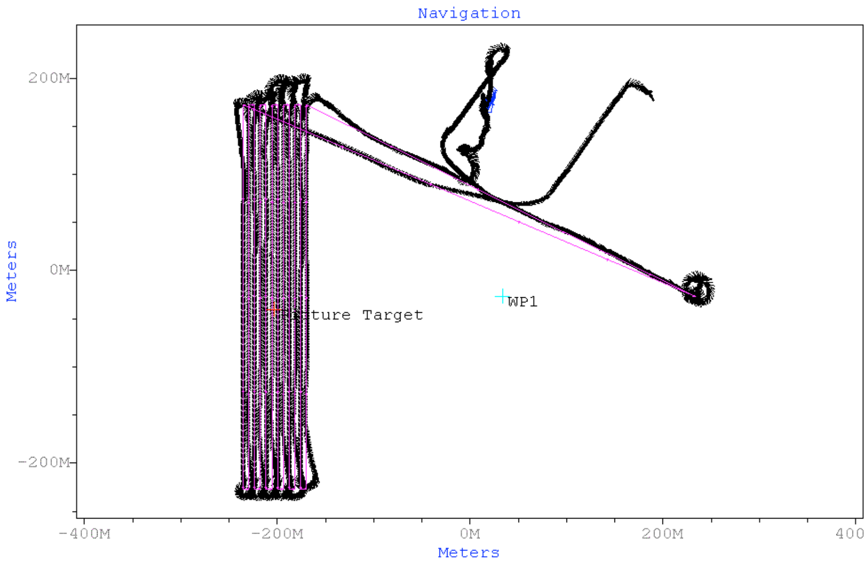
AUV-track (black) and mission profile lines for test dive 02 when INS-

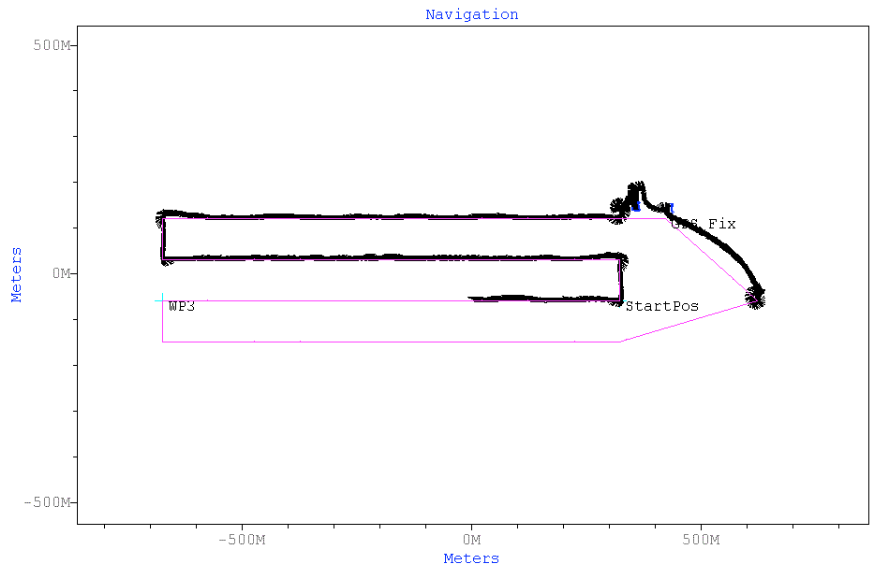
Day	Time (LT)	Plan	Result
		calibration was done.	
	17:00	Recover vehicle	
13.11.08	08:00	**Test dives 04, 05, 06, 07, and 08**; deploy vehicle for several missions with different depths to test multibeam performance. Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	3 missions completed, ca. 80GB bathymetric data per mission.
		 *AUV-track (black) and mission profile lines for test dive 05.*	
	16:00	Recover vehicle, begin data processing	Successful.
14.11.08	10:00	**Test dive 09**; deploy multibeam configuration for various settings in working area Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	Mission aborted after 30 mins. With GFI – water in main RESON bottle. Rest of day spent checking and repairing bottle.
15.11.08	10:00	Decide on status of RESON bottle	Bottle not repairable onboard. Contact Hydroid for RESON support.
	11:00	Reconfigure for camera work	
	15:00	Deploy vehicle for **test dive 10** and perform camera survey 10m from seafloor	Vehicle did not manage to dive, navigation error lead to collision with FS "Poseidon". Dive failure

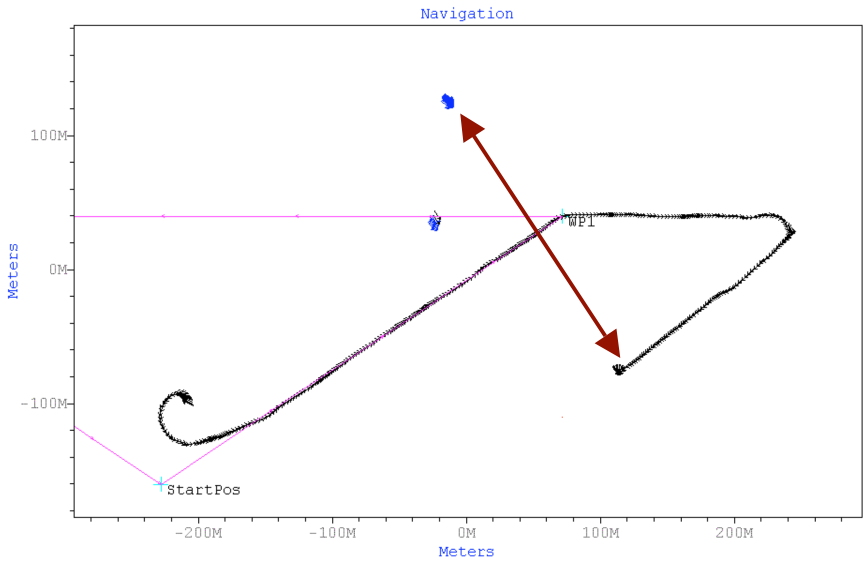
Day	Time (LT)	Plan	Result
		<u>Instruments used:</u> Electronic still camera RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	due to weights for RESON configuration placed post-FAT in tail were not known about or removed.
	16:30	Recover vehicle	Antenna needs to be replaced, J-box also opened to replace leaking connector.
16.11.08	10:00	**Test dive 11**; perform photo surveys, 500m lines at 5m spacing, 10, 8 and 6m off seafloor testing navigation and camera height settings. <u>Instruments used:</u> Electronic still camera RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	Vehicle attained maximum depth of only 40m at a descent rate of 27m down in 500m distance (descent angle 3°) despite full down pitch: trim is wrong, vehicle is too buoyant presumably due to extra foam added to vehicle for the RESON final floatation configuration.
		 *AUV-track (black) and mission profile lines for test dive 11.*	
	14:00	Recover vehicle	After difficult recovery and with a poorly trimmed vehicle in sea state 5-6 decision taken to return to Las Palmas, awaiting final trim tables from Pocassett .
	20:00	Alongside Las Palmas	
17.11.08	18:00	Chief scientist for the second leg arrives (S. Petersen, IFM-GEOMAR).	
18.11.08	09:30	Leaving Las Palmas; heading for working area 1.	

Day	Time (LT)	Plan	Result
	15:00	Arrival in working area 1; Prepare launch of the vehicle.	High sea state does not allow launch of the vehicle. Wait for one hour to see if weather conditions are improving, but no change = no launch.
19.11.08	09:30	Release 50x50cm black & white steel plate as photo target	
	10:00	**Test dive 12**; Perform photo surveys and find target plate; four 500m E/W lines at 5m spacing; 6m off seafloor testing camera height settings; add modified mission (**test dive 13**) with 8m altitude. Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Imagenex852 pencil beam	Vehicle reached target depth and worked fine. Camera still images seem slightly out of focus. Mission reprogramming "on-the-flight" successful. Photo target not found.
		 *AUV-track (black) and mission profile lines for test dive 12.*	

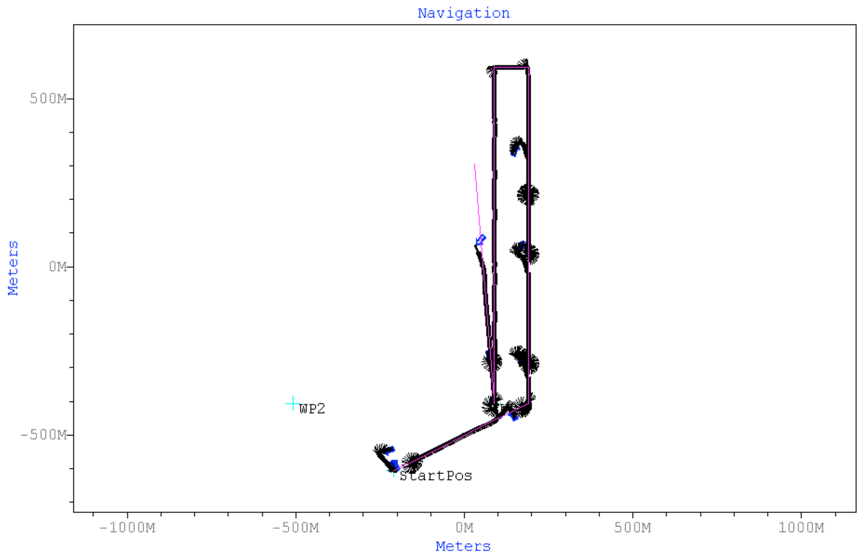
Day	Time (LT)	Plan	Result
		 *AUV-track (black) and mission profile lines for test dive 13.*  *Detailed AUV-track during turns with a line spacing of 5m. Note deviation off the line for the first 30m when using such narrow line spacing.*	
	13:00	**Test dive 14**; perform photo surveys, twelve 400m N/S lines at 6m spacing, 10m off seafloor; testing navigation and camera height settings. <u>Instruments used:</u> Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Imagenex852 pencil beam	Vehicle worked fine. Camera still images seem slightly out of focus. Found photo plate 35m west of drop-off position. Oil compensator shows leakage.

Day	Time (LT)	Plan	Result
		 *AUV-track (black) and mission profile lines for test dive 14.*	
	17:00	Recover vehicle.	Difficult recovery; pick-up float did not release; recovery with zodiac in high sea state. Scratches on AUV hull due to zodiac propeller. No further damage.
	18:00	Sail to Las Palmas to embark technician from RESON to fix multibeam.	
	23:00	Arrival at Las Palmas road	
	23:45	Embarking of Joergen Hansen (RESON technician)	
20.11.08	00:00	Leave Las Palmas and head for working area	
	08:00	Start repair of the RESON multi-beam system	
	09:30	Test of transponders and re-leaser; one with complete set of buoys and anchor weight	All tests successful.
	13:00	Continue repair of multibeam sensor; Replace receiver and IPU.	Time synchronization between ve-hicle and RESON bottle might be responsible for some of the prob-lems we see.
21.11.08	08:00	Preparation of the vehicle.	Reassemble multibeam section; oil leak fixed.
	16:00	**Test dive 15**; perform multibeam test in shallow water; four 1000m E/W lines at 90m spacing, vehi-cle at water depth of 20m. Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD	Launch and recovery good. Pick-up float worked fine.

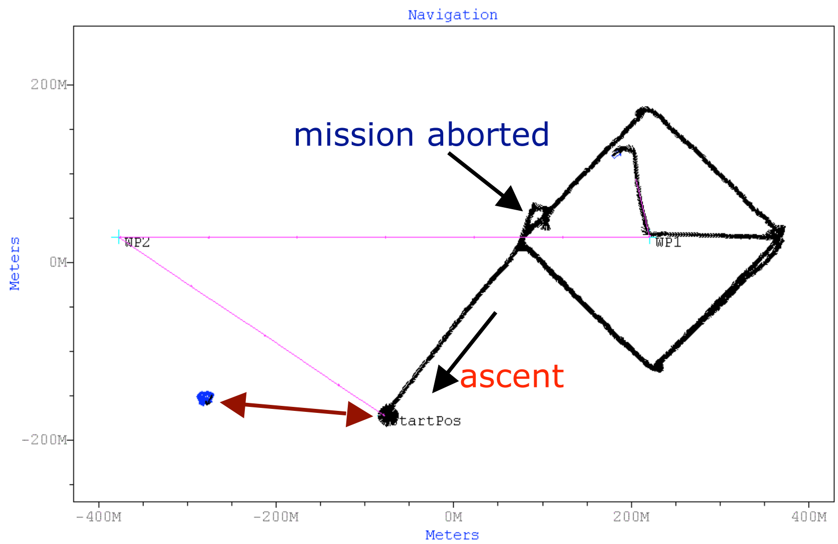
Day	Time (LT)	Plan	Result
		Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Imagenex852 pencil beam	
		 *AUV-track (black; start is not shown) and mission planning for test dive 15. Difference between INS and GPS-fix is 7m after 80 minutes.*	
	18:00	Recover vehicle during sunset.	Pick-up float with reduced line length worked fine. Strobe well visible. Bathymetric data collected along half of first profile line, than stopped.
	19:00	Hold position until dawn; transfer to working area 2 (27°15'N / 14°50'W; depth ~ 2500m).	Data downloaded from vehicle but data is not transferable to PDS2000 software.
22.11.08	08:00	Continue repair and software update on RESON sensor and vehicle.	Implementing software to execute time synchronization. Repair of ground fault within RESON bottle.
	15:00	**Test dive 16**; deploy vehicle for mission in mid-water to drive down to 1000m depth. <u>Instruments used:</u> Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	Mission aborted after few minutes. Reprogramming for second attempt. This test dive (17) fails also.

Day	Time (LT)	Plan	Result
		 *AUV-track (black) and mission profile lines for test dive 16. Note position difference between INS navigation and GPS fixes (236m) after only 7 minutes!*	
	16:30	Recover vehicle.	No problems.
23.11.08	08:00	Continue repair and software update on RESON sensor and vehicle. Implementing software patches to implement time syn-chronization.	Software test program does not change the problem of time syn-chronization. Repair of ground fault within RESON bottle.
	10:00	Deploy vehicle for mission in mid-water to drive down to 200m depth followed by mission to drive down to 1000m. Several mission runs (**test dives 18 to 22**). <u>Instruments used:</u> Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	First dive aborted, second mission (test dive 19) dives down to 200m. Next two missions fail to spiral down to 1000m. Mission 20 is aborted after a short period. Dur-ing mission 21 ABYSS reaches 80m but is stuck. Next run (mis-sion 22) follows two 3000m N/S long profile lines. Vehicle gets only to 505m over the entire profile length after 1.5 hours. Power management of the vehicle seems to be a problem. Large offset be-tween INS-navigation and GPS-fix after surfacing. Oil leakage.

Day	Time (LT)	Plan	Result



AUV-track (black) and mission profile lines for test dive 19.



AUV-track (black) and mission profile lines for test dive 21. Difference between INS and GPS-fix is 197m after 40 minutes.

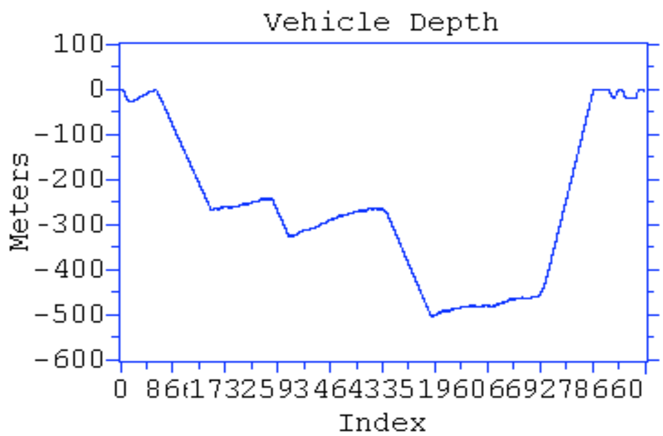
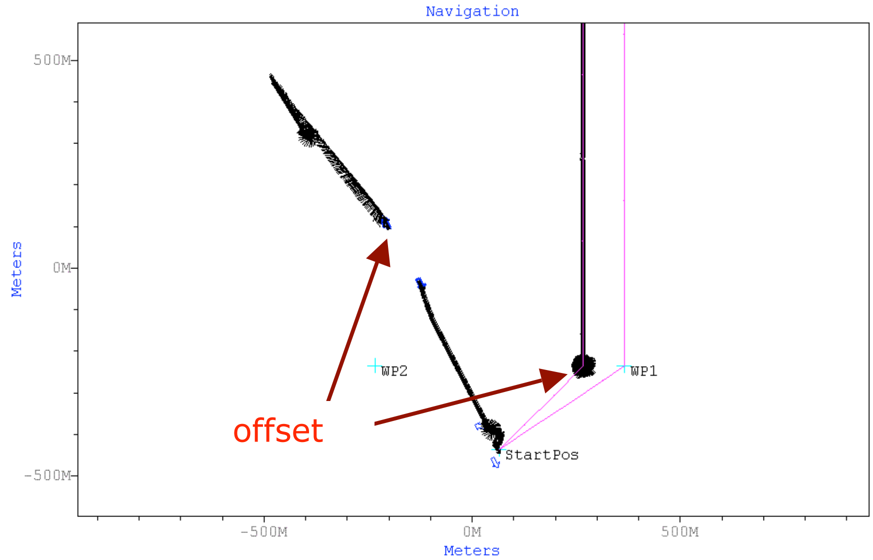
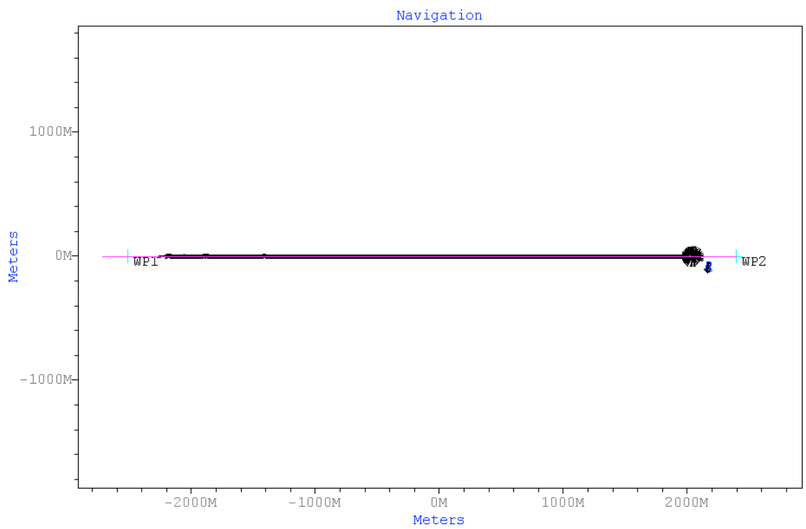
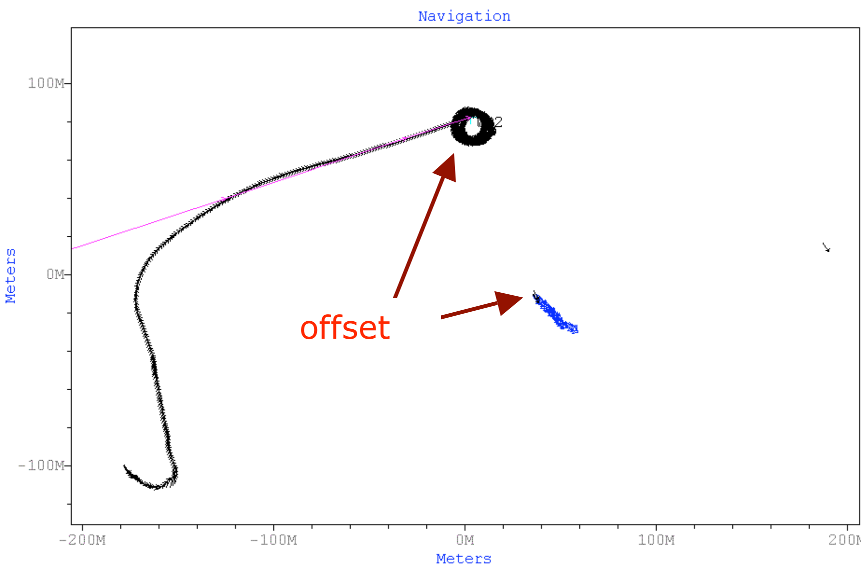


Image showing saw tooth pattern during descent from dive 22. Vehicle drives down until stalling ("at Bollard" condition), drifts upwards and, after several minutes, continues descent.

Day	Time (LT)	Plan	Result
		 *AUV-track (black) and mission profile lines for the end of test dive 22. Note difference between INS and first GPS fixes after surfacing.*	
	17:30	Recover vehicle.	No problems.
24.11.08	03:00	Transfer to shallow-water working area	
	08:00	Reinstallation of RESON software and testing.	
	11:00	Deploy vehicle for **test dive 23** in order to drive along a 5000m W/E profile from shallow water (<100m) to ~ 1000m. Stay at constant depth of 50m. RESON=ON. <u>Instruments used:</u> Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Imagenex852 pencil beam	Dive OK; DVL lost bottom log (as expected)
		 *AUV-track (black) and mission profile lines for most of test dive 23.*	

Day	Time (LT)	Plan	Result
	11:00	**Test dive 24** along the same profile but without multibeam logging and trying to drive descent to 200m. Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	Dive OK.



AUV-track (black) and mission profile lines for the end of test dive 24. Difference between INS and GPS-fix is 94m after 12 minutes.

Day	Time (LT)	Plan	Result
	17:30	Recover vehicle.	No problems.
	18:00	Transfer to working area 2.	
25.11.08	08:00	Preparation of the vehicle. Reinstallation of the RESON bottle.	Changed hotel load and test watts of the vehicle!
	10:00	Deploy vehicle for **test dive 25** in order to drive down to 2500m water depth and than follow 1000m long W/E profile line using sidescan only. Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	Instrument drives down to 2500m in 45 minutes. Follows trackline and resurfaces. Sidescan data not recorded due to interface problems.

<table>
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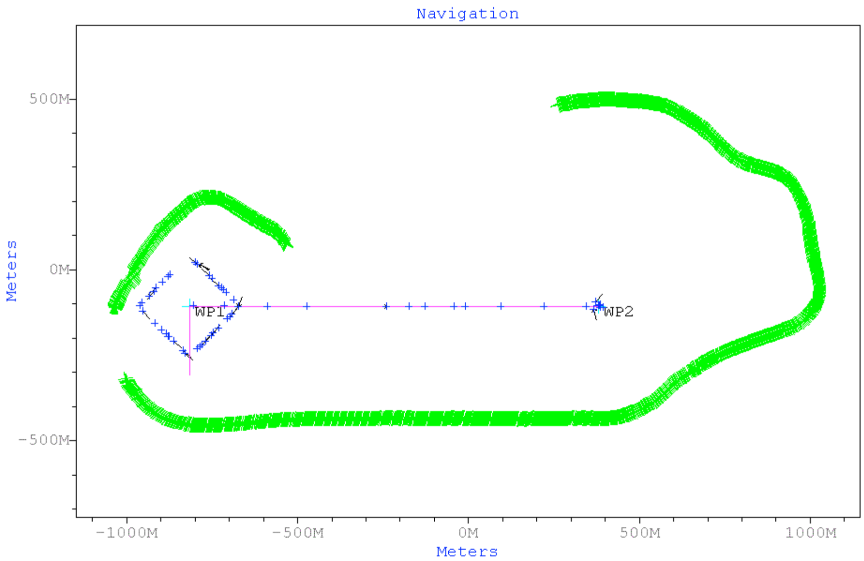
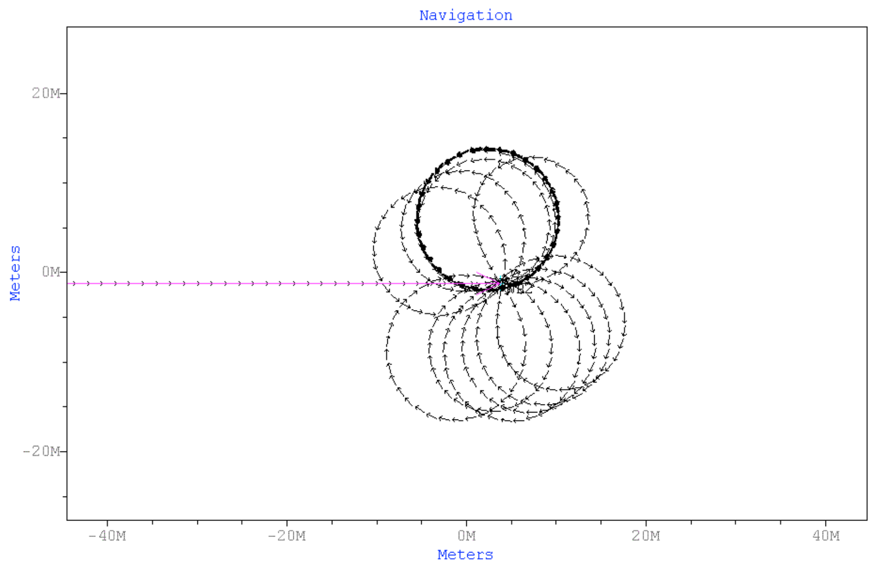
<tr><td></td><td></td><td colspan="2">

AUV-position during status messages (blue crosses), mission profile line, and ships track (green) for test dive 25.



AUV-track at the end of the profile showing AUV-movement during ascent (test dive 25).</td></tr>
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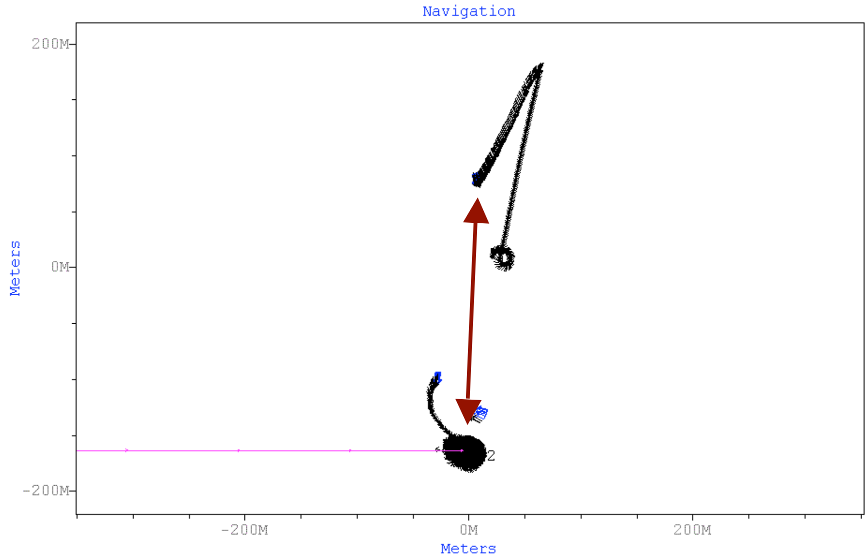
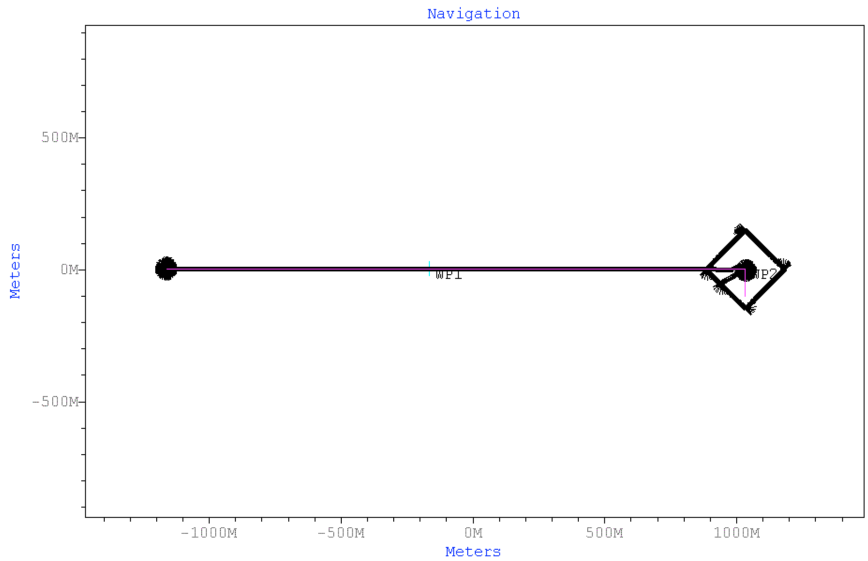
		 *AUV-track (black) and mission profile line for the end of test dive 25. Note position difference (242m after 120 minutes) between INS navigation and first GPS fixes after surfacing.*	
	13:00	Reprogram for **test dive 26** to drive down to 2500m and follow a 2000m long E/W profile (reversed from above) with multibeam = ON. <u>Instruments used:</u> Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Eh-sensor	Instrument drives down again nicely. Bathymetric data not collected because transmission power was at 0 db although it was set to 220 db in the mission objectives. CTD data is good; backscatter and Eh-sensor are working fine (see next chapter for graphs). During ascent, dive weight is dropped at 1500m, seemingly because of a wrong “low battery” message was sent out. Battery is still on 40%. Low battery command should only be sent when level below 20% is reached.
		 *AUV-track (black) and mission profile lines for test dive 26.*	

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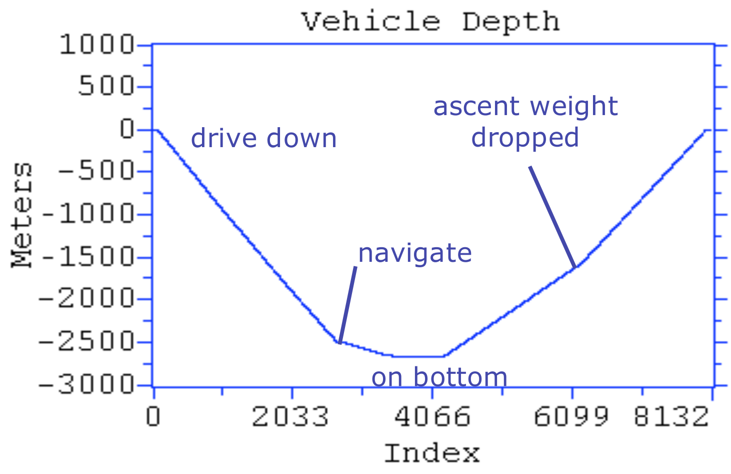
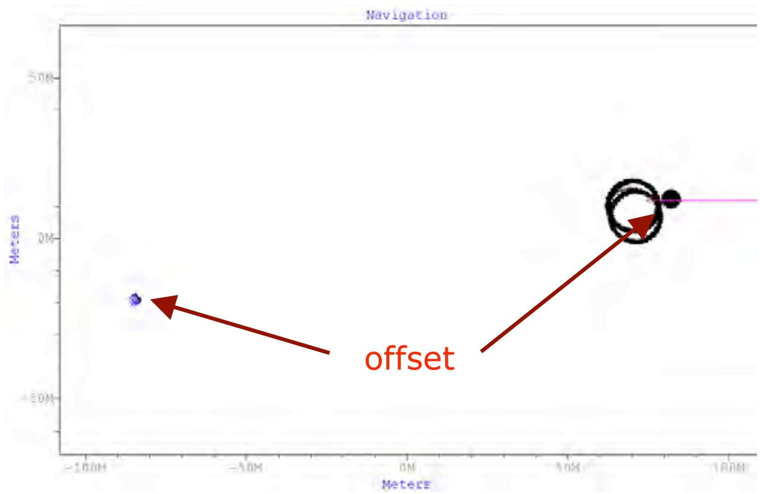
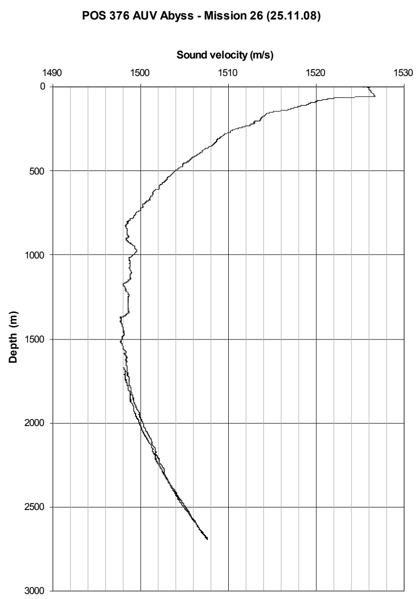
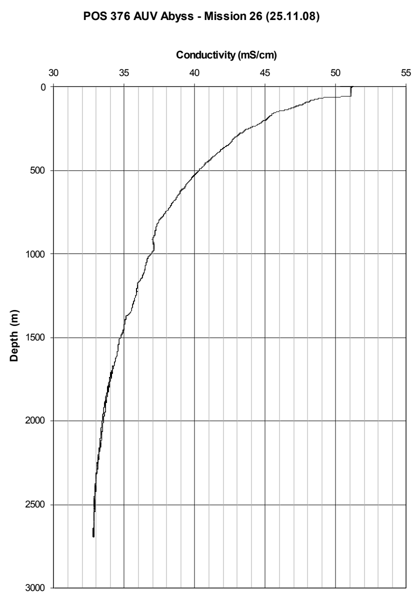


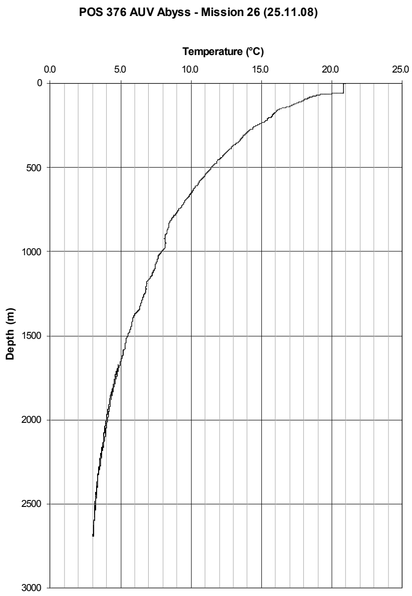
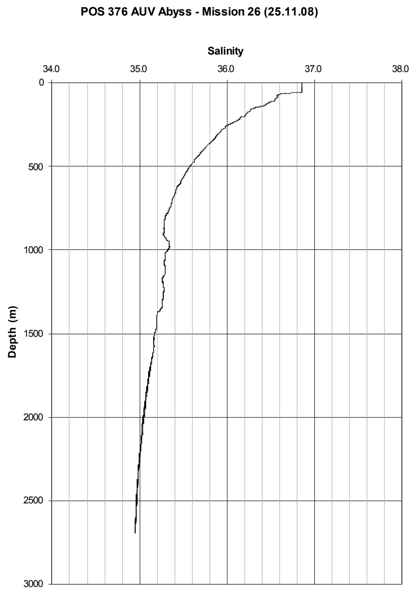
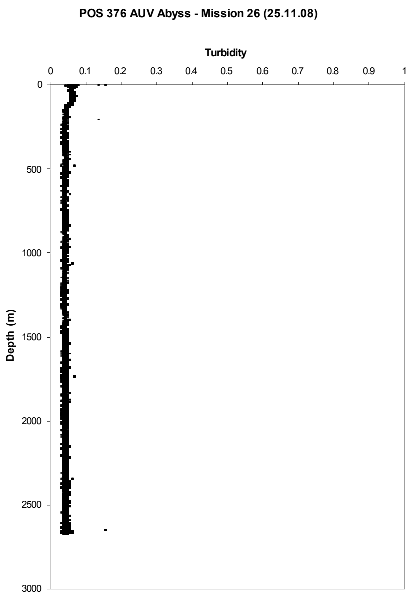
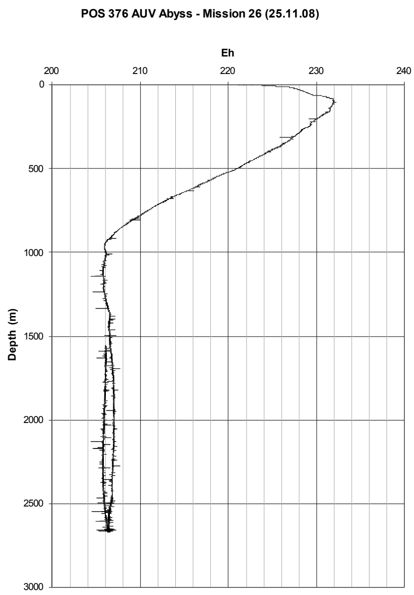
Vehicle depth over “time” for test dive 26.
Note different pitch between mission sections



AUV-track (black) and mission profile line for the end of test dive 26. Note position difference (170m after 2 hours) between inertial navigation and first GPS fixes after surfacing.
</td></tr>
<tr><td></td><td></td><td>


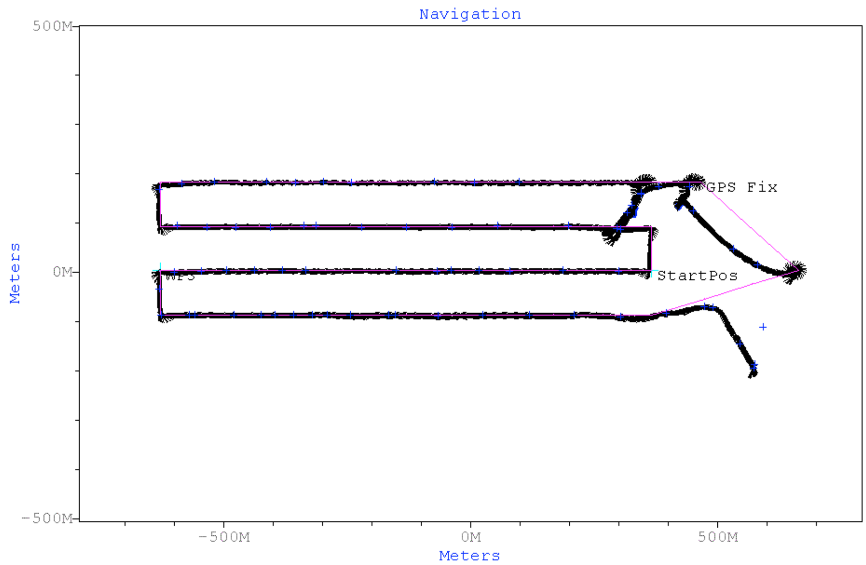
Sound velocity versus depth for mission 26.
</td><td>


Conductivity versus depth for mission 26.
</td></tr>
</table>

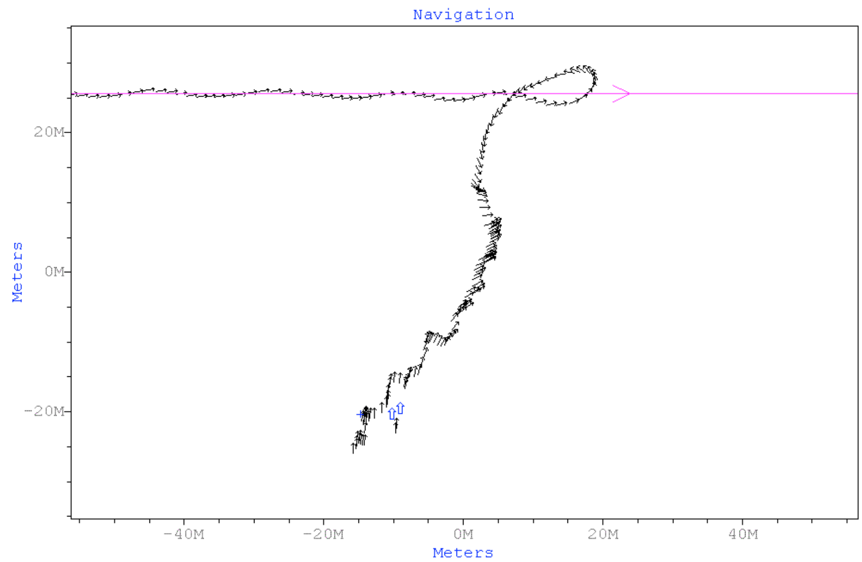
Day	Time (LT)	Plan	Result
		 *Temperature versus depth for mission 26.*	 *Salinity versus depth for mission 26.*
		 *Backscatter versus depth for mission 26.*	 *Eh versus depth for mission 26.*
	16:30	Recover vehicle.	No problems.
	17:30	Return to working area 1 (shallow-water area)	
26.11.08	10:00	Deploy all three transponders to test functionality at water depth of 1500m	All three transponders acknowledged on the first try and read the same range of 1479m (water depth at the time was 1499m; towfish was at a depth of 10m)
	15:00	Deploy vehicle **(test dive 27)** for rerun of mission 15 in order to check INS alignment and behaviour; water depth is <100m; four	Abyss follows lines nicely; INS navigation with bottom log by DVL functions fine; difference between INS navigation and first GPS fixes

<table>
<tr><th>Day</th><th>Time (LT)</th><th>Plan</th><th>Result</th></tr>
<tr><td></td><td></td><td>1000m E/W lines at 90m spacing, vehicle at water depth of 20m. Multibeam and sidescan are ON.

<u>Instruments used:</u>
Reson Seabat 7125
RDI ADCP
Seabird Fastcat SBE49 CTD
Wetlabs ECO FLNTU backscatter
Edgetech 2200M Sidescan sonar
Eh-sensor</td><td>is 5m. Sidescan data is OK; four files logged, but one file is missing at the end.</td></tr>
<tr><td></td><td></td><td colspan="2">

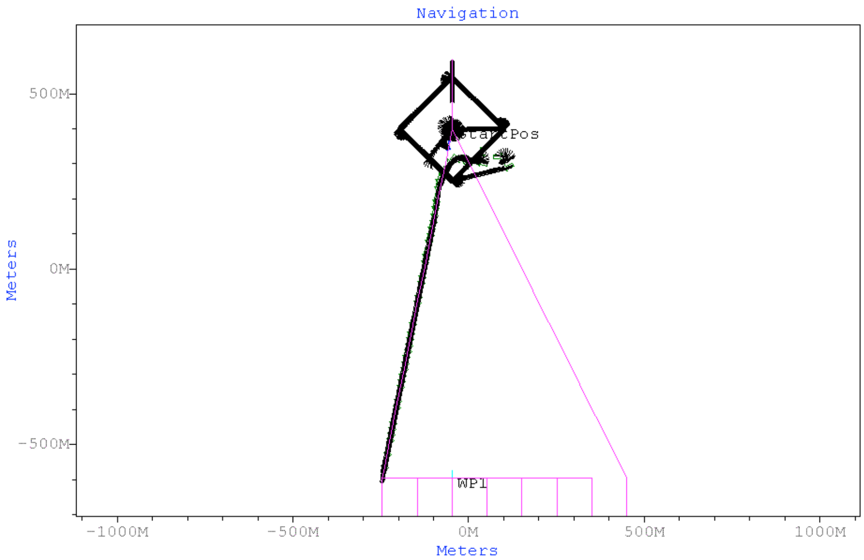


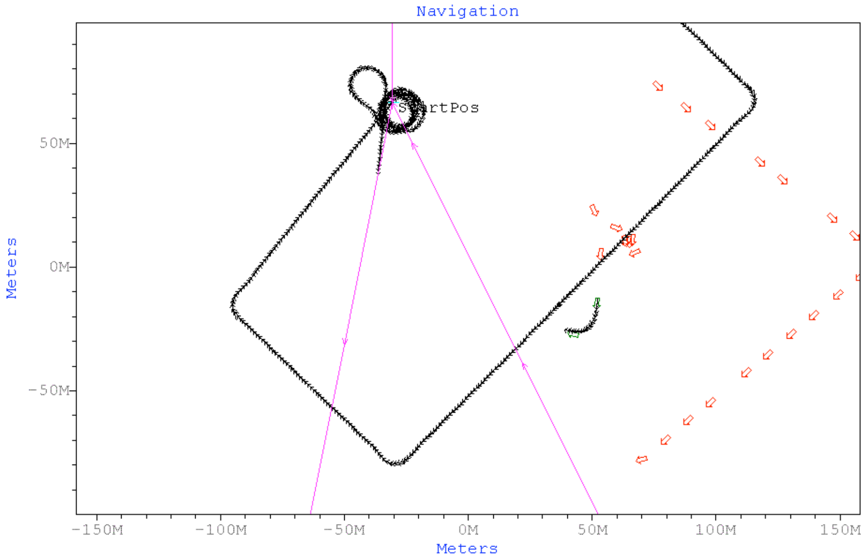
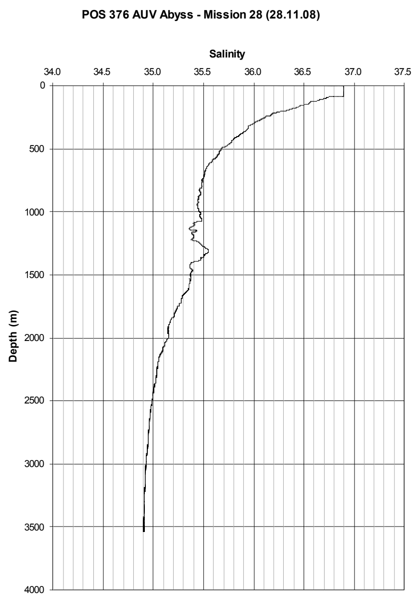
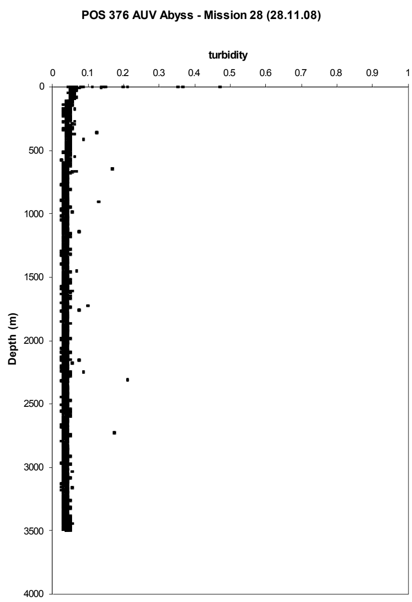
AUV-track (black) and mission profile lines for test dive 27 (=rerun of test dive 15).



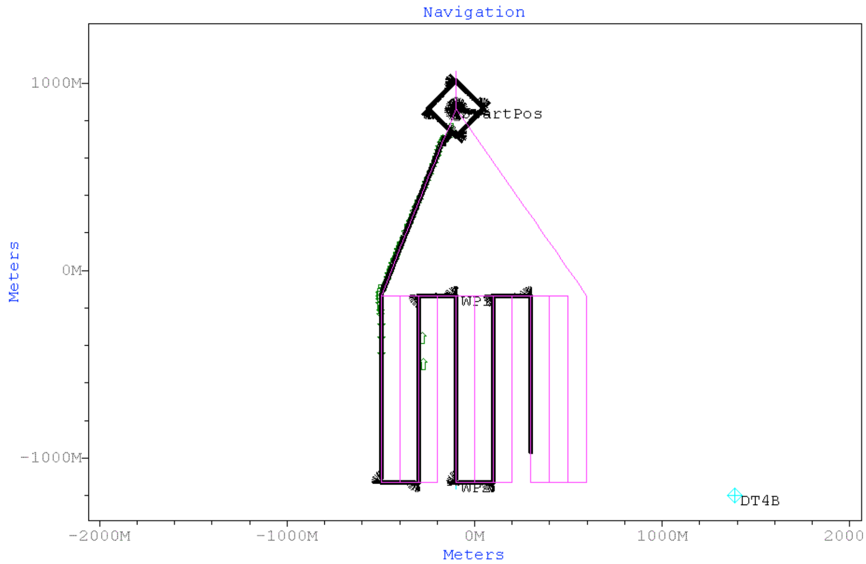
AUV-track (black) and mission profile line for the end of test dive 27 while trying to get the first GPS fix. The difference between INS navigation and GPS after surfacing is only 5m after 1 hour.

</td></tr>
<tr><td></td><td>16:30</td><td>Recover vehicle.</td><td>No problems.</td></tr>
<tr><td></td><td></td><td colspan="2">Move to offshore working area 3 for deep-water testing</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>27.11.08</td><td>08:00</td><td>Deploy two transponders for</td><td>Transponders deployed and cali-</td></tr>
</table>

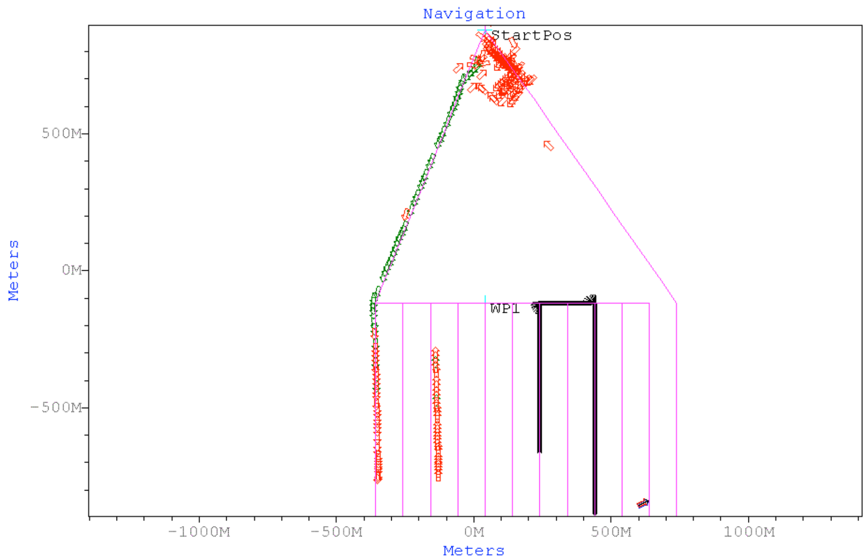
Day	Time (LT)	Plan	Result
		deep water tests.	brated. DT4A @ 28°43.797'N/14°55.833'W DT4B @ 28°43.879'N/14°54.084'W
	13:00	Deploy vehicle for 1000m long N/S profile with transponder navigation at water depth of 3500m near 28°45'N/14°55'W.	Dive cancelled due to high seas. New software patch to solve time-synchronization problem is installed and seems to work properly.
28.11.08	09:30	Deploy vehicle for four 1000m long N/S profiles with transponder navigation at water depth of 3500m near 28°45'N/14°55'W **(test dive 28)**. Two missions planned. One at 75m altitude for bathymetry and 2nd mission 20m above ground for sidescan data. <u>Instruments used:</u> Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Imagenex852 pencil beam	Abyss went down to 3500m, found the transponders and started the mission. However, shortly after the mission started the AUV went dead and restarted its system. Safety procedures required the AUV to abort the mission and ascent by dropping its weight. Descent to 3400m took 60 minutes (0.9m / second).
		 *AUV-track (black) and mission profile lines for test dive 28. The mission was aborted shortly after the start of the first bottom line.*	

Day	Time (LT)	Plan	Result
		 *AUV-track (black) and mission profile lines for the beginning of test dive 28. The AUV read the transponder and, at first, distrusted the positions (red arrows) before using them for navigation (green arrows).*	
	14:00	Recover vehicle.	Recovery went fine. Afternoon spent with trying to find the reason for the restart. Possibly ground fault in the transducer cable. Repaired with polyurethane.
		 *Salinity versus depth for mission 28.*	 *Backscatter versus depth for mission 28.*
29.11.08	09:00	Deploy vehicle for 1000m long N/S profiles with transponder navigation at water depth of 3500m near 28°45'N/14°55'W **(test dive 29)**. Two missions planned. One at 75m altitude for bathymetry and second mission 20m above ground in order to	ABYSS went down to 3500m, found the transponders and started its mission. Almost five profile lines were finished when the AUV released the pick-up float (at 3400m depth!) that was than spun around the propeller. The AUV safety program stopped the mission and

Day	Time (LT)	Plan	Result
		acquire sidescan data. Instruments used: Reson Seabat 7125 RDI ADCP Seabird Fastcat SBE49 CTD Wetlabs ECO FLNTU backscatter Edgetech 2200M Sidescan sonar Imagenex852 pencil beam	started the ascent. No bathymetric data was recorded on file due to communication failure between vehicle and RESON bottle early on during the dive. It is interesting to note that the commands for aborting the mission appear in the RESON logfile. Oil leakage during the dive.

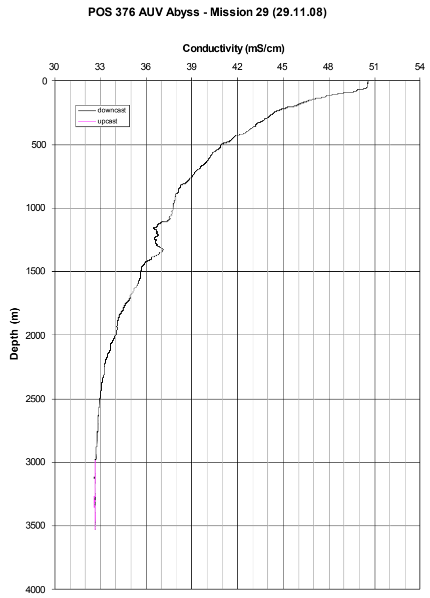
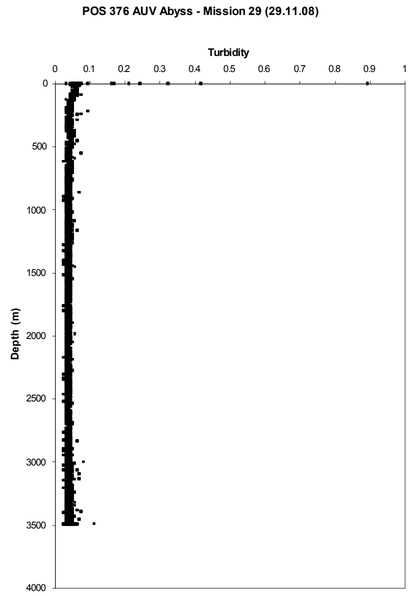


AUV-track (black) and mission profile lines for test dive 29. The AUV used transponder navigation (green arrows) during the first part of the first profile line and later used INS navigation only.



Detail of the transponder navigation fixes during test dive 29. The AUV used transponder navigation (green arrows) during the first part of the first profile line and later refused the fixes (red arrows). Remainder of the track used INS navigation only until mission was aborted (black arrows shown for the end of the mission.

Day	Time (LT)	Plan	Result
	14:00	Recover vehicle.	Zodiac had to be used in order to

Day	Time (LT)	Plan	Result
			untie the line from the propeller. After this was done, recovery with the LARS went fine.
		 *Conductivity versus depth for mission 29. Data logging stopped when mission was aborted.*	 *Backscatter versus depth for mission 29.*
30.11.08	09:00	Deploy vehicle for 1000m long N/S profiles with transponder navigation at water depth of 3500m near 28°45'N/14°55'W. Two missions planned. One at 75m altitude for bathymetry and 2nd mission 20m above ground in order to acquire sidescan data.	Replaced DSP board in the vehicle with DSP board from transponder D before the dive. Ground fault while the vehicle is still in the container. No communication between vehicle and RESON bottle. Open vehicle and check. Problems seem not to be related to cable but to the bottle itself. Checking communications boards. RESON hard disk fails! Mission cancelled
	14:00		Trying to repair RESON bottle - failed. Take down RESON configuration and switch to subbottom profiler configuration for the next day.
01.12.08	09:00	Deploy vehicle for two 1000m long N/S profiles with transponder navigation at water depth of 3500m near 28°45'N/14°55'W (test dive 30). Several missions planned. Two lines at 20m/10m altitude for subbottom profiling and one yoyo-mission (3300m long profile in water depths between 3350m and 3500m (minimum altitude = 50m).	After assembly of the vehicle the Subbottom Profiler bottle shows "no-vacuum" and the safety procedure drops the ascent weight (correctly!) within the container. Vacuum re-installed.

Day	Time (LT)	Plan	Result
	10:30		Shortly before launch a ground fault of 33 is detected. Take vehicle off the LARS to check the system.
	14:00	Deployment for mission (see above)	Mission aborted during descent at a water depth of 445m. System restarted without any error message or warning; reason unknown.
	15:30	Release transponder DT4A and DT4B	
	17:15	Pick-up of transponders	
	17:30	Transit to get closer to shore, start packing and disassembling the AUV system. Discharge batteries for storage.	
02.12.08	08:00	Start disassembling AUV and LARS; packing containers.	
	17:00	At pilots point. Entering Las Palmas harbour.	
03.12.08	08:00	Start unloading Poseidon.	
	14:00	Scientists leave Poseidon. END of POS 376.	

4 AUV Operations

K. Lackschewitz, J. Sticklus, and M. Rothenbeck

The Autonomous Underwater Vehicle (AUV) ABYSS (built by HYDROID) from IFM-Geomar was tested during POSEIDON cruise 376. It can operate in water depth of up to 6000m.

The ABYSS system comprises the AUV itself, a control and workshop container, and a mobile Launch and Recovery System (LARS) with a deployment frame which was installed on the afterdeck of RV POSEIDON (Fig. 3). The self-contained LARS was developed by Woods Hole Oceanographic Institution (WHOI) to support ship-based operations so that no Zodiac is required to launch and recover the AUV. The LARS is mounted on steel plates which are screwed on the deck of the ship. The LARS is configured in a way that the AUV can also be deployed over the port or starboard side of the German medium and big sized research vessels. The LARS is stored in a 20ft. container during transport.

Fig.3: AUV ABYSS placed in its Launch- and recovery system (LARS).

During POS376 we were able to deploy and recover the AUV in weather conditions with a swell up to 2.5 m and wind speeds of up to 6 Beaufort. For the recovery the nose float pops off when triggered through an acoustic command and releases a floating line (Fig. 4a). The float and the ca. 25m recovery line drift away from the vehicle so that a grappnel hook can snag the line. The line is then connected to the LARS winch, and the vehicle is pulled up.

The manufacturers describe the vehicle as follows: "The vehicle consists of a tapered forward section, a cylindrical midsection and a tapered tail section. An internal titanium strongback, which extends much of the vehicle length, provides the structural integrity and a mounting platform for syntactic foam, equipment housings, sensors and release mechanisms. The maximum vehicle diameter is 0.66 meters and the overall length is 3.95 meters. Vehicle weight is, depending on the payload, approximately 850 kilograms. A rectangular compartment in the midsection of the vehicle contains three pressure housings and an oil-filled junction box. Two pressure housings each contain one 5.75 kWhr 29-Volt lithium-ion battery pack. The third pressure housing contains the vehicle and sidescan sonar electronics. The vehicle's inertial navigation unit and acoustic Doppler current profiler are housed in two other independent housings that are mounted forward of the 3 main pressure housings. Wiring from each independent subsystem is connected to the main electronics pressure housing via a feed thru connector which is mounted in the end of the junction box/end cap assembly. Oil-filled tubing and conventional cabling methods are used to interconnect subsystems. A pressure compensator is used to pressurize the oil-filled tubes and junction boxes and to monitor reserve fluid levels (Fig. 4b). The propulsion and control systems are located in the tail assembly, which bolts to the aft face of the vehicle strongback. The tail assembly consists of a pressure housing with motor controller electronics, and an oil-compensated motor housing."

Propulsion is generated with a 24 VDC brushless motor driving a two-bladed propeller. Control is achieved with horizontal and vertical fins driven by 24 VDC brushless gear motors. The vehicle velocity range is 0.25 to 2.0 m/s, although best control is achieved at velocities above 1.0 m/s. The AUV dives descent with about 1 m/s whereas the ascent time is about 0.7 m/s or 1m/s if ascent weight is dropped. Together with the deployment/recovery procedure the descent to the seafloor and the ascent back to the vessel took 3 hours at a water depth of 3500 m.

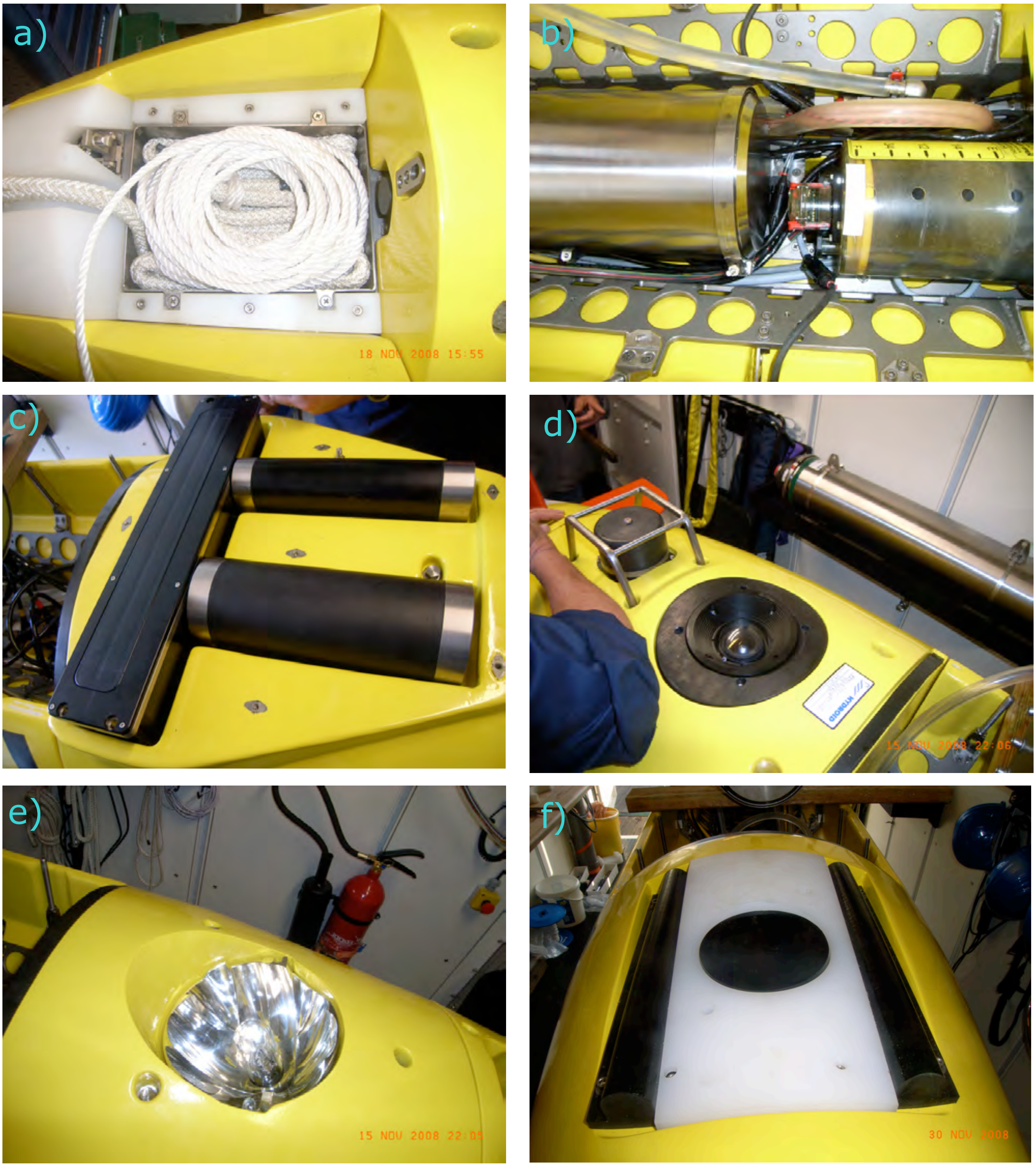


Fig. 4: Details of the AUV ABYSS. a) view inside the pick-up float box, b) view inside the vehicle with main electronic bottle (left), oil compensator (right), and the titanium

backbone, c) multibeam transducer and receiver, d) Camera, e) flashlight. f) subbottom profiler.

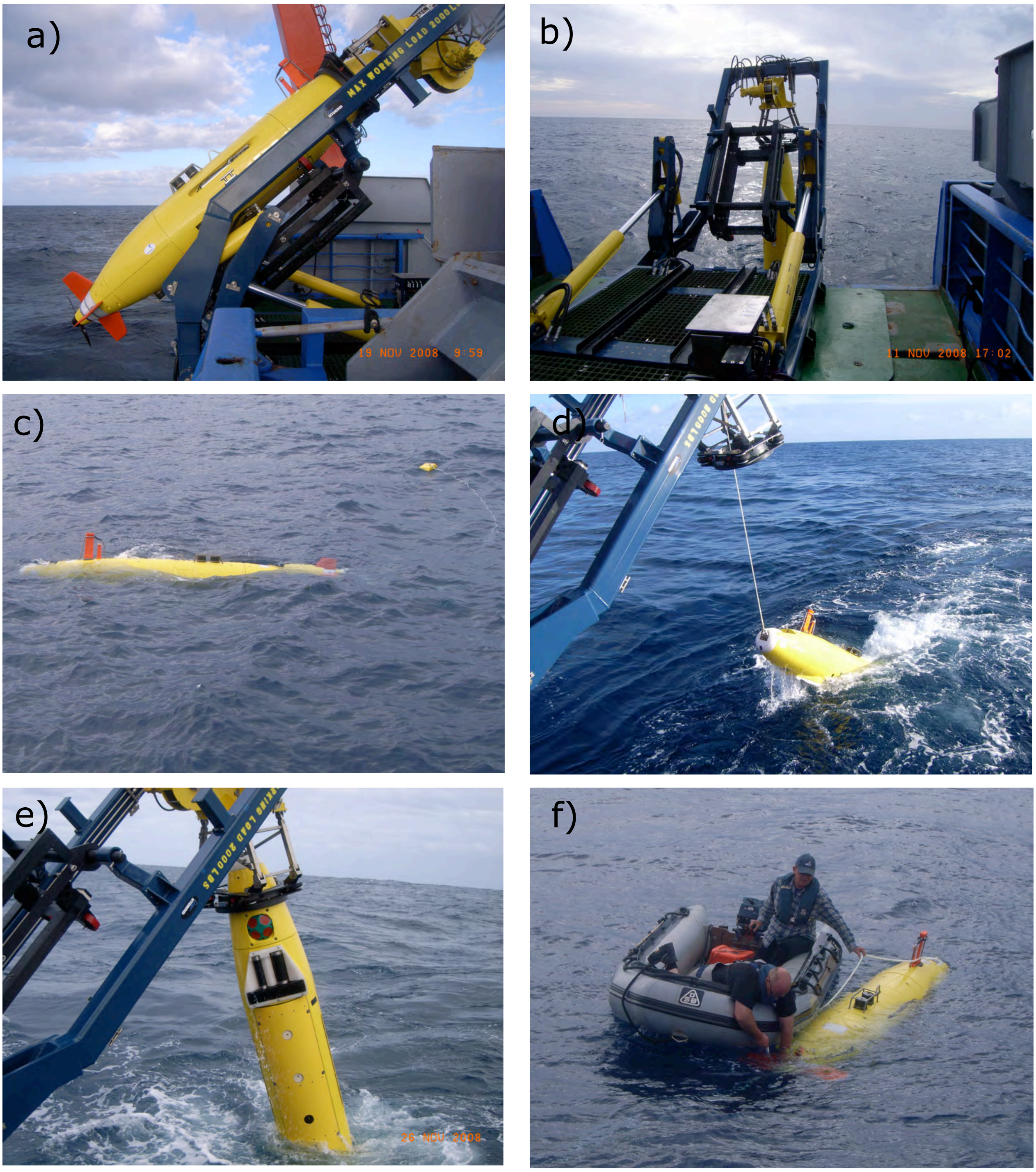


Fig. 5: Details of the AUV Abyss deployments. a) Abyss shortly before launch, b) Abyss is being launched, c) Abyss after the mission; the pick-up float is released, d) Recovery with the LARS system, e) Abyss connected to the LARS and being brought in, f) The zodiac had to be used after the recovery line was spun around the propeller of the vehicle.

Sensors of the base vehicle include an Edgetech 2200-M sidescan sonar; a Sea-Bird Fastcat SBE49, a Wetlabs ECO FLNTU optical backscatter/fluorometer, and an Eh-sensor (provided by Dr. K. Nakamura; Japan). The KEARFOTT inertial navigation system T24 is aided by an Acoustic Doppler Current Profiler (ADCP) with bottom lock capabilities.

In addition, the vehicle can be reconfigured for three different modes of operation as follows:

1. Base vehicle plus RESON Seabat 7125 Multi-Beam, or
2. Base vehicle plus Electronic Still Camera & Strobe, or
3. Base vehicle plus EDGETECH Sub-Bottom Profiler

All sensor information collected by the vehicle is marked with time, depth and latitude, and longitude as it is collected, facilitating the rapid and highly automated generation of maps and HTML based reports. An acoustic communication system permits the vehicle to send status messages to the surface ship containing information about the vehicle's health, its location, and some sensor data while it is performing a mission at up to 6 km below the surface. The acoustic communication system is also used to send data and redirection commands to the vehicle. The AUV utilizes electronics, control software, and the laptop based operator interface software from the REMUS 100 vehicle system.

The vehicle navigates autonomously using a combination of navigation methods, depending on the mission objectives, conditions, and optional equipment enabled.

- 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 CT Probe to calculate sound speed. The DVL must be within range of the bottom to measure altitude and provide bottom-lock for the INS.
- Low Frequency Long Baseline Acoustic Navigation (LFLBL) - The vehicle can navigate using Long Baseline (LBL) navigation by computing its range to two (or more) moored acoustic transponders. Low Frequency LBL navigation provides longer range acoustic navigation than standard frequency LBL navigation.

A Vehicle Interface Program (VIP), a Windows®-based program (Fig. 5) manages every aspect of AUV operation, including the following tasks:

- Mission planning on electronic navigation charts (customizable, multi-format)
- Real-time mission monitoring through the acoustic modem
- Real-time support-vessel position and heading through GPS and compass feeds (from the AUV control container
- Pre-mission system checkout
- Post-mission data analysis, mission play-back, and side-scan review

Navigation charts show missions during planning, operation, and review. A graphic Mission Planner lets users build mission files using drag-and-drop to position waypoints and mission objectives on the chart window, and fine-tune missions using editable text fields. Automatic error checking verifies all aspects of planned missions, and warns operators if any mission parameters are incorrect. Communication between the vehicle and the computer runs through a standard Ethernet connection, or wirelessly, using the WiFi connection. The vehicle interface program (VIP) provides a convenient means of mission planning and programming.

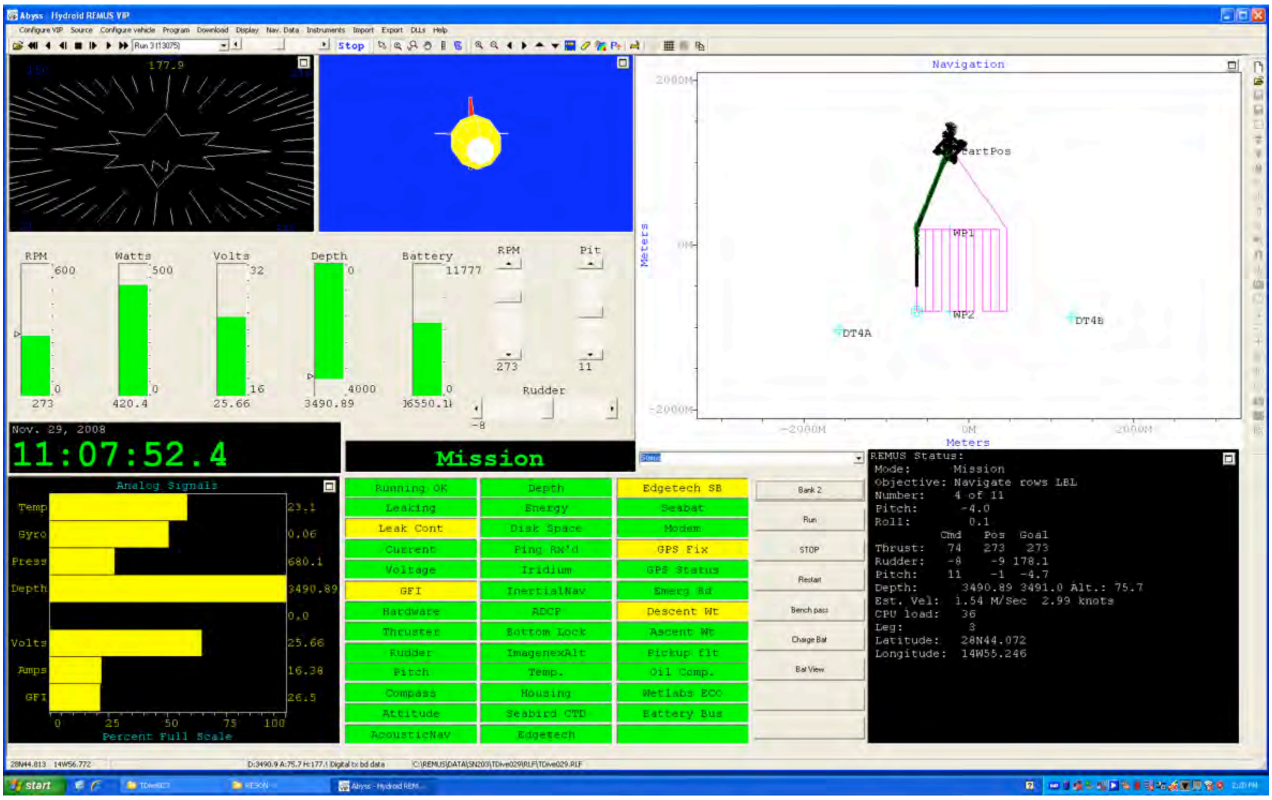


Fig. 5: Screenshot of the Windows®-based vehicle interface program software (VIP) handling the AUV operations.

5 Acknowledgments

The AUV-team thanks the officers and crew of RV Poseidon for their help, advice and the friendly working environment during the test cruise. The Spanish Authorities are thanked for permission to work close to Fuertaventura. C. Devey, K. Lackschewitz, and S. Petersen thank the German Science Foundation for providing the funds to acquire the AUV "ABYSS".

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IFM-GEOMAR Reports

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
8	RV Sonne Fahrtbericht / Cruise Report SO 190 - SINDBAD (Seismic and Geoacoustic Investigations Along The Sunda-Banda Arc Transition) 10.11.2006 - 24.12.2006. Ed. by Heidrun Kopp & Ernst R. Flueh, 2006, 193 pp. In English
9	RV Sonne Fahrtbericht / Cruise Report SO 191 - New Vents "Puaretanga Hou" 11.01. - 23.03.2007. Ed. by Jörg Bialas, Jens Greinert, Peter Linke, Olaf Pfannkuche, 2007, 190 pp. In English

No.	Title
10	FS ALKOR Fahrtbericht / Cruise Report AL 275 - Geobiological investigations and sampling of aphotic coral reef ecosystems in the NE-Skagerrak, 24.03. - 30.03.2006, Eds.: Andres Rüggeberg & Armin Form, 39 pp. In English
11	FS Sonne / Fahrtbericht / Cruise Report SO 192-1: MANGO: Marine Geoscientific Investigations on the Input and Output of the Kermadec Subduction Zone, 24.03. - 22.04.2007, Ernst Flüh & Heidrun Kopp, 127 pp. In English
12	FS Maria S. Merian / Fahrtbericht / Cruise Report MSM 04-2: Seismic Wide-Angle Profiles, Fort-de-France – Fort-de-France, 03.01. - 19.01.2007, Ed.: Ernst Flüh, 45 pp. In English
13	FS Sonne / Fahrtbericht / Cruise Report SO 193: MANIHIKI Temporal, Spatial, and Tectonic Evolution of Oceanic Plateaus, Suva/Fiji – Apia/Samoa 19.05. - 30.06.2007, Eds.: Reinhard Werner and Folkmar Hauff, 201 pp. In English
14	FS Sonne / Fahrtbericht / Cruise Report SO195: TOTAL TOnga Thrust earthquake Asperity at Louisville Ridge, Suva/Fiji – Suva/Fiji 07.01. - 16.02.2008, Eds.: Ingo Grevemeyer & Ernst R. Flüh, 106 pp. In English
15	RV Poseidon Fahrtbericht / Cruise Report P362-2: West Nile Delta Mud Volcanoes, Piräus – Heraklion 09.02. - 25.02.2008, Ed.: Thomas Feseker, 63 pp. In English
16	RV Poseidon Fahrtbericht / Cruise Report P347: Mauritanian Upwelling and Mixing Process Study (MUMP), Las-Palmas - Las Palmas, 18.01. - 05.02.2007, Ed.: Marcus Dengler et al., 34 pp. In English
17	FS Maria S. Merian Fahrtbericht / Cruise Report MSM 04-1: Meridional Overturning Variability Experiment (MOVE 2006), Fort de France – Fort de France, 02.12. – 21.12.2006, Ed.: Thomas J. Müller, 41 pp. In English
18	FS Poseidon Fahrtbericht /Cruise Report P348: SOPRAN: Mauritanian Upwelling Study 2007, Las Palmas - Las Palmas, 08.02. - 26.02.2007, Ed.: Hermann W. Bange, 42 pp. In English
19	R/V L'ATALANTE Fahrtbericht / Cruise Report IFM-GEOMAR-4: Circulation and Oxygen Distribution in the Tropical Atlantic, Mindelo/Cape Verde - Mindelo/Cape Verde, 23.02. - 15. 03.2008, Ed.: Peter Brandt, 65 pp. In English
20	RRS JAMES COOK Fahrtbericht / Cruise Report JC23-A & B: CHILE-MARGIN-SURVEY, OFEG Barter Cruise with SFB 574, 03.03.-25.03. 2008 Valparaiso – Valparaiso, 26.03.-18.04.2008 Valparaiso - Valparaiso, Eds.: Ernst Flüh & Jörg Bialas, 242 pp. In English

No.	Title
21	FS Poseidon Fahrtbericht / Cruise Report P340 – TYMAS "Tyrrhenische Massivsulfide", Messina – Messina, 06.07.-17.07.2006, Eds.: Sven Petersen and Thomas Monecke, 77 pp. In English
22	RV Atalante Fahrtbericht / Cruise Report HYDROMAR V (replacement of cruise MSM06/2), Toulon, France - Recife, Brazil, 04.12.2007 - 02.01.2008, Ed.: Sven Petersen, 103 pp. In English
23	RV Atalante Fahrtbericht / Cruise Report MARSUED IV (replacement of MSM06/3), Recife, Brazil - Dakar, Senegal, 07.01. - 31.01.2008, Ed.: Colin Devey, 126 pp. In English

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