CRUISE REPORT

Cruise HM 2012610
with R.V. Håkon Mosby

26 May – 14 June 2012

Working Areas:
Faroe Bank Channel
Iceland-Faroe Slope

Geophysical Institute, University of Bergen

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1. Cruise participants

	Name	Institute	Primary responsibility
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	Elin Darelius	UIB	Moorings & VMP
	Jenny Ullgren	UIB	Gliders
Technical personnel	Steinar Myking	UIB	Moorings and VMP winch
	Helge Bryhni	UIB	Moorings and VMP winch
	Geir Landa	HI	CTD
Students	Algot K. Petersson	UIB	Gliders
	Mari Jensen	UIB	LADCP
	Tuva Fjellsbø	UIB	CTD
	Elina Andrianopoulos	UIB	LADCP

Skipper: Kjell Ove Sandøy

Left to right: Helge, Tuva, Algot, Elin, Mari, Elina, Steinar, Ilker and Jenny.

2. Background

Funded by the Norwegian Research Council, Independent Basic Research Projects (FRINAT) programme, a project entitled "Faroe Bank Channel Overflow: Dynamics and Mixing Research" was started in 2011, with an objective to investigate the mixing and entrainment of the dense oceanic overflow from the Faroe Bank Channel (FBC). The cruise HM 2012610 onboard the Research Vessel (RV) *Håkon Mosby* is the only dedicated field work planned in the project. The physical oceanography field work was carried out through a combination of conventional conductivity-temperature-depth (CTD) measurements, densely instrumented moorings, current profile measurements using lowered acoustic Doppler Current Profiler (LADCP), ocean microstructure measurements and two autonomous gliders. One of the gliders and one of the moorings were equipped with a suite of turbulence sensors to sample the turbulence levels in the FBC overflow.

The observational programme was designed to measure turbulence and mixing in the overflow plume which, in addition to the shear-induced mixing at the plume-ambient interface, is hypothesized to be influenced by several processes including mesoscale eddies, secondary circulation and internal waves. Previous measurements of temperature and velocity recorded by moored instruments at the site were dominated by 3-4 day period oscillations. One sampling approach during HM 2012610 was to repeat sections or stations to sufficiently resolve this dominant mode of variability. The hypothesis that this mesoscale variability (eddies) can enhance the mixing rates and the rate of descent of the dense plume will be tested. A secondary, transverse circulation composed of an Ekman transport in the bottom boundary layer and a return flow at the dense layer interface has been previously reported. During the cruise, attempts were made to resolve the secondary circulation with an aim to quantify its influence on mixing. Finally, data were collected to test the hypothesis that internal-wave turbulence transition is important in the interfacial layer between the dense plume and the ambient.

This report provides an overview of the methods employed and the data collected.

At the time of the present revision, a number of papers are already published in the peer-reviewed literature. The details of more up-to-date processing of the data and detailed discussion of the findings can be found in the following:

Hydrography and currents	: Ullgren et al. (2014), Darelius et al. (2013)
Mooring data	: Ullgren et al. (2016), Darelius et al. (2015)
Turbulence glider	: shear probes (Fer et al. 2014); thermistors, (Peterson and Fer 2014)

3. Cruise Overview

A detailed cruise narrative is given in Appendix A. The cruise track is shown in Figure 1. The cruise was conducted between 26 May and 14 June 2012 with a stop in Torshavn in 7 June. In total 146 CTD/LADCP stations (LADCP operated on 143 of them), 90 microstructure casts were made. 8 moorings were deployed to sample for one year duration. An additional mooring equipped with turbulence sensors, and two gliders were deployed and recovered by the end of the cruise.

4. Hydrography

Sampling - The hydrographic work was carried out using a CTD-water sampling package from SeaBird Inc., acquiring data during both down and upcast. The package consisted of a SBE 911plus CTD with sensors for temperature (SN 2134), conductivity (SN 3080), and Oxygen (SBE43, SN 1277), and also contained a fluorometer (Chelsea SN 088251) and a transmissometer (CST-996DR). Additionally a Benthos altimeter (200 kHz, SN 55927) was installed to allow profiling close to the bottom. The CTD was equipped with a 24 position SBE 32 Caroussel, fitted with a single 10 liter sampling bottle. The CTD rosette, together with the acoustic Doppler current profilers (Section 5), is shown in Figure 2. At all stations, water samples for salinity calibration were collected at the deepest sampling level. In total 146 CTD-stations were taken, recorded in files sta0582 to sta0729; 0614 and 0682 do not exist. Their locations are listed in Appendix B. Station positions are shown in Figure 3.

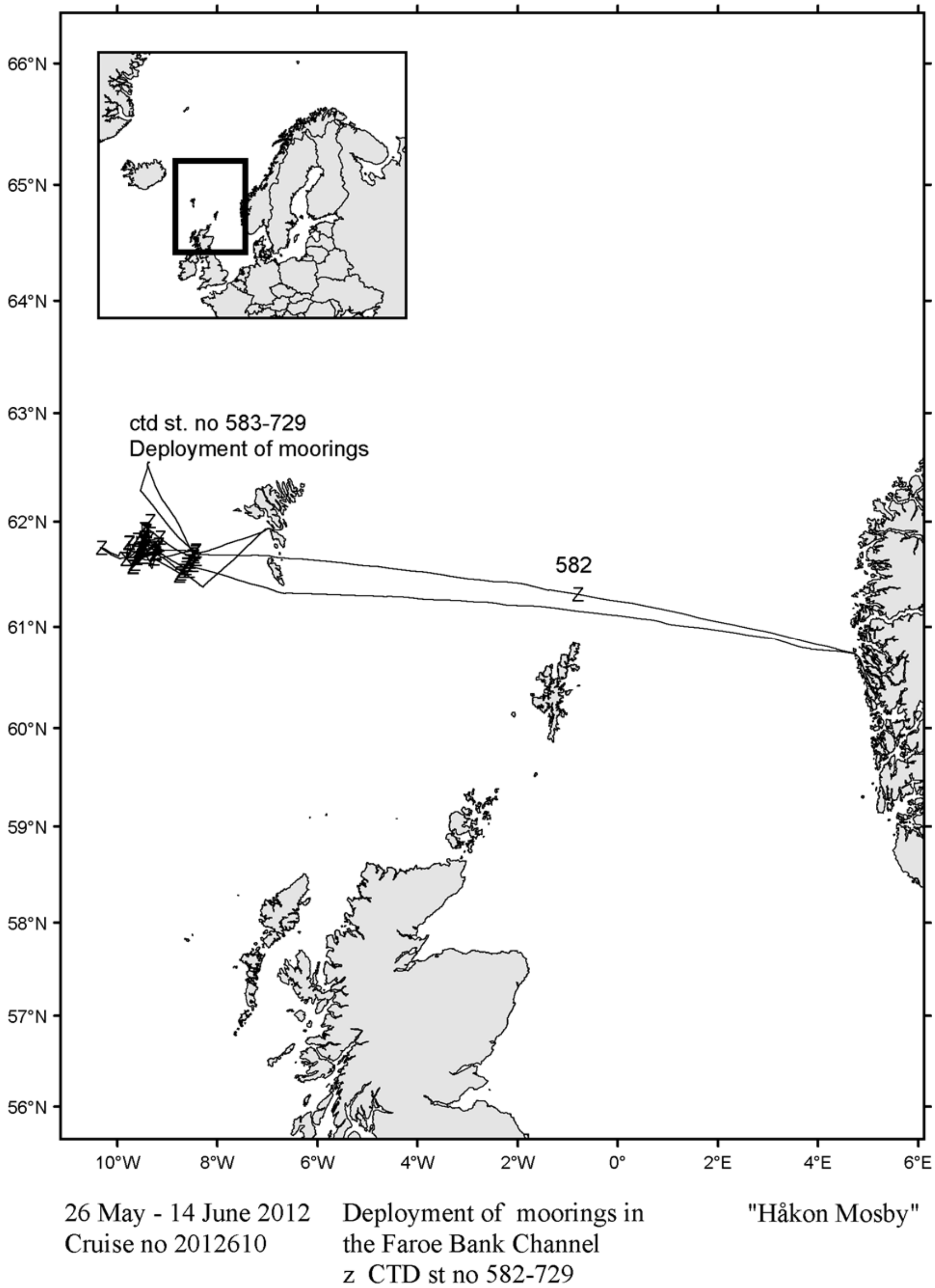


Figure 1. Cruise track, HM 2012610.

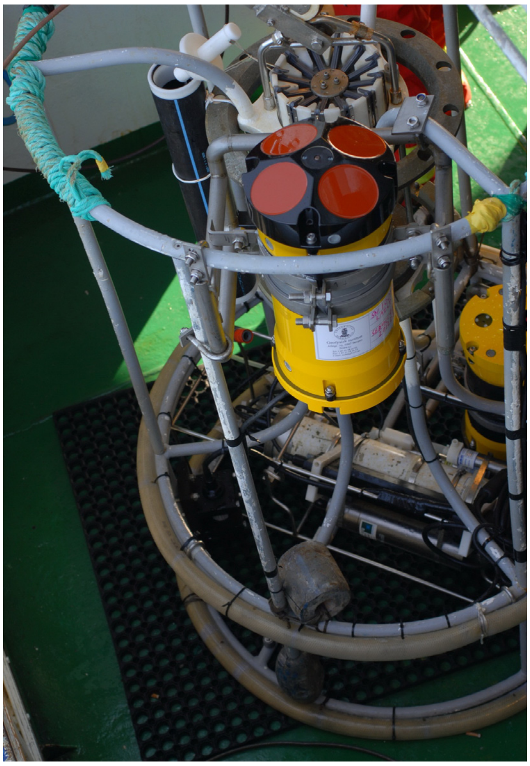


Figure 2. The CTD rosette together with the CTD sensors, one 10-liter Niskin bottle, a down and uplooker ADCP, and a benthos altimeter installed. The transducers of both ADCPs and the altimeter have a non-obstructed path. The position of the lead weights and the ADCPs are adjusted to have a negligible tilt of the entire system.

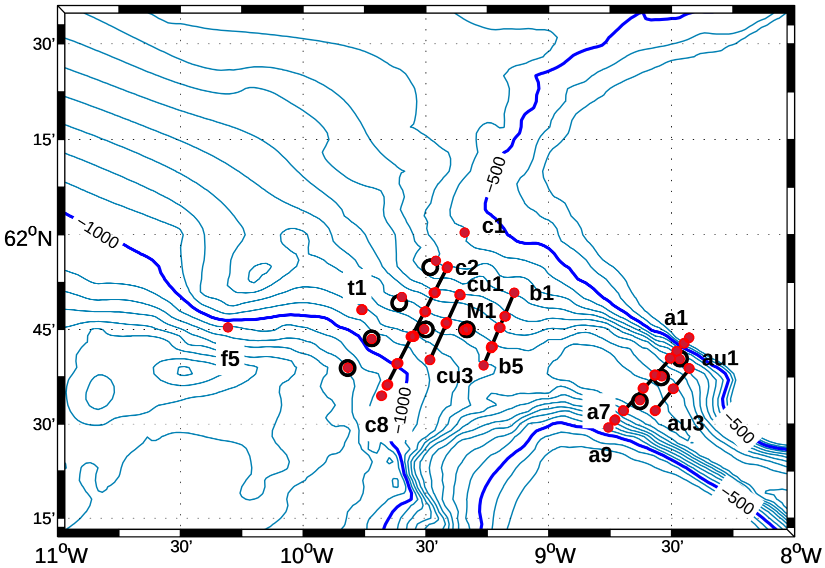


Figure 3. Station map showing the CTD/LADCP stations (red bullets). Black circles mark the mooring positions for reference. The portions of the sections joined by black lines are repeated.

Data processing - SBEDataProcessing-Win32, standard Seabird Electronics software for Windows, is used for data processing of the CTD data. Only data from downcasts are used to avoid turbulence caused by rosette package on upcast. Raw data (pressure, temperature and conductivity) are converted to physical units using calibration files modified for air pressure and conductivity slope factor (DATCNV). Outliers, differing more than 2 and 20 standard deviations for the first and second pass, respectively, from the mean of 100 scan windows are flagged and excluded from analysis

(WILDEDIT). The thermal mass effects in the conductivity cell are corrected for (CELLTM, with parameters alpha = 0.03 and 1/beta = 7.0). Pressure is low pass filtered with a time constant of 0.15 s. Scans when the CTD is moving less than the minimum fall rate (0.25 m/s) are flagged to remove pressure reversals due to ship heave (LOOPEDIT). Data are then averaged into 1 dbar bins (BINAVG). Temperature is reported in ITS-68 scale. Salinity is reported on the practical salinity scale.

Conductivity correction from salinity bottle samples - Of the 146 salinity bottle samples, a total of 139 were analyzed at IMR with a Guildline Portasal 8410 salinometer. 7 readings appear erroneous and are excluded from the analysis. Salinity and conductivity values from each bottle were merged with the corresponding CTD data. Bottle conductivity is calculated from bottle salinity and CTD temperature and pressure. Following the procedure recommended by UNESCO (1988), only data within the 95% confidence interval are used to correct the calibration of the CTD conductivity. Histogram of $\Delta C = C_{CTD} - C_{Bot}$, difference of conductivity measured by CTD and inferred from bottle salinity, is approximately normally distributed Following the recommendations given by Seabird Electronics, the conductivity values are corrected by the formula, $C_{new} = m\ C_{old}$, where m is the slope calculated by

$$m = \frac{\sum_{i=1}^{n} a_i \times b_i}{\sum_{i=1}^{n} a_i \times a_i}.$$

Here a_i and b_i are the CTD conductivity and the bottle conductivity, respectively and n is the total number of bottles. Using the 139 values inside the 95% confidence interval, the value for the slope is calculated to be **m = 1.00016**. Prior to correction, the conductivity difference between CTD and bottles, $\Delta C = C_{CTD} - C_{bot}$ averaged -3.6 (± 2.0) $\times 10^{-4}$ (± 1 standard deviation) over 139 samples. After correction ΔC = 0.0 (± 5.8) $\times 10^{-4}$ S/m.

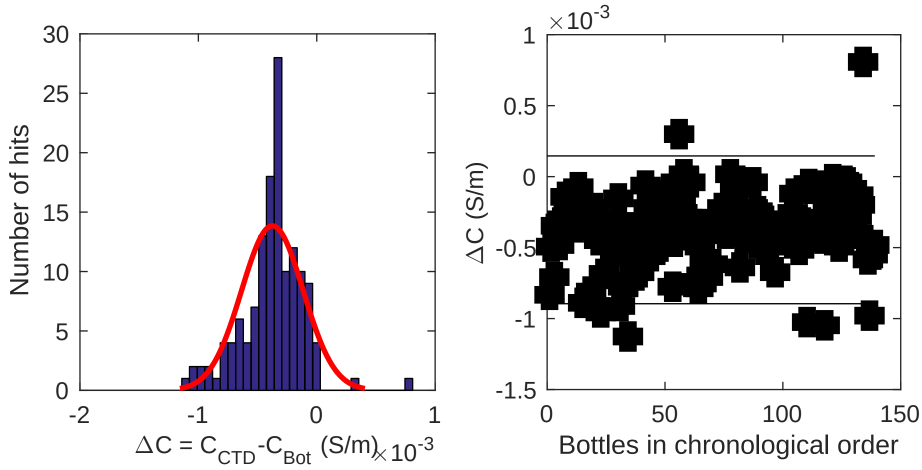


Figure 4. (Left) Histogram of CTD-derived and bottle conductivity differences. Red curve is the normal-distribution fit for the sample mean and standard deviation. (Right) ΔC in chronological order with 95% confidence intervals on the mean indicated (black envelopes).

An example CTD/LADCP profile is shown in Figure 5. Example section plots of hydrography are shown in Figure 6, Figure 7, and Figure 8.

The cold overflow plume water is characterized by the well-mixed near bottom layers of u to 100 m thick in its core, and temperature near 0C. The plume has a distinct velocity structure with bottom-enhanced currents reaching 1 m/s.

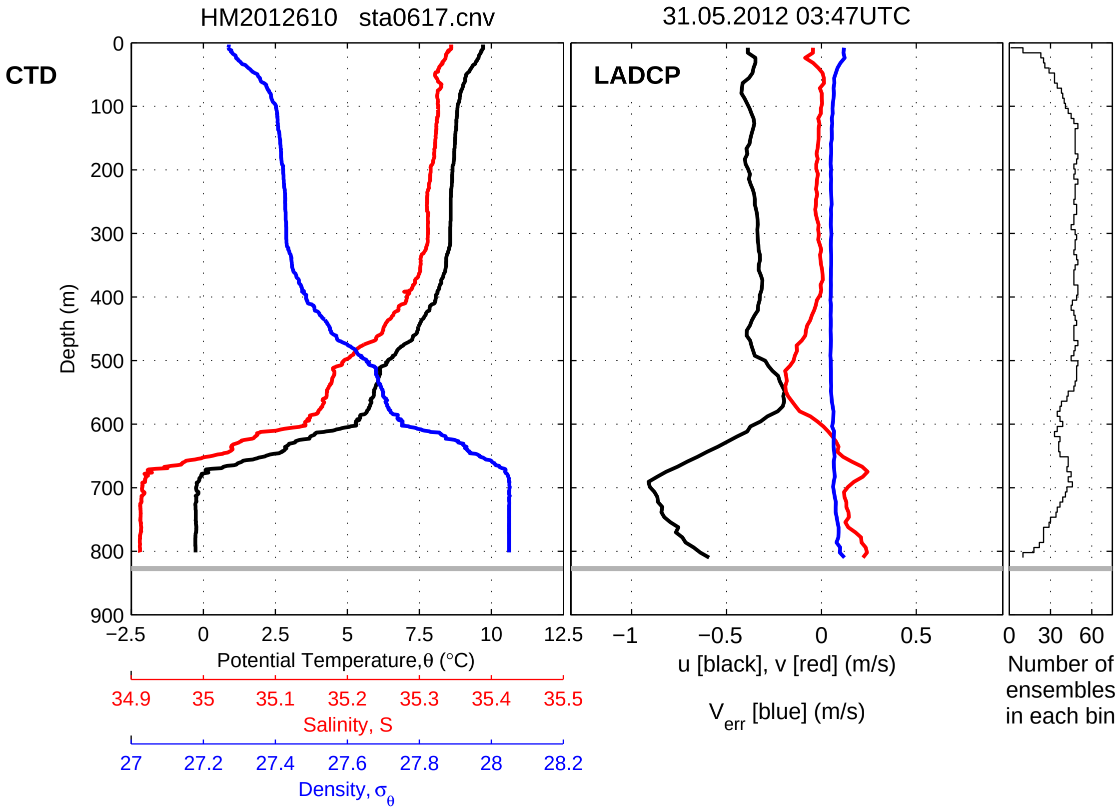


Figure 5. An example CTD/LADCP cast from the dense overflow plume region.

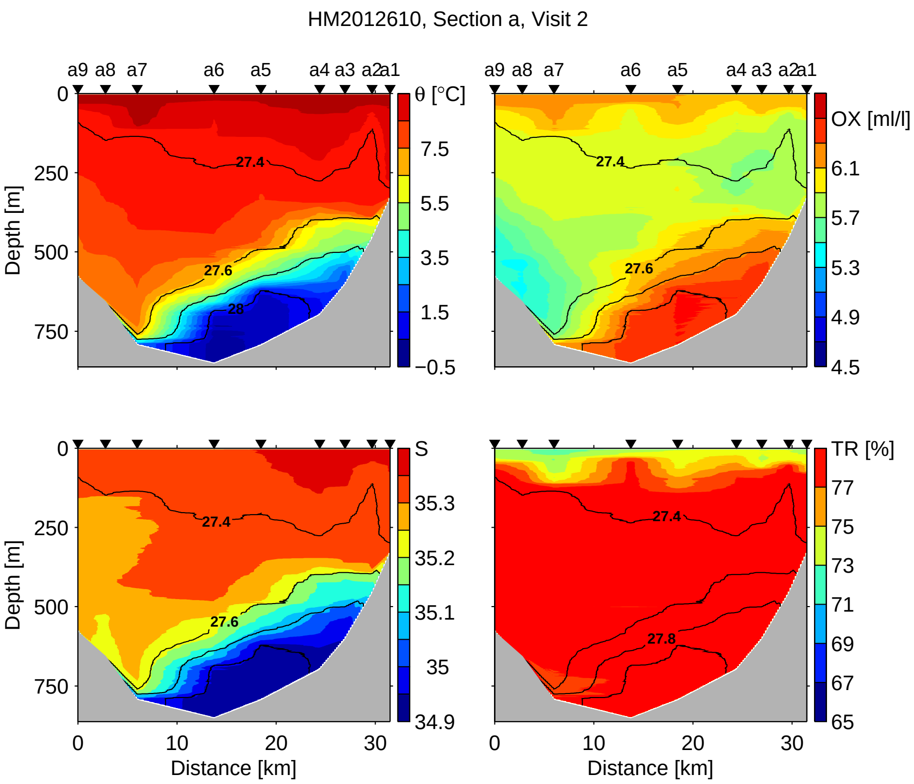


Figure 6. Contours of potential temperature (θ), salinity (S), oxygen concentration (OX), and transmissivity (TR) for Section a, visit 2. Isolines of potential density anomaly (σ_θ) are also shown (black) on each panel.

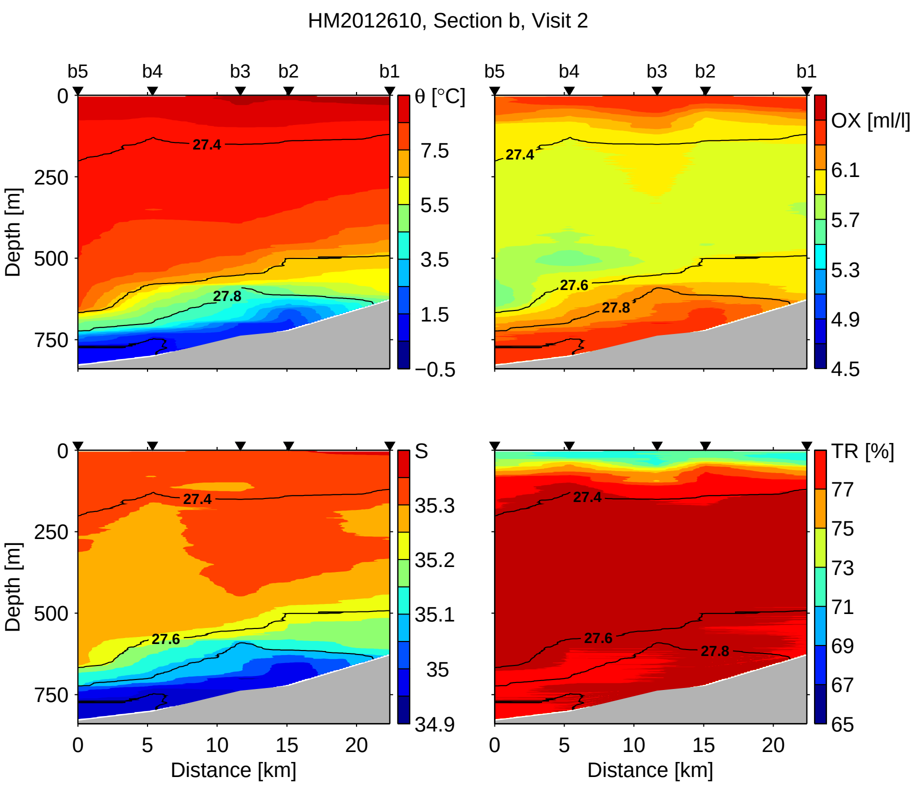


Figure 7. Same as Figure 3, but for Section b, visit 2

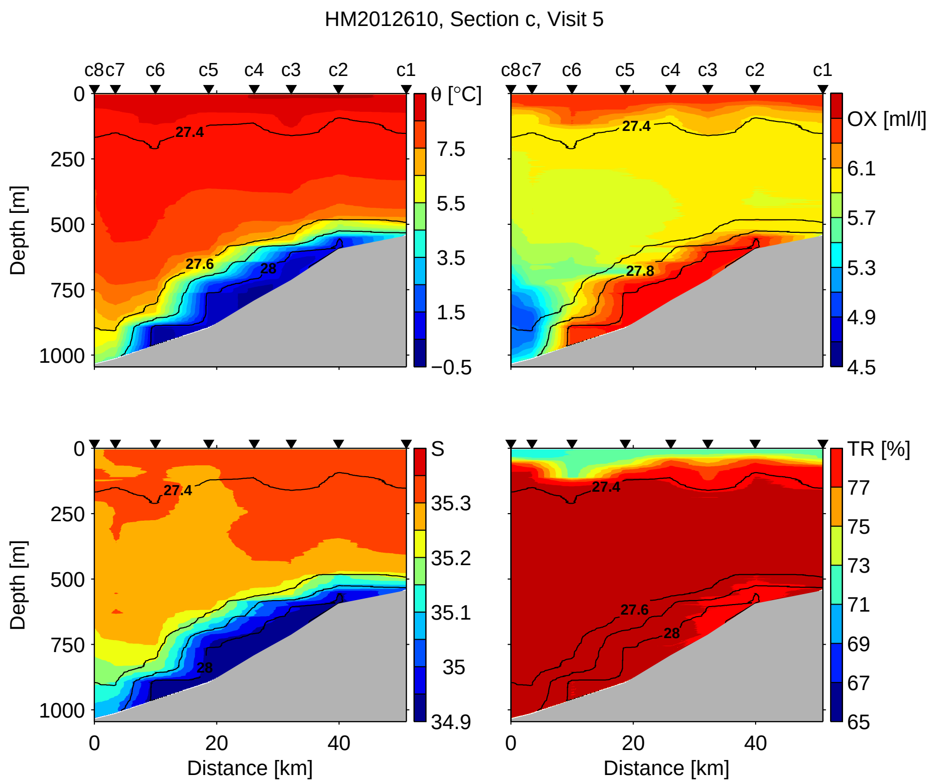


Figure 8. Same as Figure 7, but for Section c, visit 5.

5. Current Profiling

5.1. Lowered-ADCP (LADCP)

Two LADCP-profilers (RD Instruments) were mounted on the CTD rosette in order to obtain current profiles (Figure 2). The ADCPs are 6000 m-rated 300 kHz Sentinel Workhorses with internal batteries. Each ADCP has the L-ADCP option installed and has the firmware v16.3. The ADCPs were configured to sample in master/slave mode to ensure synchronization. The master ADCP was the downlooker (SN 10151) and the slave ADCP was the uplooker (SN 10012). Communication with the instruments, start & stop of data acquisition and data download were done using BBTalk software. PC time (UTC) was transferred to each instrument before each cast. The vertical bin size (and pulse length) was set to 8 m for each ADCP. Single ping data were recorded in narrow bandwidth (to increase range), in beam coordinates, with balk distance set to zero. The data from the first bin are discarded during post processing. In order to mitigate a possible influence of previous pinging, especially close to steep slopes, staggered pinging with alternating sampling intervals of 0.8 s and 1.2 s were used. The altimeter worked reliably and no sign of degradation of LADCP data quality was observed. The command files for the master and slave LADCPs are given in Appendix D.

The LADCP data are processed using the LDEO software version IX.8. For each master/slave profile data, synchronized time series of CTD and navigation is used. For the purpose, NMEA GPS stream is added to each scan of the ship CTD and the data files are processed as 1 s bin averages, similar to the ADCP ping rate. LADCP-relevant processing of the CTD data included the following steps in the SBE-Data Processing software: DatCnv, WildEdit, CellTm, Filter, Binavg (1 s) and Derive. The data set from the vessel-mounted ADCP are also used for additional constraint on the inversion of the LADCP data.

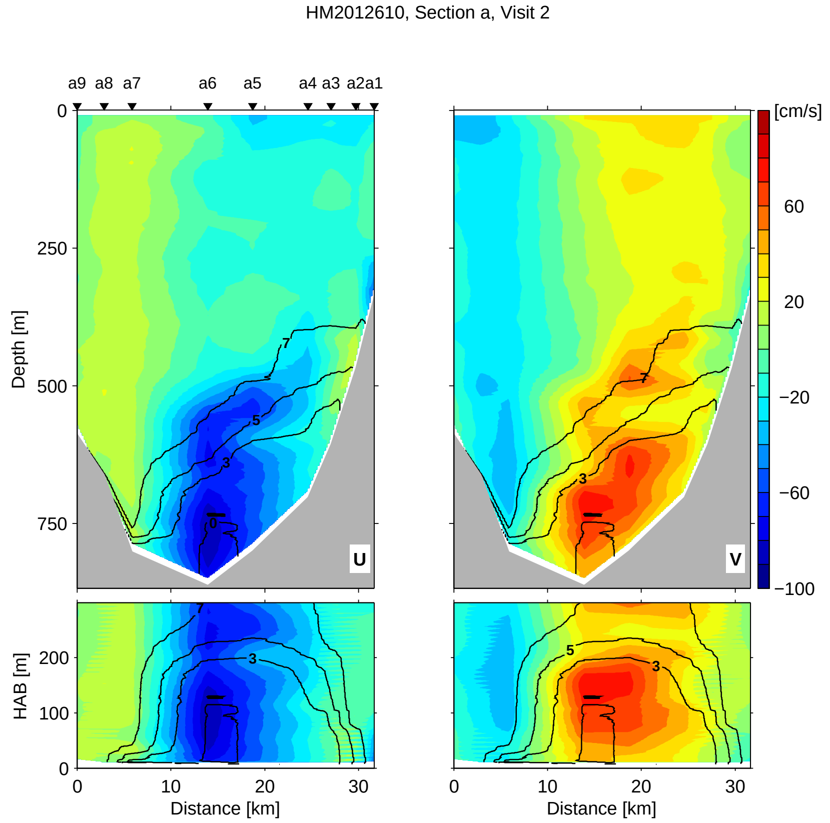


Figure 9. An example section (Section a, Visit 2) showing contours of the east (U) and north (V) velocity components obtained from the LADCP. Isolines of potential temperature (θ), are also shown (black) on each panel. Lower panels are contoured with respect to height above bottom (HAB) to emphasize the overflow plume structure.

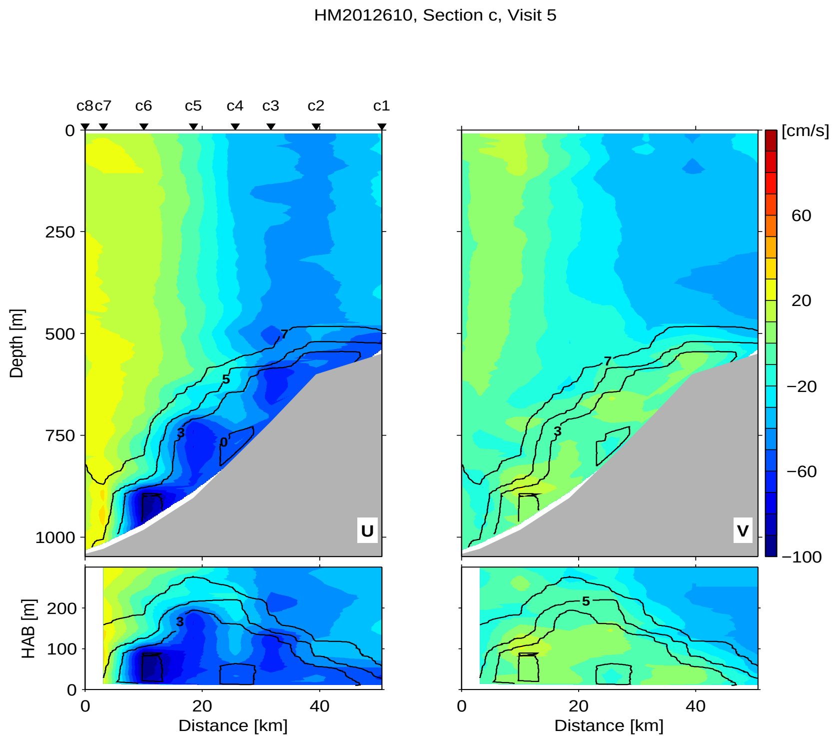


Figure 10. Same as Figure 9 but for Section c, Visit 5.

5.2. Vessel-mounted ADCP (VMADCP)

The Vessel Mounted Acoustic Doppler Velocity Profiler (VMADCP) is a 75 kHz RDI ADCP on board the RV *Håkon Mosby*, and continuously collected velocity profiles below the ship, in the upper 800 m of the water column. The command file *DeepWaterLongRange_8m_NB_2012610* is given in Appendix D. The ADCP was set up to sample in narrow band, in 100x8 m vertical bins, as 1 s pings. The blank distance is 8 m, the transducer depth is 4.2 m and the transducer misalignment is 45.30°. Selected duration of averaging for STA and LTA files are 60 s and 300 s, respectively.

The VMADCP Long Time Average (LTA) files, giving one profile every five minutes, were processed using the Cascade 6.1 software (http://wwz.ifremer.fr/lpo_eng/Produits/Logiciels/Cascade-V6.1-a-matlab-software-to-process-Vessel-Mounted-ADCP-data). The reference layer from bins 3 to 5, and navigation from GPS (i.e., not bottom track) are used. For the cleaning, the default parameters are used. In addition to the data flagged bad by the software, the data closest to the bottom (10% of the depth or minimum 50 m) were replaced with not-a-numbers (NaN). A second data set form VMADCP is also prepared in the LDEO specified format for LADCP processing, to provide for an additional constraint. The VMADCP-profiles were found to agree well with the LADCP-profiles, see Figure 11. The additional constraint of VMADCP-profiles improves the final LADCP-profiles slightly, but not significantly (Figure 12).

Tides - The barotropic tide at the time and location of each profile was found using the ESR/OSU tidal model, version European Shelves (Egbert et al. 2010). The model domain extends to 62N, thus part of the cruise track (the excursion to recover Snotra) is outside (i.e. no predictions are given) or close to the boundary. Model predictions close to the boundary (north of 61.7N) should be used with caution (S. Y. Erofeeva, personal communication). A coarser version of the model, covering the whole Atlantic, gives similar results (Figure 13). The predictions from the model agrees relatively well with low-frequency oscillations in the VMADCP records (Figure 13). The apparent mis-fit towards the end of the record, when section A was occupied, is, at least partly, due to the strong velocity shear across the section.

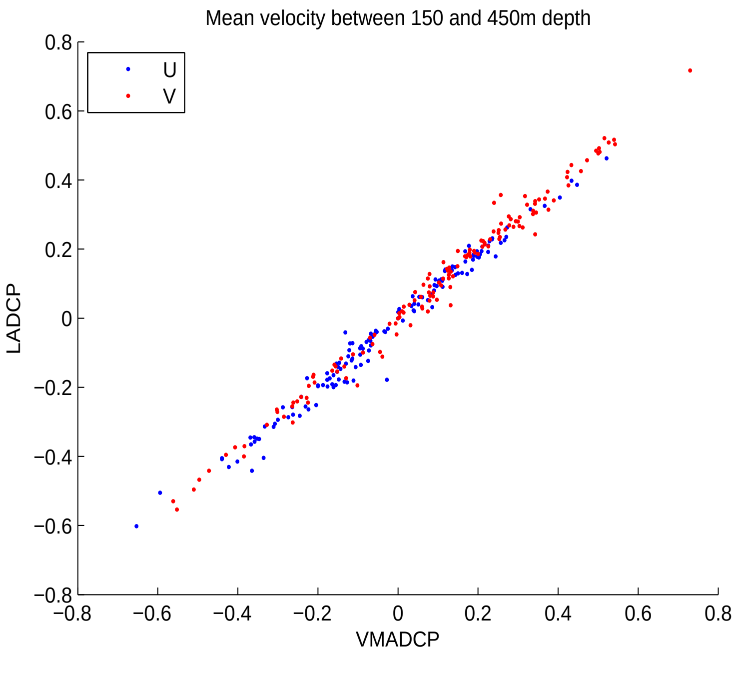


Figure 11. Mean depth averaged velocity (200-300 m) depth from all stations: LADCP vs VMADCP, were a mean VMADCP profile is found using profiles collected 30 minutes before and 30 minutes after the start of the LADCP-cast.

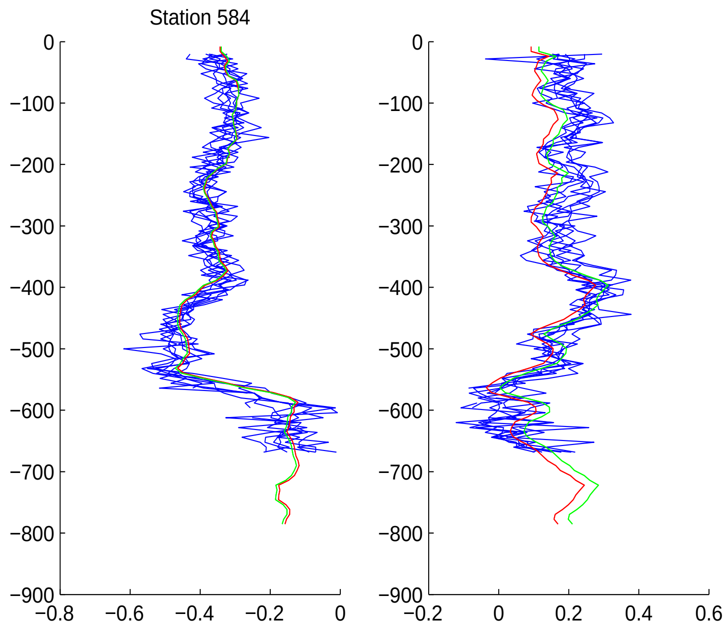


Figure 12. Velocity profiles in a) x-direction (u) and b) y-direction (v) collected with LADCP at station 584, processed with (red) and without (green) VMADCP data and profiles from VMADCP (blue) during occupation of the station

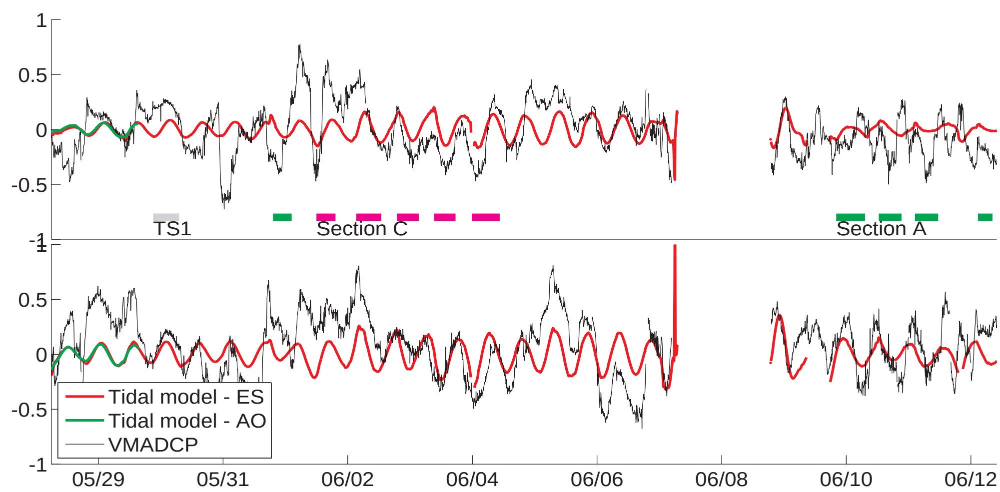


Figure 13. Comparison of depth averaged (50-300m) velocity from VMADCP (black) and predicted tides with European shelf (red) and Atlantic ocean (green) in a) x-direction (u) and b) y-direction (v).

6. Microstructure Profiling

Ocean microstructure measurements were made using the vertical microstructure profiler (VMP2000, VMP hereafter) manufactured by Rockland Scientific International (http://www.rocklandscientific.com). VMP is a loosely tethered microstructure profiler for the measurement of dissipation-scale turbulence to depths down to 2000 m. During the cruise VMP SN009 was deployed. It is equipped with high-accuracy conductivity temperature depth (CTD) sensors (P Keller, T, SBE-3F, C, SBE-4C with pump SBE-5T), two state-of-art microstructure velocity probes (shear probes), one high-resolution temperature sensor (FP07-38-1 thermistor), one high-resolution micro-conductivity sensor (SBE7-38-1 micro-C), and three accelerometers. VMP samples signal-plus-signal-derivative on thermistor, micro-conductivity and pressure transducer, and derivative for shear signals, which is crucial for turbulence measurements, especially for the temperature microstructure. Data are transmitted in real time to a ship-board data acquisition system. VMP has an overall length of 2 m with 40/3.5 kg weight in air/water and with a nominal fall rate of ~ 0.6 m/s.

Deployments were made using a Sytech Research Ltd. CMK-2 Hydraulic winch with Linepuller (an active line payout system that makes it possible to perform rapid repeated profiles) and 2500 m deployment cable. The winch and line puller system was designed to feed cable over the side of the ship, allowing the profiler to free-fall through the water column.

The dissipation rate of TKE was calculated using the isotropic relation $\varepsilon = 7.5\nu\left\langle u_z'^2 \right\rangle$, where ν is the viscosity of seawater. Small scale shear variance $\left\langle u_z'^2 \right\rangle$ was obtained by iteratively integrating the low wavenumber portion of the shear spectrum of half-overlapping 2-second segments (Fer 2006). Unresolved shear variance in the noise-affected high wavenumber portions was corrected using the empirical theoretical shape (Oakey 1982). The profiles of ε were produced as 1 m vertical averages to a noise level of 10^{-10} W kg^{-1}.

Figure 14. The set-up, on deck, of the VMP microstructure profiling system. The hydraulic winch is on the right; the cabel is fed through a block supported by the crane in the middle. The block is fastened by robes to the deck to avoid swings due to wind and ship's roll. The tether then is fed into the line-puller fastened to the ships' railing. In addition to the winch operator, a second person observes the cable in water during the deployment, and assists with deployment and recovery.

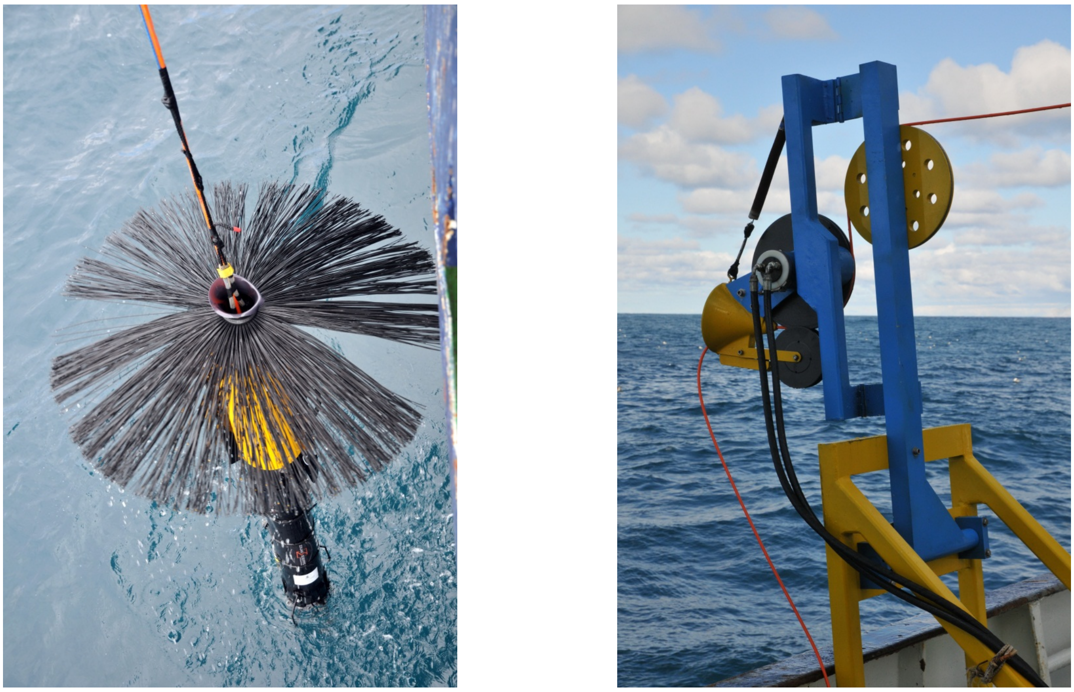


Figure 15. (Left) The VMP profiler during deployment. The brushes provide the drag for the profiler. Drag, together with the buoyancy elements (yellow) set the nominal sink velocity of the profiler. Note the recovery line attached to the cable which allows recovery by a crane without damaging the cable. (Right) The hydraulic line-puller.

7. Moorings

A total of nine moorings were deployed during the cruise, see Appendix D for drawings and Table 1 for location and deployment times. All moorings, except for the turbulence mooring, are recovered during the cruise HM 2013613 in June 2013. The turbulence mooring was successfully recovered at the end of the cruise. Moorings were designed, i.e. the amount and placement of buoyancy and anchor weight needed were decided using the Matlab program “Mooring design and dynamics”(MDD).

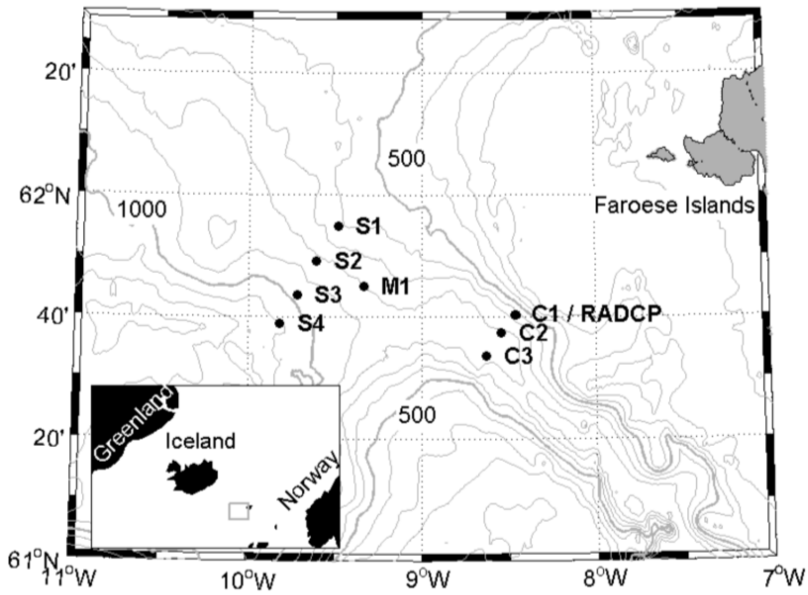


Figure 16. Location of moorings C1-3, RADCP,M1 and S1-4. Mooring RADCP was placed about 750 m east of C1.Isobaths (GEBCO) are shown every 100m (thin lines) and every 500m (thick lines) are labelled.

Table 1. Mooring location and deployment and recovery times

	Location	Deployed	Recovered
C1	61N 40.429’ 8W 27.900’	28.05.2012 09:30 UTC	05.06.2013 06:45 UTC
RADCP	61N 40.389’ 8W 27.4891’	09.06.2012 06:50 UTC	05.06.2013 07:20 UTC
C2	61N 37.397’ 8W 32.545’	28.05.2012 14:00 UTC	05.06.2013 08:45 UTC
C3	61N 33.605’ 8W 37.703’	28.05.2012 17:00 UTC	05.06.2013 10:00 UTC
M1	61N 45.013’ 9W 19.975’	29.05.2012 08.10 UTC	05.06.2013 15.20 UTC
S1	61N 54.870’ 9W 28.980’	29.05.2012 11:30 UTC	05.06.2013 17:00 UTC
S2	61N 49.2’ 9W 36.54’	29.05.2012 14:25 UTC	05.06.2013 16:20 UTC
S3	61N 43.591’ 9W 43.221’	29.05.012 20:00 UTC	05.06.2013 18:25 UTC
S4	61N 38.89’ 9W 49.102’	30.05.2012 10:50 UTC	05.06.2013 19:40 UTC

Line: All moorings consist of 6 mm Dynema line. Seabird sensors and Aquadopp were all attached as "clamp-on", and the line were covered with tape for protection and, when the line was to thin, with plastic housing (i.e. pieces of plastic tubing cut open and thread onto the line) at attachment points. The thinner line reduced the drag (and thus the instrument tilt) significantly in MDD. All lines were 2 m longer than commanded.

Seabird sensors: The moorings were equipped with a total of 21 SBE37 and11 SBE39 with a sampling interval of 300s, 35 SBE56 with a sampling interval of 15 s.

RCM 7: 8 RCM's were used, with a sampling interval of 300 s.

ADCPs: See Appendix E for information of the ADCP setup. The RDCP600, meant for S1, did not fit in any of the available frames and was replaced with a RCM7. The 6000m rated 300 kHz ADCP from RDi did not fit into the elliptical buoy and was placed in a frame below three glass spheres. The compass of all ADCPs from RDI (also new) were calibrated prior to deployment (see below)

Bouyancy: Vitrovex glass-spheres and/or larger spherical/elliptical buoys were used. The new elliptical buoys did not fit the 6000m rated RDI 300kHz, and was replaced with 3 glass spheres. The 44" sphere at S3 housed 1 RDI 75kHz(inside buoy, downward looking) and one 150 kHz (upwardlooking, mostly outside the buoy). The Argos sender, originally place on the upper, 150kHz side, was moved to the lower side as the buoy turned upside down in water due to the weight of the 150 kHz Quartermaster.

Argostracker: A total of four Argos trackers were used at C1,C2, S3 and turbulence-mooring, see cruise diary (Appendix A) for details on Argos identification.

Acoustic realease: The acoustic releases used are listed in the cruise diary.

Compass calibration: The compass of all RDI ADCPs (and LADCPs) were calibrated prior to deployment following the instructions in the manual. Sn 10740 was calibrated outside Marineholmen while other instruments were calibrated on the lawn below Ilker's office. Quartermasters and Longrangers were rotated within their boxes, while Sentinels were rotated outside their boxes. Hard iron only calibration appeared to give best results and was used for all but one instrument.

Table 2. Details on compass calibration. New instruments are marked with * and LADCPs with L.

RDI	s/n	Orientation	Hard/soft iron	error prior	Error after
Sentinel	3505	Down	h	10.5	0.9
	10012L	Up	h	5.9	2
	10151L	Down	h+s		2.7
	11434	Down	h	8.6	1.8
	15331*	Down	h		1.6
	17319*	Down	h		2.8
Quartermaster	17226*	Down	h	6.6	1.7
	17227*	Up	h	5.5	2.5
Longranger	10740	Down	h	6.3	2.6
	15964*	Down	h	7.9	1.3

NOTES DURING RECOVERY (June 2013):

Mooring C1: SN 8973 (SBE37, 200mab) and SN 1312 (SBE56, 175mab) were loose on the line and hang just above SN3251 (SBE39, 150mab).

Mooring C2: SN 1320 (SBE56, 300mab) had slide down and hang just above SN 5446 (SBE37, 250mab)

Mooring C3: SN 1326 (SBE56, 75mab) and SN 1327 (SBE56, 50mab) had fallen off. RCM7 (25mab) had serial number 1586 – not in original drawing.

Mooring M1: No comment.

Mooring S1: No comment.

Mooring S2: SN 1336 (SBE56, 125mab) had fallen off.

Mooring S3: SN 1346 (SBE56, 75mab) had fallen off. SN1340 (SBE56, 400mab) was loose and hung just above SN 1341 (SBE56, 350mab).

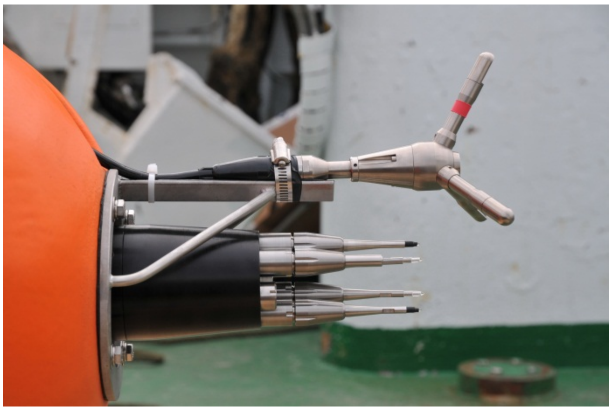
Mooring S4: SN 3569 (200mab) is a SBE39 and not SBE56 as the original drawing says. SN 12040 (RCM7, 25 mab) had leaked slightly through a crack in the transducer and contained correct velocity measurements from two days only, temperature measurements were good.

SBE56: In total 4 SBE56 (SN 1326, 1327, 1336 and 1346) were lost. The SBE56s were all attached with electrical tape (upper and lower end) and with 2 plastic strips; one through the hole and around the line and one around the first strip to avoid movement. It is possible that the instruments were lost during recovery, i.e. that the (sometimes tangled) line got between the line and the instrument and pulled it off.

8. MATS: Moored Autonomous Turbulence System

Moored Autonomous Turbulence System (MATS) (Figure 17) is an ocean turbulence measurement system designed to collect microstructure time series at a fixed level. MATS consists of a main body platform, a modified RSI turbulence package microRider-1000LP, a three component Nortek Vector acoustic Doppler velocimeter, and a pair of rechargeable lithium-ion battery packs. The assembled instrument weighs approximately 290 kg and has a buoyancy of 160 kg. It has an overall length of 3 m, and a mid-body diameter of 46 cm. The entire system is powered by the battery packs, each rated for 40Ah at 14.8 VDC, giving an estimated operating time of 500 h. With a 25% duty cycle, e.g. 15 min bust sampling every hour, MATS can sample 20 GB of data for about 85 days.

The platform is a low-drag buoy, StableMoor 400 from Flotation Technologies, custom modified to fit the turbulence instruments and the battery packs. A swivel allows the instrument to align with the current, pointing the sensors toward the undisturbed, free flow. The miroRider is fitted with two air-foil shear probes, two fast response FP07 thermistors, a pressure transducer, a 2-axis vibration sensor, and a high-accuracy dual axis inclinometer (ADIS 16209, pitch and roll angles accurate to 0.1°), a low-power 6-axis motion sensor (O-Navi, Gyrocube 3F) and an integrated low-power 3-axis magnetic field sensing module (microMag3). The Vector is a 6 MHz acoustic velocimeter measuring the 3D velocity fluctuations in water. All turbulence sensors of the microRider and the sensor head of the Vector protrude horizontally from the nose of the buoy pointing to the mean flow. No probe guard is installed. The sensor head of the Vector is rigidly fixed to the buoy, as close as possible to the microRider sensors.



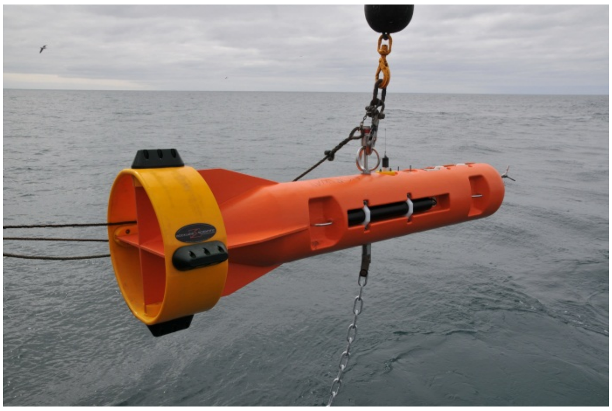


Figure 17. MATS. (Upper left) Side view of the sensor head showing the velocimeter Vector and the turbulence probes of the microRider. (Right) Front view of the sensors and cabling to the Vector. (Above) MATS during deployment. One of the battery cases (on the side) and the Argos tracker (at the top) can be seen.

Details of MATS and data processing can be found in Fer and Bakhoday Paskyabi (2014), from a near-surface deployment off Norway.

In the Faroe Bank Channel, MATS was deployed for the cruise duration, close to mooring M1, on 30 May 1515 UTC at the 866 m depth isobath. The vertical position of the buoy was planned to be located in the turbulent plume-ambient interface, approximately 100 m from the seabed. The time mean and one standard deviation height above bottom, inferred from the pressure sensor, was 102 ±8 m.

The deployment duration and the time variability of temperature and currents are shown in Figure 18.

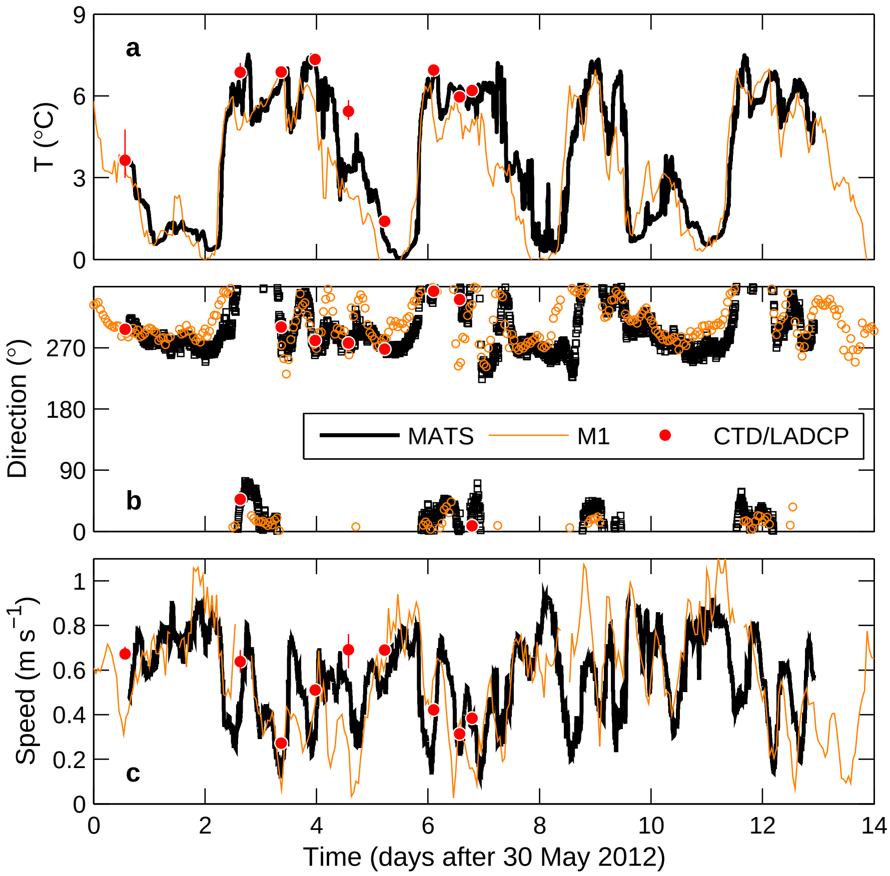


Figure 18. Time series of temperature and current speed and direction recorded by the MATS (black), and compared to nearby measurements at the same vertical level at mooring M1. Red bullets are the data points obtained from nearby CTD/LADCP sampling.

9. Gliders

9.1. General

Slocum gliders from Webb Research are autonomous underwater vehicles that move through the water by controlling their buoyancy through pumping oil in or out of a bladder, thereby changing the amount of water displaced by the glider body. The vertical motion so induced is converted into forward propulsion by the wings and tail fin of the glider, so that the glider moves through the water in a see-saw pattern at an angle of about 30° to the horizontal. The flight angle is adjusted by moving the battery pack - and thus the centre of gravity -forward or backward. Gliders get their position by GPS when they surface, and navigate by dead reckoning when under water. Two-way communication with the glider can take place via Freewave radio (at close range) or via Iridium satellite; communication is possible only at the surface. The planned waypoints of the glider, target diving depth, sampling behaviour, and other operational parameters are specified in mission (.mi) and mission acquisition (.ma) files sent to the glider.

During the cruise two electric Slocum gliders from Webb Research were deployed: Snotra and Gnå, each depth rated to 1000 m. Both are equipped with a SeaBird Electronics CTD, Aanderaa oxygen optode, and WetLabs fluorescence and turbidity meter, but on both gliders all built-in sensors except CTD were switched off during these deployments. The plan for the glider operations included transects across the Channel, during which the gliders would perform a full dive followed by a climb to 450 m, then dive again, before climbing to the surface. The purpose of this sampling was to better resolve the depth range of interest, i.e. the deep layer below about 450 m. The maximum dive depth was set to 900 m and the altimeter, which enables the glider to acoustically sense the bottom and turn upwards, was switched on below 500 m depth. The gliders were deployed using a small boat (see cruise diary, Appendix A) which enables safer handling than deployment directly from the side of the ship.

Data Visualizer software supplied by Webb Research was used to get a first glance at glider data during operations. Post-processing of the glider data was done using a set of Matlab routines created by Gerd Krahmann at GEOMAR, Kiel. The standard processing includes converting glider binary data into ASCII, merging and saving as Matlab files, quality checking glider positions, cutting data into single down or up casts, blanking data outside of the observational phase of the dive, and interpolating to regular (1 s) time steps.

The gliders recorded along-track temperature, conductivity and pressure. Due to an erroneous setting in the initial sample ma-file, Gnå was not recording CTD data during its first deployment, but only after the rescue, service and redeployment on 5 June (see cruise narrative). The actual routes taken by both gliders were quite different from the cross-sections initially aimed for, because the gliders with their speed of approximately 30 cm s^{-1} could not withstand the strong currents in the region (on the order of 1 m s^{-1}).

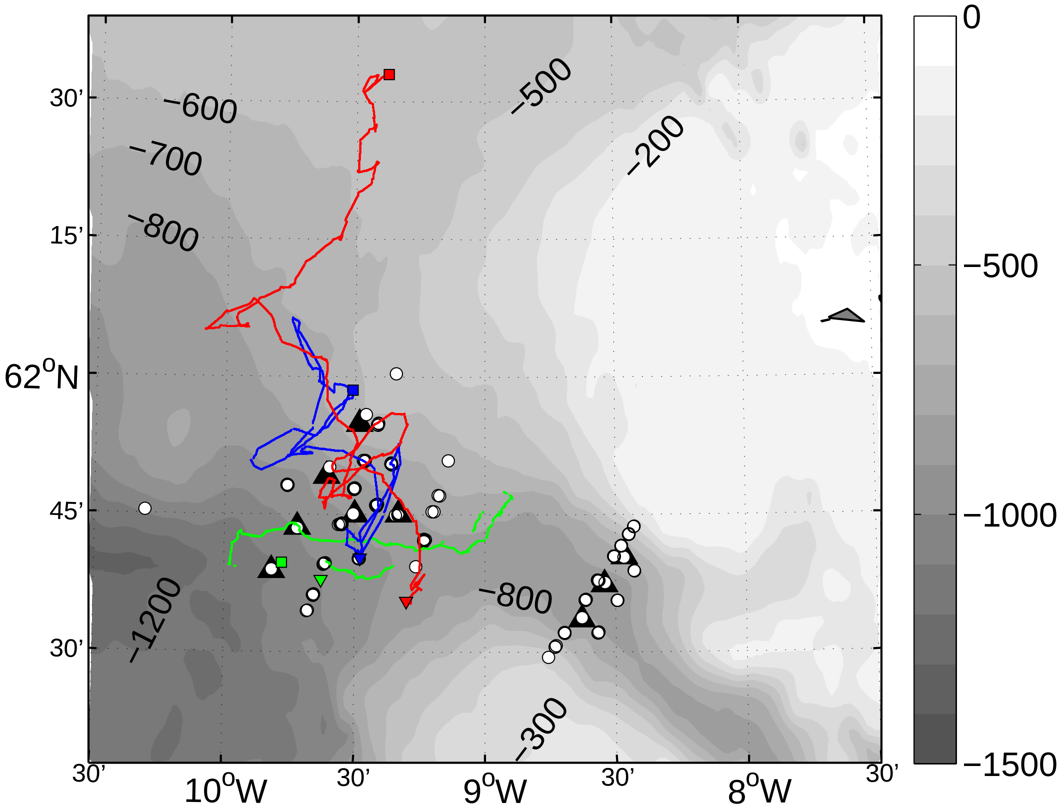


Figure 19. Map showing glider trajectories: Gnå 1st deployment in green, 2nd in blue, and Snotra in red. A downward pointing triangle shows the start of each deployment and a square the end. Surface drifting is left out (gaps in the track). Other cruise activities: CTD stations (white circles), and moorings (black triangles).

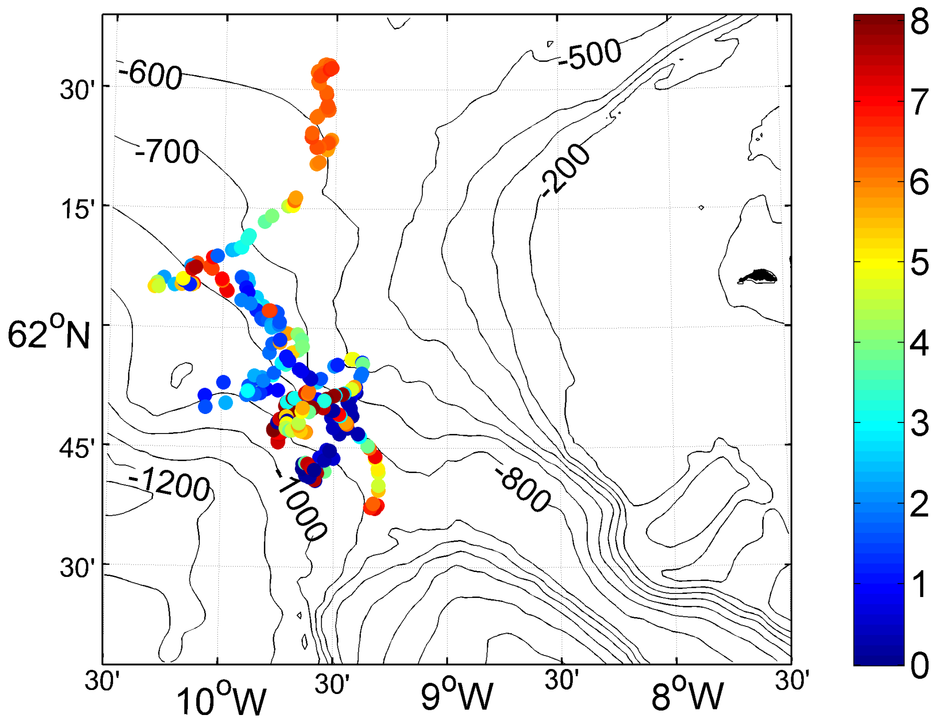


Figure 20. Circles mark the positions of the minimum temperature recorded on each down yo; color-coded for temperature in °C.

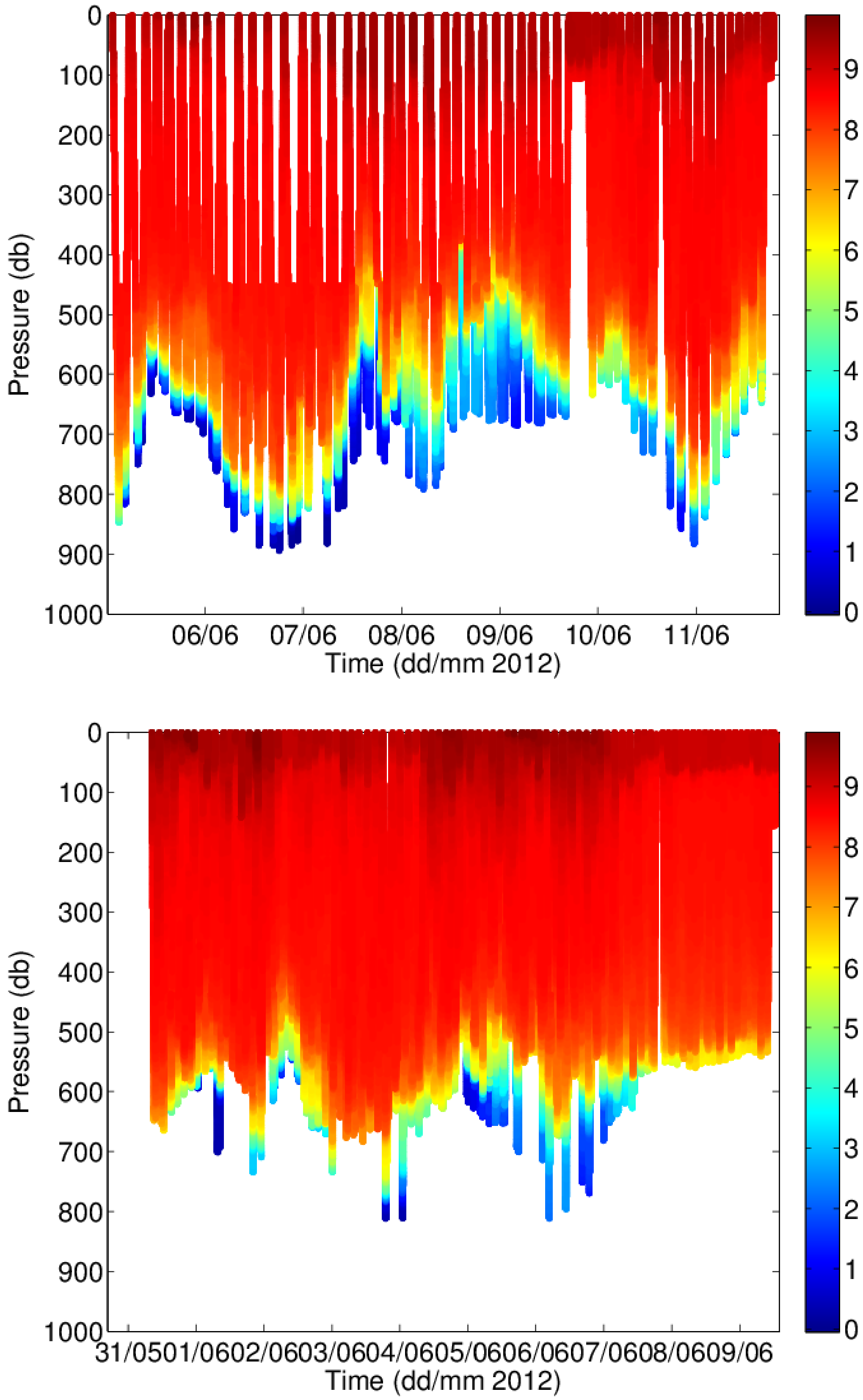


Figure 21. Record of temperature (colour scale on right) with pressure and time, for (top) Gnå and (bottom) Snotra.

9.2. Turbulence Glider

One of the Slocum Electric gliders was equipped with a Rockland Scientific MicroRider (Figure 22), which is a self-contained turbulence instrument package. It is equipped with the following sensors (Figure 23); two velocity shear probes (SPM-38), two fast response thermistors (FP07), one micro conductivity probe (SBE7-38-1) and high resolution pressure, acceleration and tilt sensors. Sampling rate for the turbulence sensors is 512Hz, while the slow-response sensors sample at 64Hz. The MicroRider is powered by the glider's battery, but stores data separately on a flash card.

Data from the MicroRider can be used to find the dissipation of turbulent kinetic energy (TKE, ε) using high resolution velocity shear, and the rate of loss of temperature variance from temperature microstructure.

The glider must be deployed and recovered using a light boat, where it is easy to carefully slip the glider into and out of the water. Because of the turbulence sensors, the front of the glider must be handled with utmost care. The glider dives down close to the bottom (~50m above bottom), either in single V-pattern or penetrating the plume twice in a W-pattern.

A vertical profile summary plot from one dive is shown in Figure 26, including the temperature and temperature shear from the two thermistors, speed and velocity shear from the two shear probes, as well as navigational data (vertical velocity, pitch, roll, path angle and speed). Pitch for this dive is between 15° and 25°, with steeper dive angle higher in the water column, and roll is within ±3°. Path angle is defined as pitch angle + angle of attack (AOA). AOA is generally not known for gliders, and is assumed to be 4°. Speed of the glider is calculated from the change in pressure with time $\left(\frac{\partial p}{\partial t}\right)$ and path angle, so the error in assuming AOA of 4° is transferred into the glider speed. A hydrodynamic flight model must be employed for accurate flow across sensor and AOA calculations.

Figure 27 shows spectral estimates of temperature and velocity shear gradients for the interface depth (500-600m) for the same dive as in Figure 26, fitted to the Nasmyth universal spectrum. Also shown is the vibration sensors spectrum, used to remove vibration noise (see the filtered $sh_{1,2}$ clean). For the tentative calculations of epsilon presented here, the wave number spectrum is integrated up to 30 cycles per minute, for higher frequencies the Nasmyth spectral shape is assumed. Both the temperature- and the velocity shear variance spectrum follow the Nasmyth curve closely, indicating high quality data.

Figure 22. Photo of the glider Gnå mounted with MicroRider, strapped on the transportation trolley.

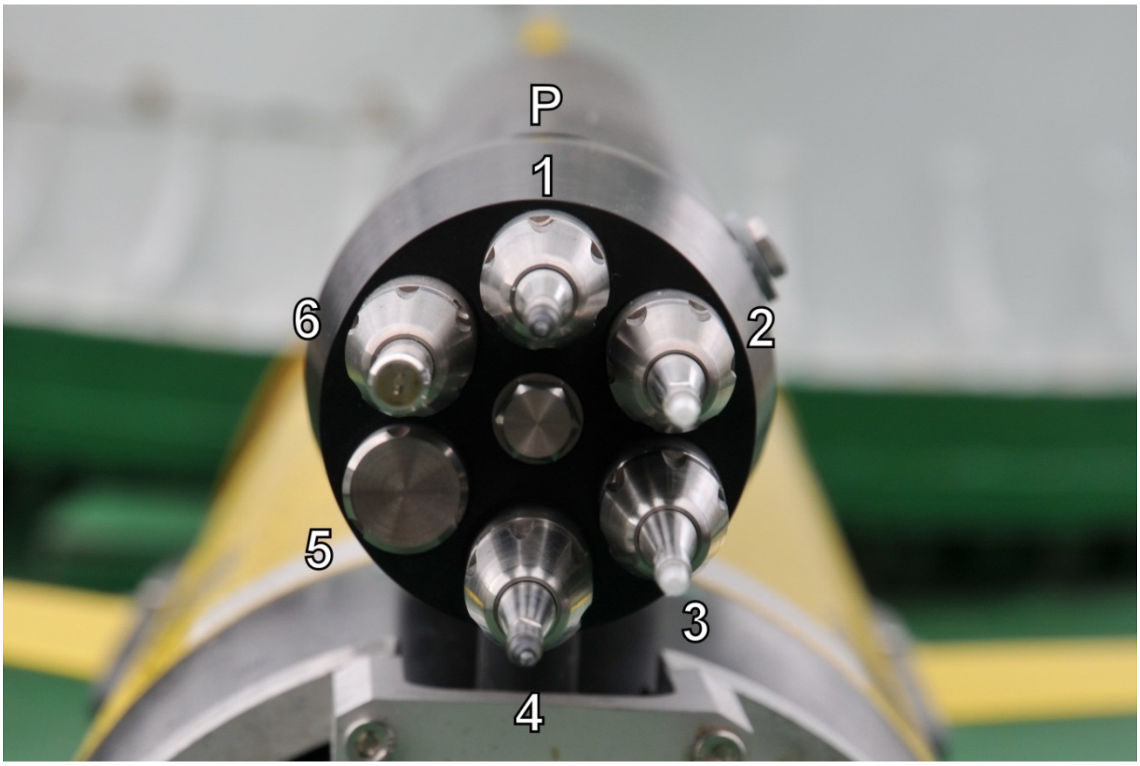


Figure 23. Photo of the MicroRider microstructure sensors. Sensors 1 and 4 are FP07 thermistors, sensors 2 and 3 are SPM-38 turbulence shear probes. Slot 5 is not in use, and 6 is a LED on/off indicator. A hole for the pressure sensor is indicated with a "P".

Figure 24. Pictures from deployment of Gnå.

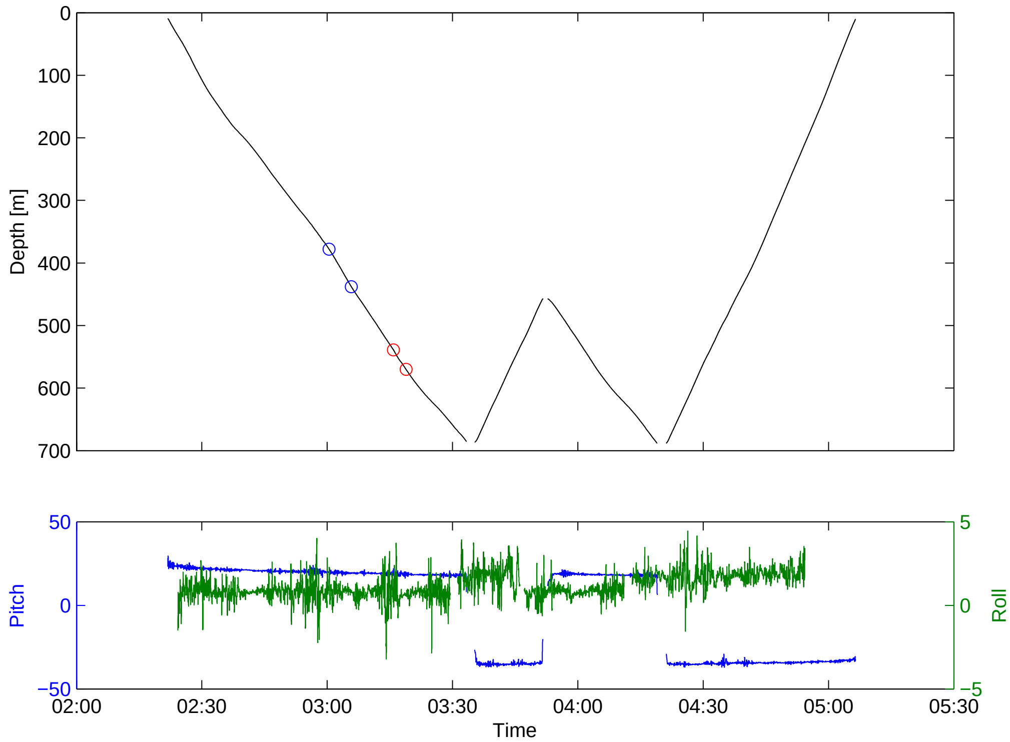


Figure 25. Time series of pressure (in Depth, m), and pitch and roll, showing a typical dive-half climb-dive-climb cycle.

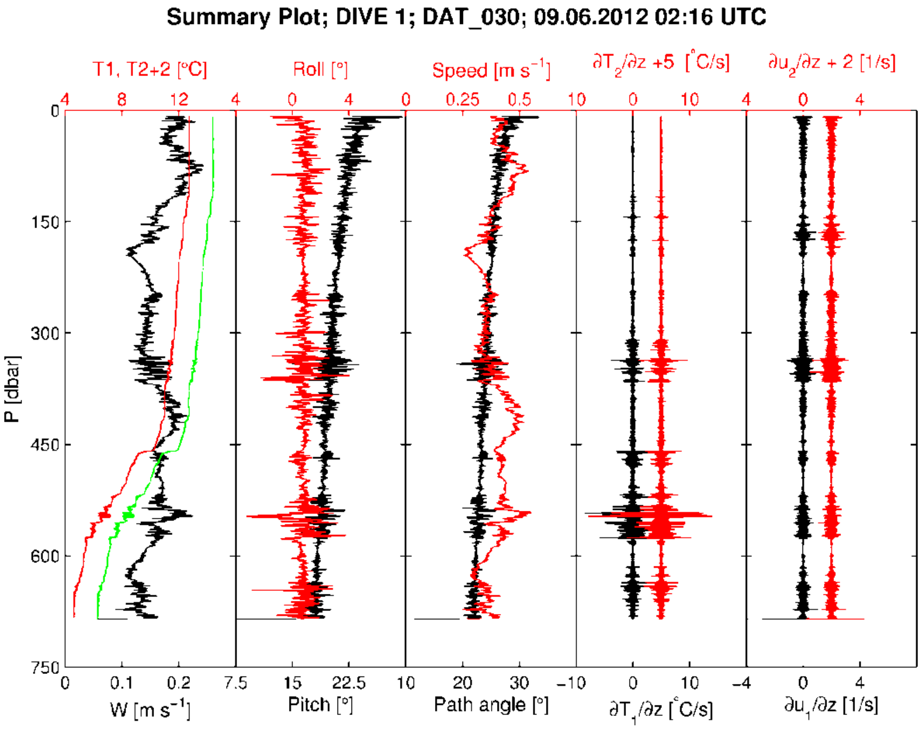


Figure 26. Summary plot from the glider with MicroRider. Profiles of temperature and temperature shear, velocity and velocity shear from the high resolution sensors are shown, along with vertical velocity, pitch, roll, path angle and speed.

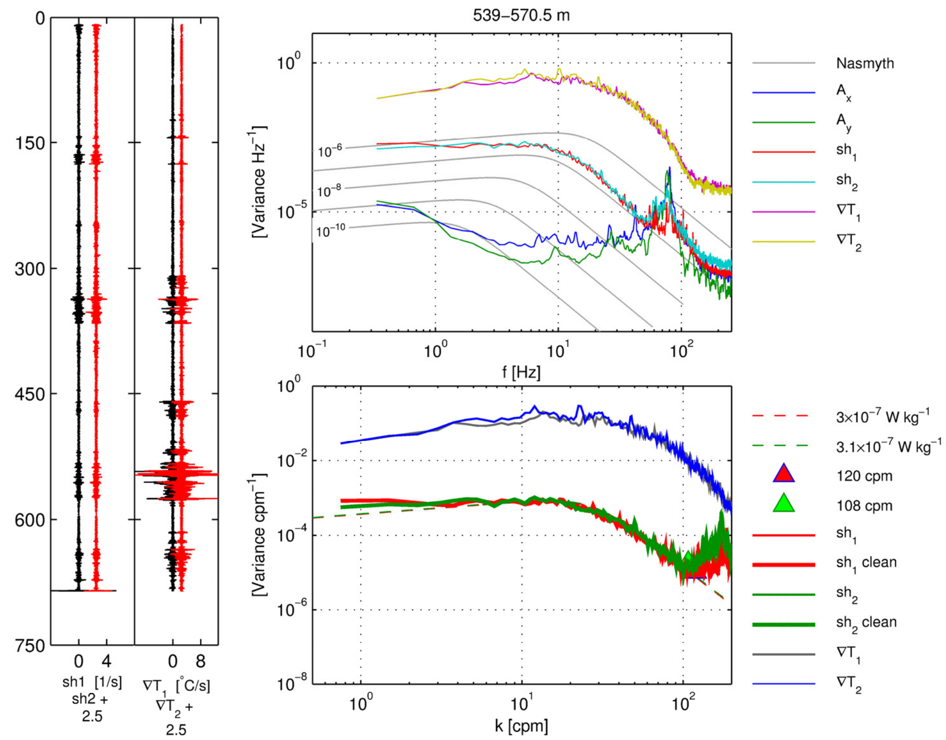


Figure 27. To the left is vertical profiles of $\frac{\partial u}{\partial z}$ and $\frac{\partial T}{\partial z}$. To the right shows the temperature ($\nabla T_{1,2}$) variance and velocity shear ($sh_{1,2}$) spectra for the depth range from 500 to 600m, fitted to the Nasmyth universal spectrum. A_y and A_x are the vibration sensors spectral shape. Upper right box is variance vs. frequency (Hz), while the lower right shows variance vs. cycles per minute. Indicated by broken lines are the calculated dissipation (ε) values.

10. Appendix A: Cruise Diary

26 May 2012, Saturday

RV Håkon Mosby (HM hereafter) arrived at Marineholmen at 0900 LT. Loading of all gear completed by 1430 LT. Earlier purchased equipment (Dynema Kevlar, 4xARGOS, 2xellipsoid synthetic floats for WH300) was already delivered aboard. Started steaming at 1500 LT, stopped for fueling etc. Transit toward FBC started at 1700 LT.

Ship SBE configuration was modified to run with the Benthos altimeter. Two LADCPs (Master, downlooker WH300 SN: 10151; SLAVE, WH300 SN: 10012) and the altimeter (SN: 55927) were installed on rosette by 2100 LT.

27 May

0915 LT: Started on bench simulation of Gnå (mission testfbc.mi)

0910 UTC: A CTD/LADCP test station (sta0582) was taken.

All current profilers and current meters were armed to start sampling on 28 May 1200 UTC. SBE loggers were already armed in the lab prior to the cruise, to start at the same date. RCMs were started independently to record hourly data.

2000 LT: Started on bench simulation of Snotra (mission testsnot.mi).

28 May

0800 LT: Started the vessel-mounted ADCP.
Command file: DeepWaterLongRange_8m_NB_2012610. Deployment name: HM2012610.

Added about 10 kg weight on CTD rosette to balance it and reduce the tilt observed at the test station.

0930 UTC: Deployed **mooring C1**

61N40.428, 8W27.90, 650 m depth
ARGOS: A04-007
Release: Oceano 2500S, SN 949. Arm/range: 1813
Rel: Arm + 1855
Diag: Arm + 1849
CTD profile (sta0583) was taken prior to deployment.

1400 UTC: Deployed **mooring C2**

61N37.397, 8W32.545, 807 m depth
ARGOS: 200106 HEX18172 / AC10EC7
Release: Oceano 2500S, SN 948. Arm/range: 1812
Rel: Arm + 1855
Diag: Arm + 1849
CTD profile (sta0584) was taken prior to deployment.

1630 UTC: Deployed **mooring C3**

61N33.605, 8W37.703, 859 m depth
Release: SN 1132 Range/INT: 0820
Rel: 0855
CTD profile (sta0585) was taken prior to deployment.

2000 UTC: Started CTD/LADCP time series (hourly profiles for 12 h) near M1 location. Casts: sta586 to 597.

29 May

0800 UTC: End of the CTD/LADCP time series. Cast: sta597. The mooring M1 was deployed before the last cast.

0810 UTC: Deployed **mooring M1**

61N45.013, 9W19.975, 808 m depth
Release: Oceano 2500S, SN 1223 Arm/range: 089A
Rel: Arm + 855
Diag: Arm + 0849
CTD profile (sta0596) was taken prior to deployment. Sta597 after deployment.

1130 UTC: Deployed **mooring S1**

61N54.87, 9W28.98, 610 m depth
Release: SN 1388 Arm: 096B
Rel: Arm + 09555
CTD profile (sta0598) was taken prior to deployment.

1430 UTC: Deployed **mooring S2**

61N49.2, 9W36.54, 805 m depth
Release: AR611 SN 409 Range/INT: 2417
Rel: 2418
CTD profile (sta0599) was taken prior to deployment.

2000 UTC: Deployed **mooring S3**

61N43.591, 9W43.221, 950 m depth
Release: Oceano 2500S, SN 1222 Arm/range: 0899
Rel: Arm + 0855
Diag: Arm + 0849
CTD profile (sta0600) was taken prior to deployment.

30May

1050 UTC: Deployed **mooring S4**

61N38.88, 9W49.1, 1082 m depth
Release: AR661, SN 411 INT: 2425
REL: 2426
CTD profile (sta0612) was taken prior to deployment.

1300 UTC: Assembled mRider and Vector on microSPOTs. Started 20 min duty cycle with 5 min off and confirmed by radio.

1515 UTC: Deployed **MATS**

61N45, 9W30, 866 m depth
Release: SN 1012 Arm/range: 182D
Rel: Arm + 1855
CTD profile (sta0613) was taken prior to deployment.

Afternoon: VMP and winch assembly. Tested the entire set-up. Conducted a bench test.

1650 UTC. Starting bench testing of Snotra, and preparing for deployment.

1815 UTC. Deployed Snotra (61N 35.765, 9W18.068) from work boat. Ran, status.mi, test mission ini01.mi (with buoy); followed by yo10 with 100 m. After completion, the work boat returned. . Glider then did one deep test dive to 900 m, thereafter set on planned mission fbcsno.mi with double deep dives (W-shape).

2130 UTC: VMP test station (cast_001) with sh1 & sh2 and mT1.

After cast001, installed mC sensor and worked 3 stations: b2, b3 and b4.

31 May

0405 LT: Glider Snotra aborted mission due to overtime. No other errors, resumed mission sequence. Later a revised mission file, fbcsno2.mi, was sent with overtime argument disabled.

0600 UTC: Transit to GNÅ deployment site

1245 LT: Prepared Gnå for deployment. Glider in water ca 1315 LT. Ran test mission ini0.mi with buoy attached. Removed buoy, did a test dive to 100 m with servo. Data from test dive evaluated to set fixed battery position necessary for turbulence measurements. Glider in water and starting real mission fbcgna.mi ca 1630 LT. No communication after that.

Transit to repeat section a.

1826 UTC: Started CTD/VMP section a, from station a1.

1 June

After cast_009 the VMP cable damaged by line-puller. Cable re-terminated.

0505 LT: First communication from glider Gnå, aborted due to device error. Changed course to rescue it. Visual contact and Freewave communication with Gnå at 0730 LT. Glider repeatedly aborts due to digifin error.

2330 LT: Reduced safety limits for digifin movement. Continue 100 m test dives.

Night: Due to rough sea VMP deployment on hold. CTD continues.

2 June

0110 LT: Gnå operates well with new fin safety max; sent on deep (900 m) single dive.

After completing CTD-only c section (visit 1), we took CTD + VMP on the return along cu. (1 June 2130 to 2 June 0150 UTC).

1020 LT: Gnå changed to deep W dives.

Started working section c (visit 2) using CTD + VMP, stations c2-c7 only.

3 June

Continue with the section c / cu repeats.

4 June

After completing section c, transit to Gnå to pick her up. Excessive roll and drift out of track.

While waiting for surfacing of Gnå (delayed significantly), took a CTD (sta669)/VMP (cast041) station at 2008 station F5.

2000 LT: Problems with the cable on the VMP winch drum at about 850 m through F5. Previous recovery was too fast and not guided leading to many loops on the drum. Payed out cable while steaming and spooled back in carefully.

2043 LT: Gnå surfaced. We ordered 30 m yos. In transit to recovery.

2330 LT: Gnå recovered from light boat. Port wing holder was loose on its screw and the wing was twisted. No damage observed.

5 June

No files (other than 4 short near-surface episodes) were recorded on the microRider on Gnå. Opened the instrument, inspected and replaced the lithium battery. Ran a simulation on deck with exact files as the mission. Again, the mRider did not open data files. Upon inspection we found an error in the sample10 file. Ensured c_science_all_on by setting sensor_type 0 (changed from 1, c_profile_on). Re-tested simulations. Functions properly.

0230 LT: Re-deployed Gnå from light boat. This time observed 1 Hz LED blinks on the microRider both during ini0.mi and fbcgna.mi.

0330 LT: Started a triangular set-up of CTD/VMP stations, continuously between c5 / cu2 / c4.

Replaced LADCP batteries before cast675. LADCP data of casts 670 to 674 are of highly degraded quality due to depleted battery.

6 June

0037 UTC: Started working section b from b1 (sta0683).

0605 UTC: Completed section b at b5 (sta0687)

Started time series at b4, between 0747 (sta0688) and 1703 UTC (sta0693).

Time series interrupted due to bad weather after VMP cast following sta0693.

Transit to Torshavn. VM-ADCP turned off.

7 June

0730 UTC: Arrived at Torshavn

1000 UTC: RDCP600 buoy delivered. Replaced RDCP batteries and the buoy is assembled.

Due to bad weather decided to stay in Torshavn until 1600 UTC on 8 June.

8 June

1600 UTC: Left Torshavn, transit to C1 to deploy the RDCP600 buoy.

2000 UTC: VM-ADCP re-started

9 June

0650 UTC: Deployed RDCP600 buoy near **C1**
61N40.389, 8W27.489, 642 m depth
Release: SN 1185 Arm/range: 0874
Rel: 0855
ARGOS: SN 032

Glider Snotra is caught in strong currents and drifting far north. Decided to steam and recover.

1330 UTC: Recovered Snotra from the side of the ship (from the CTD gate) using the handle and crane. No damage.

1700 UTC: Started section a from a1 (ctd: sta0694; vmp: cast 067). First occupation covers sections a1 to a9. Return is (CTD only) at stations au3 to au1. The following repeats of section a are between a2 and a8.

11 June

2000 UTC: Recovered Glider Gnå. After attempts to recover from the side of the ship, the work boat was eventually used and Gnå was safely on deck at 2035 UTC.

11. Appendix B: List of CTD/LADCP stations

Table 3. List of CTD stations. Echo depth is from the ship's echo sounder corrected for transducer depth and depth averaged (adjusted for full depth) speed of sound. File names for corresponding master/slave LADCP (staXXX_LADCPM.000) and VMP2000 (cast_0XX.p) profiles are indicated.

Cast	Station Name	Date-Time (UTC)		LAT	LON	E. Depth (m)	LADCP	VMP-2000
582	TEST	2012-05-27	09:14	61N18.58	000W47.77	172	582	-
583	m-C1	2012-05-28	07:14	61N40.34	008W28.02	656	583	-
584	m-C2	2012-05-28	10:32	61N37.57	008W32.43	800	584	-
585	m-C3	2012-05-28	14:58	61N33.77	008W37.75	860	585	-
586	M1	2012-05-28	20:04	61N45.15	009W19.86	808	586	-
587	M1	2012-05-28	21:02	61N44.91	009W20.05	806	587	-
588	M1	2012-05-28	22:05	61N45.07	009W19.95	806	588	-
589	M1	2012-05-28	23:08	61N45.11	009W19.92	808	589	-
590	M1	2012-05-29	00:04	61N45.10	009W20.04	806	590	-
591	M1	2012-05-29	01:01	61N45.08	009W19.96	807	591	-
592	M1	2012-05-29	02:00	61N45.07	009W19.98	806	592	-
593	M1	2012-05-29	03:01	61N45.01	009W19.95	808	593	-
594	M1	2012-05-29	04:08	61N45.12	009W20.02	805	594	-
595	M1	2012-05-29	05:03	61N45.01	009W20.02	806	595	-
596	M1	2012-05-29	06:02	61N45.07	009W20.02	806	596	-
597	M1	2012-05-29	08:24	61N44.91	009W20.57	809	597	-
598	S1	2012-05-29	10:13	61N55.88	009W27.54	577	598	-
599	S2	2012-05-29	12:43	61N50.17	009W35.86	780	599	-
600	S3	2012-05-29	16:14	61N43.55	009W43.13	954	600	-
601	t1	2012-05-29	21:04	61N48.19	009W45.54	903	601	-
602	t1	2012-05-29	22:04	61N48.17	009W45.48	903	602	-
603	t1	2012-05-29	23:01	61N48.11	009W45.63	905	603	-
604	t1	2012-05-30	00:00	61N48.13	009W45.61	904	604	-
605	t1	2012-05-30	01:01	61N48.18	009W45.68	904	605	-
606	t1	2012-05-30	02:03	61N48.15	009W45.68	906	606	-
607	t1	2012-05-30	03:01	61N48.12	009W45.62	904	607	-
608	t1	2012-05-30	04:02	61N48.12	009W45.57	904	608	-
609	t1	2012-05-30	05:01	61N48.13	009W45.75	904	609	-
610	t1	2012-05-30	06:02	61N48.17	009W45.66	903	610	-
611	t1	2012-05-30	07:04	61N48.11	009W45.62	903	611	-
612	S4	2012-05-30	08:45	61N38.95	009W49.11	1084	612	-
613	M2	2012-05-30	13:37	61N45.07	009W30.39	590	613	-
615	b2-700	2012-05-30	23:55	61N47.12	009W10.83	615	615	2
616	b3-750	2012-05-31	01:40	61N45.34	009W12.14	744	616	3
617	b4-800	2012-05-31	03:32	61N42.08	009W14.03	810	617	4
618	a1-300	2012-05-31	18:26	61N43.71	008W25.74	309	618	5
619	a2-450	2012-05-31	19:13	61N42.82	008W26.88	454	619	6
620	a3-600	2012-05-31	20:18	61N41.58	008W28.76	603	620	7
621	a4-700	2012-05-31	21:36	61N40.49	008W30.44	700	621	8
622	a5-800	2012-05-31	23:10	61N37.82	008W33.99	806	622	-
623	a6-860	2012-06-01	00:51	61N35.66	008W36.92	859	623	9
624	a7-800	2012-06-01	02:23	61N32.07	008W41.67	799	624	-
625	C3-700	2012-06-01	11:57	61N50.87	009W28.12	704	625	-
626	C4-800	2012-06-01	13:09	61N47.77	009W30.23	796	626	-
627	C5-900	2012-06-01	15:09	61N43.91	009W33.22	900	627	-
628	C6-1000	2012-06-01	16:55	61N39.69	009W36.68	971	628	-
629	C7-1050	2012-06-01	18:14	61N36.26	009W39.29	1032	629	-
630	C8-1100	2012-06-01	19:16	61N34.47	009W40.93	1036	630	-
631	cu3	2012-06-01	20:48	61N40.20	009W28.99	911	631	10
632	cu2	2012-06-01	23:20	61N46.14	009W24.81	802	632	11

Cast	Station Name	Date-Time (UTC)		LAT	LON	E. Depth (m)	LADCP	VMP-2000
633	cu1	2012-06-02	01:21	61N50.62	009W21.70	695	633	12
634	C2	2012-06-02	03:18	61N54.92	009W24.68	599	634	13
635	C3	2012-06-02	05:02	61N50.90	009W27.61	698	635	14
636	C4	2012-06-02	07:05	61N47.84	009W30.20	790	636	15
637	C5	2012-06-02	08:48	61N43.90	009W33.18	898	637	16
638	C6	2012-06-02	11:09	61N39.48	009W37.54	973	638	17
639	C7	2012-06-02	12:56	61N36.13	009W39.50	988	639	18
640	cu3	2012-06-02	15:26	61N40.17	009W29.09	910	640	-
641	cu2	2012-06-02	16:51	61N46.05	009W24.95	799	641	-
642	cu1	2012-06-02	17:57	61N50.50	009W21.80	698	642	-
643	C2	2012-06-02	18:53	61N54.98	009W24.64	592	643	19
644	C3	2012-06-02	20:12	61N50.77	009W27.86	705	644	20
645	C4	2012-06-02	21:35	61N47.86	009W30.35	790	645	21
646	C5	2012-06-02	23:28	61N43.95	009W33.46	896	646	22
647	C6	2012-06-03	01:26	61N39.54	009W37.15	975	647	23
648	C7	2012-06-03	03:21	61N36.18	009W39.53	1028	648	24
649	cu3	2012-06-03	05:55	61N40.20	009W28.93	909	649	-
650	cu2	2012-06-03	07:13	61N46.10	009W24.90	800	650	-
651	cu1	2012-06-03	08:15	61N50.43	009W21.53	696	651	-
652	C2	2012-06-03	09:14	61N54.78	009W24.89	592	652	25
653	C3	2012-06-03	10:37	61N50.80	009W27.80	698	653	26
654	C4	2012-06-03	12:00	61N47.75	009W30.21	793	654	27
655	C5	2012-06-03	13:44	61N43.86	009W33.74	903	655	28
656	C6	2012-06-03	15:40	61N39.64	009W37.08	973	656	30
657	C7	2012-06-03	17:30	61N36.23	009W39.54	1030	657	31
658	cu3	2012-06-03	19:48	61N40.23	009W29.05	909	658	-
659	cu2	2012-06-03	21:01	61N45.96	009W25.07	802	659	-
660	cu1	2012-06-03	22:08	61N50.51	009W21.70	697	660	-
661	C1	2012-06-03	23:47	62N00.36	009W20.55	539	661	32
662	C2	2012-06-04	01:10	61N54.74	009W24.79	600	662	33
663	C3	2012-06-04	02:25	61N50.80	009W27.76	701	663	34
664	C4	2012-06-04	03:47	61N47.74	009W30.23	795	664	35
665	C5	2012-06-04	05:20	61N43.98	009W33.20	902	665	36
666	C6	2012-06-04	07:02	61N39.64	009W36.97	976	666	37
667	C7	2012-06-04	08:48	61N36.28	009W39.28	1026	667	39
668	C8	2012-06-04	10:32	61N34.53	009W40.69	1032	668	40
669	f5	2012-06-04	17:13	61N45.33	010W18.33	1046	669	41
670	C5	2012-06-05	02:28	61N43.86	009W32.89	899	670	43
671	cu2	2012-06-05	04:17	61N46.06	009W25.00	803	671	44
672	C4	2012-06-05	05:55	61N47.88	009W30.07	796	672	45
673	C5	2012-06-05	07:49	61N44.07	009W32.99	898	673	46
674	cu2	2012-06-05	09:32	61N46.00	009W25.17	803	674	47
675	C4	2012-06-05	11:51	61N47.83	009W30.07	799	675	48
676	C5	2012-06-05	13:39	61N43.88	009W33.15	900	676	49
677	cu2	2012-06-05	15:37	61N45.90	009W25.00	804	677	50
678	C4	2012-06-05	17:15	61N47.86	009W30.02	796	678	51
679	C5	2012-06-05	18:54	61N43.92	009W33.22	902	679	52
680	cu2	2012-06-05	20:37	61N46.04	009W25.05	804	680	53
681	C4	2012-06-05	22:12	61N47.81	009W30.00	800	681	54
683	b1	2012-06-06	00:37	61N50.87	009W08.42	634	683	55
684	b2	2012-06-06	01:57	61N47.07	009W10.50	698	684	56
685	b3	2012-06-06	03:06	61N45.30	009W11.78	751	685	57
686	b4	2012-06-06	04:31	61N42.07	009W14.04	819	686	58
687	b5	2012-06-06	06:05	61N39.31	009W15.89	833	687	59
688	b4	2012-06-06	07:47	61N42.27	009W13.66	794	688	60
689	b4	2012-06-06	09:06	61N42.33	009W14.01	811	689	61

Cast	Station Name	Date-Time (UTC)		LAT	LON	E. Depth (m)	LADCP	VMP-2000
690	b4	2012-06-06	11:03	61N42.17	009W13.95	818	690	63
691	b4	2012-06-06	13:04	61N42.15	009W14.03	814	691	64
692	b4	2012-06-06	15:01	61N42.20	009W14.06	823	692	65
693	b4	2012-06-06	17:03	61N42.14	009W14.06	818	693	66
694	a1	2012-06-09	20:06	61N43.64	008W25.78	329	694	67
695	a2	2012-06-09	21:01	61N42.84	008W26.97	456	695	68
696	a3	2012-06-09	22:02	61N41.60	008W28.63	601	696	69
697	a4	2012-06-09	23:14	61N40.48	008W30.30	701	697	70
698	a5	2012-06-10	00:50	61N37.84	008W34.15	704	698	71
699	a6	2012-06-10	02:30	61N35.69	008W36.99	860	699	72
700	a7	2012-06-10	04:16	61N32.15	008W41.71	804	700	73
701	a8	2012-06-10	05:58	61N30.73	008W43.75	666	701	74
702	a9	2012-06-10	07:13	61N29.46	008W45.47	591	702	75
703	au3	2012-06-10	09:09	61N32.19	008W33.88	848	703	-
704	au2	2012-06-10	10:21	61N35.63	008W29.66	807	704	-
705	au1	2012-06-10	11:37	61N38.89	008W25.79	683	705	-
706	a2	2012-06-10	12:33	61N42.85	008W26.98	457	706	76
707	a3	2012-06-10	13:31	61N41.57	008W28.66	600	707	77
708	a4	2012-06-10	14:38	61N40.42	008W30.28	702	708	78
709	a5	2012-06-10	16:00	61N37.75	008W34.04	802	709	79
710	a6	2012-06-10	17:44	61N35.74	008W36.89	860	710	80
711	a7	2012-06-10	19:40	61N32.11	008W41.81	800	711	81
712	a8	2012-06-10	21:14	61N30.57	008W43.96	648	712	82
713	au3	2012-06-10	23:08	61N32.10	008W34.12	849	713	-
714	au2	2012-06-11	00:19	61N35.61	008W29.63	802	714	-
715	au1	2012-06-11	01:24	61N38.82	008W25.60	683	715	-
716	a2	2012-06-11	02:26	61N42.86	008W26.89	452	716	83
717	a3	2012-06-11	03:34	61N41.60	008W28.66	600	717	84
718	a4	2012-06-11	04:46	61N40.45	008W30.30	700	718	85
719	a5	2012-06-11	06:24	61N37.73	008W34.06	808	719	86
720	a6	2012-06-11	07:57	61N35.64	008W37.06	860	720	87
721	a7	2012-06-11	09:56	61N32.18	008W41.84	809	721	88
722	a8	2012-06-11	11:32	61N30.60	008W43.92	652	722	89
723	au3	2012-06-11	13:10	61N32.11	008W34.00	800	723	-
724	au2	2012-06-11	14:13	61N35.62	008W29.49	800	724	-
725	au1	2012-06-12	02:43	61N42.84	008W26.92	452	725	90
726	a3	2012-06-12	03:43	61N41.61	008W28.67	600	726	91
727	a4	2012-06-12	04:54	61N40.47	008W30.35	702	727	92
728	a5	2012-06-12	06:50	61N37.82	008W33.86	801	728	93
729	a6	2012-06-12	08:18	61N35.76	008W36.81	860	729	94

12. Appendix C: List of VMP stations

Table 4. List of the VMP2000 deployments. Echo depth (ED) is from the ship's echo sounder. Start and end pressures mark the reading on the VMP data acquisition software when started and stopped logging. CTD file is the corresponding ship CTD cast taken before the VMP deployment.

Cast	Station Name	Date-Time (UTC)		LAT	LON	Depth (m)	Start (m)	End (m)	CTD File	Comments
1	TEST	2012-05-30	21:11	61N34.45	09W19.35	835	5.0	850	-	sh1, sh2, mT1, 1 bad buffer;
2	b2	2012-05-31	00:35	61N47.23	09W10.61	722	5.0	730	615	hit the bottom
3	b3	2012-05-31	02:21	61N45.41	09W11.91	755	8.0	720	616	1 bad buffer
4	b4	2012-05-31	04:14	61N42.17	09W14.07	810	5.0	850	617	1 bad buffer
5	a1	2012-05-31	18:40	61N43.67	08W25.90	334	5.0	310	618	
6	a2	2012-05-31	19:32	61N42.80	08W27.00	464	5.0	466	619	Bottom
7	a3	2012-05-31	20:40	61N41.53	08W29.15	618	5.0	629	620	Bottom
8	a4	2012-05-31	22:08	61N40.50	08W31.46	718	10.0	670	621	
9	a5	2012-05-31	23:46	61N37.83	08W34.13	807	10.0	792	623	
10	cu3	2012-06-01	21:30	61N40.21	09W28.21	912	4.0	915	631	Bottom
11	cu2	2012-06-01	23:54	61N46.40	09W23.96	792	160.0	780	632	
12	cu1	2012-06-02	01:52	61N50.99	09W20.89	685	10.0	695	633	Bottom
13	c2	2012-06-02	03:43	61N55.44	09W23.89	601	7.0	560	634	
14	c3	2012-06-02	05:49	61N51.20	09W26.06	697	5.0	700	635	Bottom
15	c4	2012-06-02	07:35	61N48.08	09W29.67	787	5.0	793	636	NOT bottom
16	c5	2012-06-02	09:21	61N43.94	09W33.66	900	5.0	900	637	NOT bottom
17	c6	2012-06-02	11:40	61N39.34	09W38.07	984	10.0	1010	638_1	Bottom (not sure)
18	c7	2012-06-02	13:40	61N35.77	09W40.19	1024	10.0	1010	639	NOT bottom
19	c2	2012-06-02	19:15	61N54.99	09W24.24	594	2.0	567	643	
20	c3	2012-06-02	20:39	61N50.83	09W27.85	701	3.0	672	644	
21	c4	2012-06-02	22:15	61N47.91	09W31.04	806	12.0	790	645	
22	c5	2012-06-03	00:05	61N43.86	09W34.95	908	10.0	920	646	Bottom
23	c6	2012-06-03	02:06	61N39.39	09W37.67	983	9.0	1050	647	Bottom
24	c7	2012-06-03	04:01	61N36.24	09W39.72	1029	5.0	1000	648	
25	c2	2012-06-03	09:37	61N54.48	09W24.88	595	4.0	590	652	
26	c3	2012-06-03	11:05	61N50.52	09W28.12	721	8.0	725	653	
27	c4	2012-06-03	12:32	61N47.45	09W30.74	804	7.0	820	654	
28	c5	2012-06-03	14:23	61N43.67	09W34.40	906	10.0	933	655	NB. No cast 29
30	c6	2012-06-03	16:17	61N39.83	09W37.70	991	5.0	989	656	
31	c7	2012-06-03	18:08	61N36.24	09W39.70	1030	5.0	1010	657	
32	c1	2012-06-04	00:13	61N59.99	09W20.88	545	10.0	535	661	
33	c2	2012-06-04	01:35	61N54.34	09W25.22	597	10.0	590	662	
34	c3	2012-06-04	02:55	61N50.43	09W28.31	728	10.0	729	663	
35	c4	2012-06-04	04:17	61N47.42	09W30.66	810	6.0	826	664	NOT bottom
36	c5	2012-06-04	05:54	61N43.88	09W33.18	904	3.0	893	665	
37	c6	2012-06-04	07:35	61N39.80	09W36.32	974	5.0	983	666	NOT bottom
39	c7	2012-06-04	09:29	61N36.06	09W38.94	1020	5?	990	667	NB nocast38
40	c8	2012-06-04	11:39	61N34.39	09W40.08	1029	10.0	1048	668	bottom
41	f5	2012-06-04	17:52	61N45.40	10W18.30	1042	0.0	1055	669	bottom
42	tow	2012-06-04	18:32	61N45.30	10W20.00	1042	0.0	0	-	towing at 700-900 m
43	c5	2012-06-05	03:05	61N44.07	09W32.11	894	10.0	903	670	not bottom
44	cu2	2012-06-05	04:50	61N46.22	09W24.81	800	10.0	802	671	bottom
45	c4	2012-06-05	06:25	61N48.20	09W29.45	781	5.0	760	672	
46	c5	2012-06-05	08:24	61N44.45	09W32.50	889	5.0	890	673	bottom
47	cu2	2012-06-05	10:05	61N46.50	09W24.42	789	10.0	790	674	not bottom
48	c4	2012-06-05	12:26	61N47.98	09W29.67	790	10.0	776	675	
49	c5	2012-06-05	14:42	61N43.62	09W32.61	919	10.0	913	676	bottom
50	cu2	2012-06-05	16:08	61N45.72	09W25.18	810	5.0	824	677	bottom
51	c4	2012-06-05	17:46	61N47.96	09W30.00	790	5.0	785	678	
52	c5	2012-06-05	19:28	61N44.11	09W33.30	900	5.0	908	679	bottom

Cast	Station Name	Date-Time (UTC)		LAT	LON	Depth (m)	Start (m)	End (m)	CTD File	Comments
53	cu2	2012-06-05	21:07	61N46.29	09W24.75	800	5.0	801	680	NOT bottom
54	c4	2012-06-05	22:45	61N47.92	09W29.69	794	10.0	780	681	not bottom
55	b1	2012-06-06	01:01	61N50.56	09W08.65	625	10.0	603	683	
56	b2	2012-06-06	02:26	61N46.49	09W11.04	713	12.0	680	684	
57	b3	2012-06-06	03:45	61N44.39	09W12.53	758	10.0	776	685	bottom
58	b4	2012-06-06	05:00	61N41.71	09W14.23	807	5.0	800	686	
59	b5	2012-06-06	06:37	61N39.00	09W16.30	850	5.0	825	687	
60	b4	2012-06-06	08:18	61N41.91	09W13.27	800	5.0	794	688	
61	b4	2012-06-06	09:37	61N42.00	09W13.75	796	5.0	787	689	
63	b4	2012-06-06	11:41	61N42.15	09W14.05	810	5.0	784	690	no cast 62
64	b4	2012-06-06	13:43	61N42.15	09W14.13	807	10.0	806	691	
65	b4	2012-06-06	15:42	61N42.13	09W14.19	810	20.0	NaN	692	
66	b4	2012-06-06	17:37	61N41.87	09W15.00	826	3.0	800	693	
67	a1	2012-06-09	20:35	61N43.80	08W25.60	287	4.0	256	694	
68	a2	2012-06-09	21:25	61N42.87	08W26.88	452	4.0	460	695	bottom
69	a3	2012-06-09	22:27	61N41.63	08W29.09	610	10.0	610	696	bottom?
70	a4	2012-06-09	23:48	61N40.48	08W30.32	702	10.0	680	697	
71	a5	2012-06-10	01:29	61N37.79	08W34.28	806	10.0	750	698	
72	a6	2012-06-10	03:04	61N35.70	08W37.04	860	10.0	820	699	
73	a7	2012-06-10	04:53	61N32.26	08W41.84	810	5.0	814	700	bottom
74	a8	2012-06-10	06:30	61N30.72	08W43.90	661	5.0	654	701	
75	a9	2012-06-10	07:43	61N29.58	08W45.65	596	4.0	591	702	
76	a2	2012-06-10	12:55	61N42.89	08W26.97	455	10.0	450	706	
77	a3	2012-06-10	13:55	61N41.53	08W28.87	611	10.0	619	707	
78	a4	2012-06-10	15:05	61N40.29	08W30.60	708	10.0	695	708	
79	a5	2012-06-10	16:42	61N37.96	08W33.72	790	5.0	782	709	
80	a6	2012-06-10	18:25	61N35.81	08W36.84	860	4.0	854	710	
81	a7	2012-06-10	20:20	61N32.18	08W41.98	805	4.0	810	711	bottom
82	a8	2012-06-10	21:51	61N30.62	08W44.08	648	3.0	630	712	
83	a2	2012-06-11	02:50	61N42.83	08W26.85	450	10.0	430	716	
84	a3	2012-06-11	04:03	61N41.68	08W28.75	598	5.0	606	717	bottom
85	a4	2012-06-11	05:15	61N40.45	08W30.54	704	3.0	715	718	bottom
86	a5	2012-06-11	07:05	61N37.81	08W34.09	803	3.0	787	719	
87	a6	2012-06-11	08:42	61N35.75	08W37.05	862	3.0	845	720	
88	a7	2012-06-11	10:27	61N32.01	08W41.84	798	10.0	807	721	bottom
89	a8	2012-06-11	11:55	61N30.56	08W43.93	653	10.0	655	722	
90	a2	2012-06-12	03:04	61N42.90	08W27.00	455	20.0	445	725	
91	a3	2012-06-12	04:09	61N41.70	08W28.80	598	2.0	603	726	bottom
92	a4	2012-06-12	05:47	61N40.39	08W30.23	700	4.0	710	727	
93	a5	2012-06-12	07:22	61N37.82	08W34.13	805	3.0	788	728	
94	a6	2012-06-12	08:57	61N35.77	08W36.87	862	4.0	865	729	

13. Appendix D: Deployment Files: LADCP & VMADCP

Master deployment file

```
; Append command to the log file
$LC:\HM2012610\ladcp\Mladcp.log
$P ***********************************************
$P * LADCP Master. Looking down (firmware v16.30) *
$P ** Master and Slave will ping at the same time *
$P ** staggered single-pings every 0.8/1.2 s ***
$P *********************************************
; Send ADCP a BREAK
$B
; Wait for command prompt (sent after each command)
$W62
; Display real time clock setting
tt?
$W62
; Set to factory defaults
CR1
$W62
; use WM15 for firmware 16.3
; activates LADCP mode (BT from WT pings)
WM15
; Flow control (Record data internally):
; - automatic ensemble cycling (next ens when ready)
; - automatic ping cycling (ping when ready)
; - binary data output
; - disable serial output
; - enable data recorder
CF11101
$W62
; coordinate transformation:
; - radial beam coordinates (2 bits)
; - use pitch/roll (not used for beam coords)
; - no 3-beam solutions
; - no bin mapping
EX00100
$W62
; Sensor source:
; - manual speed of sound (EC)
; - manual depth of transducer (ED = 0 [dm])
; - measured heading (EH)
; - measured pitch (EP)
; - measured roll (ER)
; - manual salinity (ES = 35 [psu])
; - measured temperature (ET)
EZ0011101
$W62
;
; - configure staggered ping-cycle
; ensembles per burst
TC2
$W62
; pings per ensemble
WP1
$W62
; time per burst
TB 00:00:01.20
$W62
; time per ensemble
TE 00:00:00.80
$W62
; time between pings
TP 00:00.00
$W62
; - configure no. of bins, length, blank
; number of bins
WN015
$W62
; bin length [cm]
WS0800
$W62
; blank after transmit [cm]
WF0000
$W62
; ambiguity velocity [cm]
WV250
$W62
; amplitude and correlation thresholds for bottom
detection
LZ30,220
$W62
```

```
; Set ADCP to narrow bandwidth and extend range by
10%
LW1
$W62
; Name data file
RN MLADCP
$W62
; SET AS MASTER ADCP
SM1
$W62
; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH ENSEMBLE
SA011
$W62
; WAIT .55 s after sending sync pulse
SW05500
$W62
; SYNCHRONIZING PULSE SENT ON EVERY PING
SI0
$W62
; keep params as user defaults (across power
failures)
CK
$W62
; echo configuration
T?
$W62
W?
$W62
; start Pinging
CS
; Delay 3 seconds
$D3
$p ***********************************************
$P Please disconnect the ADCP from the computer.
$P ***********************************************
; Close the log file
$L
```

Slave deployment file

```
; Append command to the log file
$LC:\HM2012610\ladcp\Sladcp.log
$P *********************************************
$P **** LADCP SLAVE. Looking UP (firmware v16.30) *
$P ** Master and Slave will ping at the same time **
$P * staggered single-ping every 0.8/1.2 s ***
$P ***********************************************
; Send ADCP a BREAK
$B
% Wait for the command promt; BBTalk needs this
before each command
$W62
; Display real time clock setting
tt?
$W62
; Set to factory defaults
CR1
$W62
; use WM15 for firmware 16.3
; activates LADCP mode (BT from WT pings)
WM15
$W62
; Flow control (Record data internally):
; - automatic ensemble cycling (next ens when ready)
; - automatic ping cycling (ping when ready)
; - binary data output
; - disable serial output
; - enable data recorder
CF11101
$W62
; coordinate transformation:
; - radial beam coordinates (2 bits)
; - use pitch/roll (not used for beam coords?)
; - no 3-beam solutions
; - no bin mapping
EX00100
$W62
; Sensor source:
; - manual speed of sound (EC)
; - manual depth of transducer (ED = 0 [dm])
; - measured heading (EH)
; - measured pitch (EP)
; - measured roll (ER)
; - manual salinity (ES = 35 [psu])
; - measured temperature (ET)
EZ0011101
$W62
; - configure staggered ping-cycle
; ensembles per burst
TC2
$W62
; pings per ensemble
WP1
$W62
; time per burst
TB 00:00:01.20
$W62
; time per ensemble
TE 00:00:00.80
$W62
; time between pings
TP 00:00.00
$W62
; - configure no. of bins, length, blank
; number of bins
WN015
$W62
; bin length [cm]
WS0800
$W62
; blank after transmit [cm]
WF0000
$W62
; ambiguity velocity [cm]
WV250
$W62
; amplitude and correlation thresholds for bottom
detection
LZ30,220
$W62
; narrow bandwidth and extend range by 10%
LW1
$W62
; Name data file
RN SLADCP
$W62
; SET AS SLAVE ADCP
SM2
$W62
; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH ENSEMBLE
SA011
$W62
; don't sleep
SS0
$W62
; WAIT UP TO 300 SECONDS FOR SYNCHRONIZING PULSE
ST0300
$W62
; keep params as user defaults (across power
failures)
CK
$W62
; echo configuration
T?
$W62
W?
$W62
; start Pinging
CS
; Delay 3 seconds
$D3
$p *********************************************
$P Please disconnect the ADCP from the computer.
$P *********************************************
; Close the log file
$L
```

VMADCP deployment file

```
;------------------------------------------------------------------------------\
; ADCP Command File for use with VmDas software.
;
; ADCP type:     75 Khz Ocean Surveyor
; Setup name:    default
; Setup type:    Low resolution, long range profile(narrowband)
;
; NOTE:  Any line beginning with a semicolon in the first
;        column is treated as a comment and is ignored by
;        the VmDas software.
; Modified Last: 12August2003
;--------------------------------------------/

; Restore factory default settings in the ADCP
cr1
; set the data collection baud rate to 38400 bps,
; no parity, one stop bit, 8 data bits
; NOTE:  VmDas sends baud rate change command after all other commands in
; this file, so that it is not made permanent by a CK command.
cb611
; Set for narrowband single-ping profile mode (NP), hundred (NN) 8 meter bins (NS),
; 8 meter blanking distance (NF)
WP0
NN100
NP00001
NS0800
NF0800
; Disable single-ping bottom track (BP),
; Set maximum bottom search depth to 1000 meters (BX)
BP000
BX10000
; output velocity, correlation, echo intensity, percent good
ND111110000
; One second between bottom and water pings
TP000150
; Zero seconds between ensembles
; Since VmDas uses manual pinging, TE is ignored by the ADCP.
; You must set the time between ensemble in the VmDas Communication options
TE00000000
; Not set to calculate speed-of-sound, no depth sensor, external synchro heading
; sensor, no pitch or roll being used, no salinity sensor, use internal transducer
; temperature sensor
EZ0000001
; Sets the speed of sound to 1500m/s
EC1500
; Output beam data (rotations are done in software)
EX00000
; Set transducer misalignment (hundredths of degrees)
EA04530
; Set transducer depth (decimeters)
ED0042
; Set Salinity (ppt)
ES35
; save this setup to non-volatile memory in the ADCP
CK
; narrow bandwidth and extend range by 10%
LW1
$W62
; Name data file
RN SLADCP
$W62
; SET AS SLAVE ADCP
SM2
$W62
; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH ENSEMBLE
SA011
$W62
; don't sleep
SS0
```

14. Appendix E: Deployment Files: Moored ADCPs

<table>
<tr><th>WH150 SN17226</th><th>WH150 SN17227</th></tr>
<tr><td>

```
CR1
CF11101
EA0
EB0
ED5750
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF0
WN30
WP40
WS800
WV175
TE00:20:00.00
TP00:02.00
TF12/05/28 12:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 153600
;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    = 7920.00
;Battery packs       = 2
;Automatic TP        = NO
;Memory size [MB]    = 256
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version
2.06:
;First cell range    = 8.82 m
;Last cell range     = 240.82 m
;Max range           = 243.95 m
;Standard deviation = 0.56 cm/s
;Ensemble size       = 754 bytes
;Storage required    = 17.09 MB (17915040
bytes)
;Power usage         = 859.98 Wh
;Battery usage       = 1.9
;
; WARNINGS AND CAUTIONS:
; Advanced settings have been changed.
; Expert settings have been changed.
```

</td><td>

```
CR1
CF11101
EA0
EB0
ED5000
ES35
EX11111
EZ1111101
WA50
WB1
WD111100000
WF0
WN39
WP40
WS800
WV175
TE00:20:00.00
TP00:02.00
TF12/05/28 12:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 153600
;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    = 7680.00
;Battery packs       = 2
;Automatic TP        = NO
;Memory size [MB]    = 256
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version
2.06:
;First cell range    = 8.69 m
;Last cell range     = 312.69 m
;Max range           = 311.54 m
;Standard deviation = 1.12 cm/s
;Ensemble size       = 934 bytes
;Storage required    = 20.52 MB (21519360
bytes)
;Power usage         = 890.08 Wh
;Battery usage       = 2.0
;
; WARNINGS AND CAUTIONS:
; Advanced settings have been changed.
; Expert settings have been changed.
```

</td></tr>
</table>

<table>
<tr><th>WH300 SN10149</th><th>WH300 SN15331</th></tr>
<tr><td>

```
CR1
CF11101
EA0
EB0
ED5000
ES35
EX11111
EZ1111101
WA50
WB1
WD111100000
WF0
WN34
WP35
WS400
WV175
TE00:20:00.00
TP00:01.00
TF12/05/28 12:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;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    = 7920.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 256
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version
2.06:
;First cell range    = 4.34 m
;Last cell range     = 136.34 m
;Max range           = 145.18 m
;Standard deviation = 1.26 cm/s
;Ensemble size       = 834 bytes
;Storage required    = 18.90 MB (19815840
bytes)
;Power usage         = 413.13 Wh
;Battery usage       = 0.9
;
; WARNINGS AND CAUTIONS:
; Advanced settings have been changed.
; Expert settings have been changed.
```

</td><td>

```
CR1
CF11101
EA0
EB0
ED7250
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF0
WN27
WP40
WS400
WV175
TE00:05:00.00
TP00:01.00
TF12/05/28 12:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;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    = 1920.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 256
;Saved Screen        = 3
;
;Consequences generated by PlanADCP version
2.06:
;First cell range    = 4.41 m
;Last cell range     = 108.41 m
;Max range           = 108.10 m
;Standard deviation = 0.56 cm/s
;Ensemble size       = 694 bytes
;Storage required    = 15.25 MB (15989760
bytes)
;Power usage         = 431.65 Wh
;Battery usage       = 1.0
;
; WARNINGS AND CAUTIONS:
; Advanced settings have been changed.
; Expert settings have been changed.
```

</td></tr>
</table>

WH300 SN17319	WH300 SN3505
CR1 CF11101 EA0 EB0 ED8250 ES35 EX11111 EZ1111101 WA50 WB0 WD111100000 WF0 WN27 WP40 WS400 WV175 TE00:05:00.00 TP00:01.00 TF12/05/28 12:00:00 CK CS ; ;Instrument = Workhorse Sentinel ;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 = 1920.00 ;Battery packs = 1 ;Automatic TP = NO ;Memory size [MB] = 256 ;Saved Screen = 2 ; ;Consequences generated by PlanADCP version 2.06: ;First cell range = 4.41 m ;Last cell range = 108.41 m ;Max range = 108.73 m ;Standard deviation = 0.56 cm/s ;Ensemble size = 694 bytes ;Storage required = 15.25 MB (15989760 bytes) ;Power usage = 431.45 Wh ;Battery usage = 1.0 ; ; WARNINGS AND CAUTIONS: ; Advanced settings have been changed. ; Expert settings have been changed.	CR1 CF11101 EA0 EB0 ED6000 ES35 EX11111 EZ1111101 WA50 WB0 WD111100000 WF0 WN27 WP40 WS400 WV175 TE00:05:00.00 TP00:01.00 TF12/05/28 12:00:00 CK CS ; ;Instrument = Workhorse Sentinel ;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 = 1920.00 ;Battery packs = 1 ;Automatic TP = NO ;Memory size [MB] = 256 ;Saved Screen = 1 ; ;Consequences generated by PlanADCP version 2.06: ;First cell range = 4.41 m ;Last cell range = 108.41 m ;Max range = 107.32 m ;Standard deviation = 0.56 cm/s ;Ensemble size = 694 bytes ;Storage required = 15.25 MB (15989760 bytes) ;Power usage = 431.91 Wh ;Battery usage = 1.0 ; ; WARNINGS AND CAUTIONS: ; Advanced settings have been changed. ; Expert settings have been changed.

15. Appendix F: Mooring Drawings

Appended to the end of the document from a separate PDF file.

16. References

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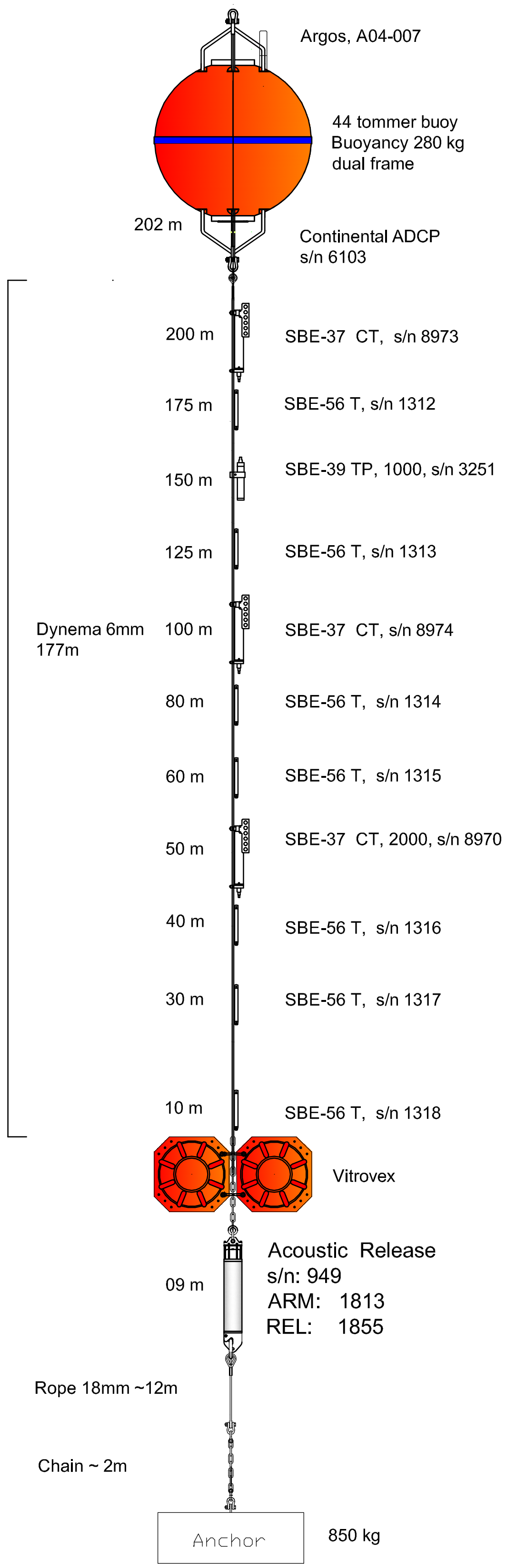
C1



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project:

Location: FÆRØYENE

Position: 61N 40.429' 008W 27.900'

Depth: 650m

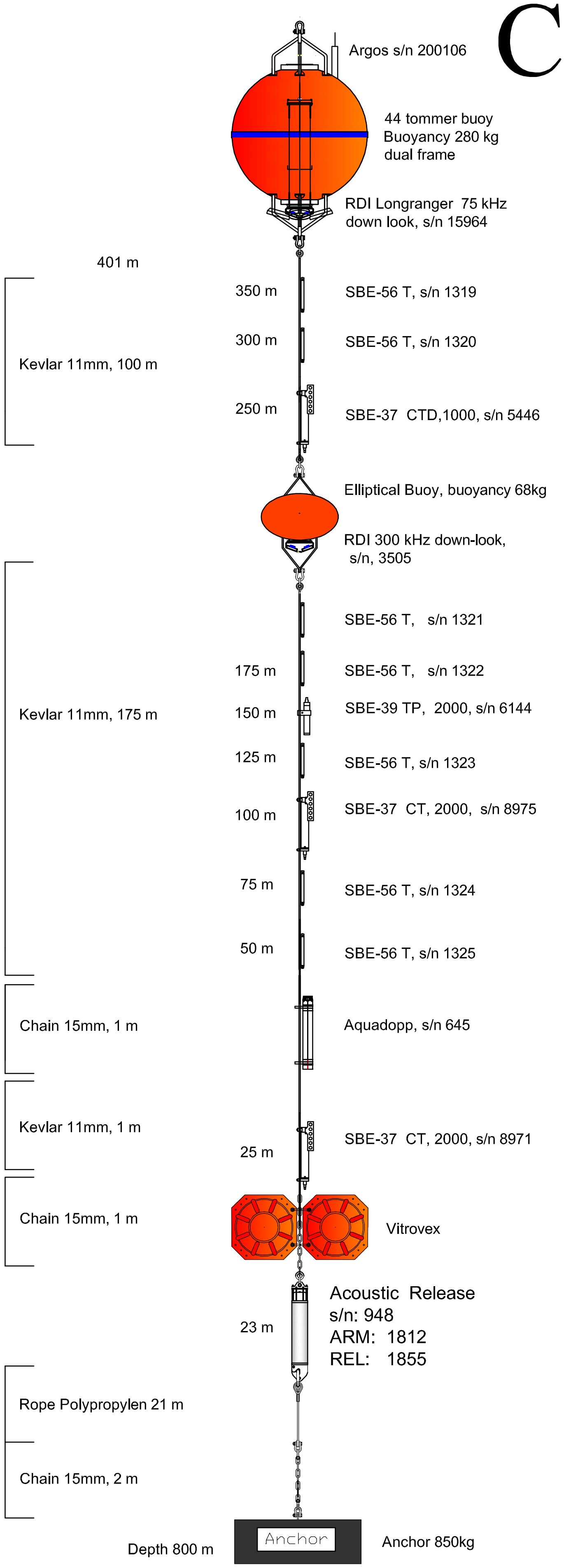
Deployment: 28.05.2012 09:30 UTC

Retrieval:

Comments:

4	Vitrovex , 20kg buoyancy
1	44 " buoy, 280kg, buoyancy
1	Continental ADCP
3	SBE - 37
1	SBE - 39 T
7	SBE - 56 T
1	Acoustic Release
177m	06mm Dynema Line
1m	Chain 15mm steel galvanic (vitrovex)
1m	Chain 15mm steel galvanic (vitrovex)
6m	Rope Polypropylen 18mm 12m
2m	Chain 15mm steel galvanic (anchor)
1	Anchor 850kg dry weight

C2



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project:

Location: FÆRØYENE

Position: 61N37.397 8W32.545

Depth: 807m

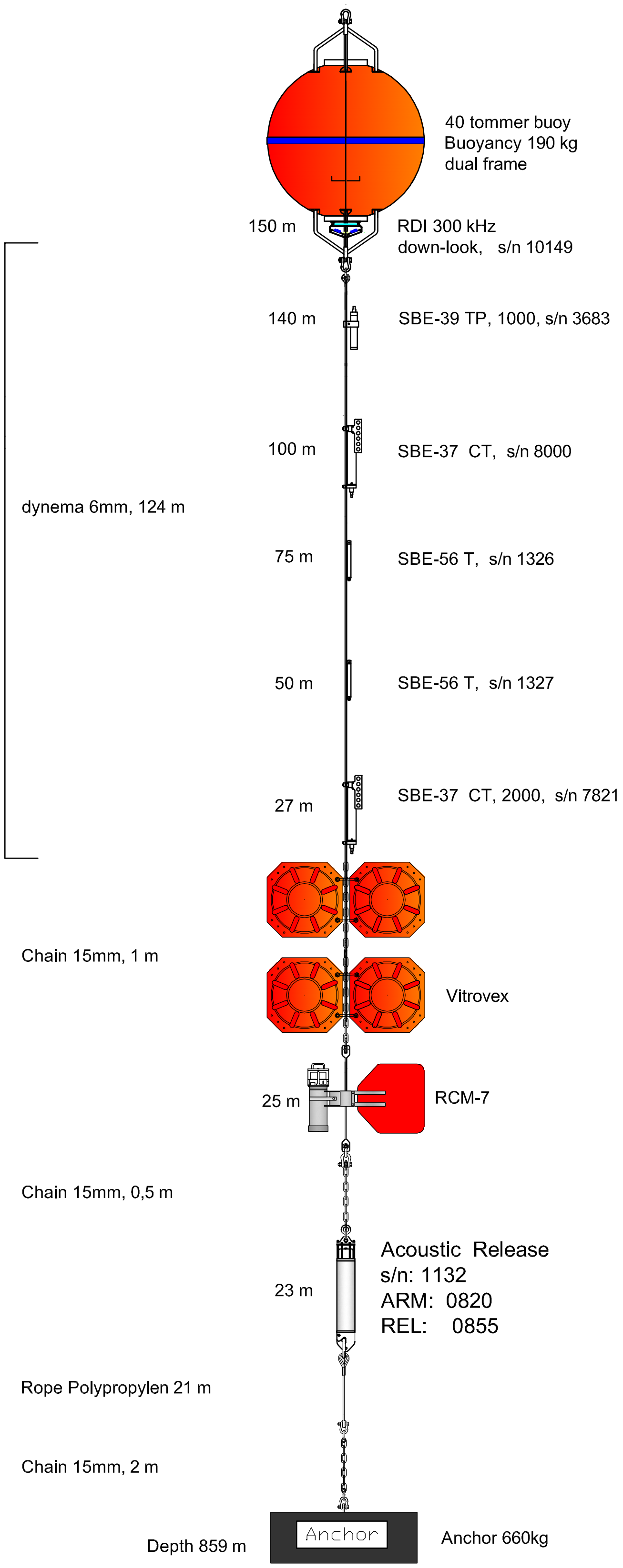
Deployment: 28.05.2012 12:50 - 14:00

Retrieval:

Comments:

4	44" Buoy , 280 kg buoyancy
1	Elliptical Buoy, 68 kg buoyancy
2	Vitrovex , 20kg buoyancy
1	RDI Longranger ADCP
1	RDI 150 kHz ADCP
1	RDI 300 kHz ADCP
3	SBE - 37
1	SBE - 39, TP 2000
7	SBE - 56 T
1	Aquadopp
1	Acoustic Release
200m	6 mm Dynema Line
175m	6 1mm Dynema Line
21m	Rope Polypropylen 18mm
2m	Chain 15mm steel galvanic
1m	Chain 15mm steel galvanic
|1m	Chain 15mm steel galvanic
1	Anchor 850kg, dry weight

C3



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project:

Location: FÆRØYENE

Position: 61 N 33.605 800 W 37.703

Depth: 859 m

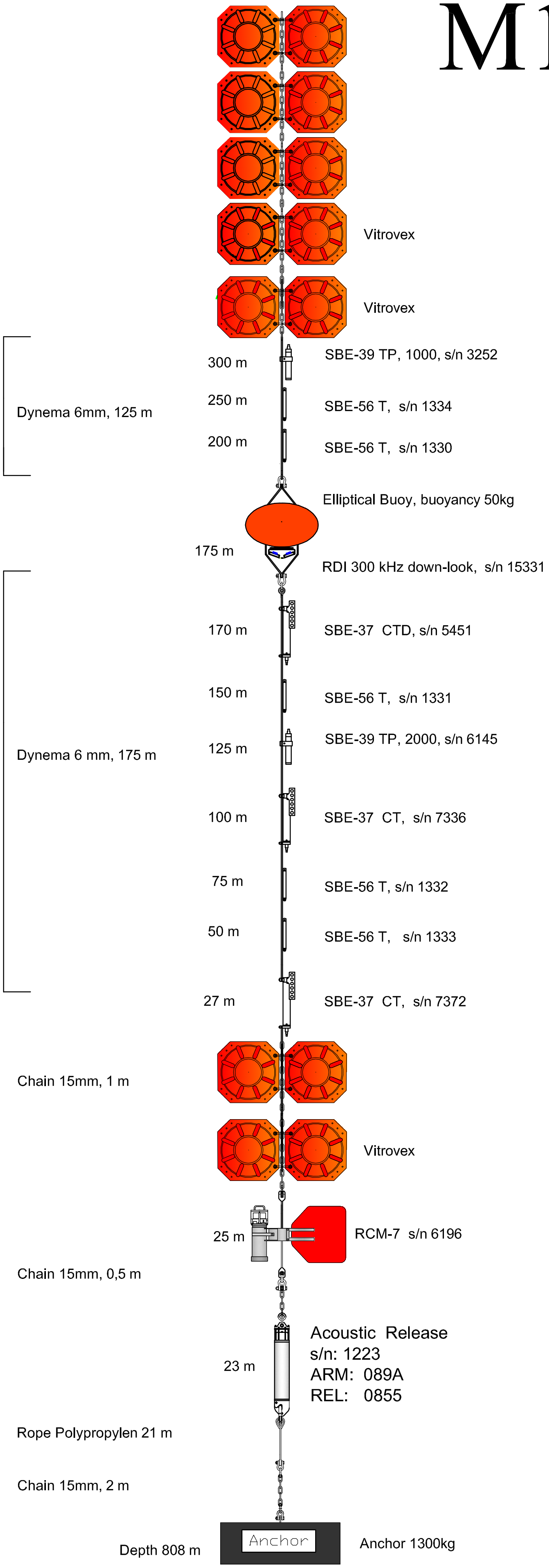
Deployment: 28,05,2012 16.30 - 16.56 UTC

Retrieval:

Comments:

4	Vitrovex , 20kg buoyancy
1	40" Buoy, 190 kg buoyancy
1	RDI 300 kHz ADCP
2	SBE - 37
1	SBE - 39, TP 1000
3	SBE - 56 T
1	RCM-7
1	Acoustic Release
124m	6mm Dynema Line
21m	Rope Polypropylen 18mm
2m	Chain 15mm steel galvanic (anchor)
1m	Chain 15mm steel galvanic (vitrovex)
1	Anchor 660kg wet weight

M1



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project:

Location: FÆRØYENE

Position: 61 N 45.013' 009 W 19.975'

Depth: 808 m

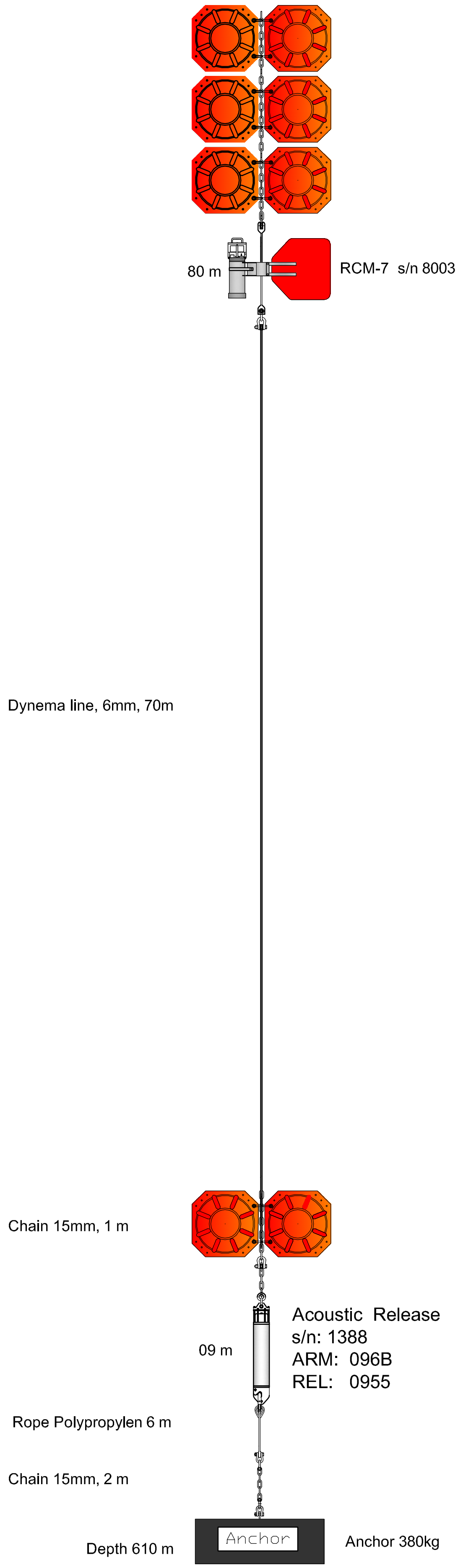
Deployment: 29.05.2012 08.10 UTC

Retrieval:

Comments:

14	Vitrovex , 20kg buoyancy
14	Elliptical Buoy , 68kg buoyancy
3	SBE - 37
2	SBE - 39,
5	SBE - 56 T
1	RDI 300kHz ADCP
2	RCM-7
1	Acoustic Release
125 m	6 mm Dynema Line
150 m	6 mm Dynema Line
1m	11mm Kevlar Line
21m	Rope Polypropylen 18mm
5m	Chain 15mm steel galvanic
2m	Chain 15mm steel galvanic
2m	Chain 15mm steel galvanic
1	Anchor 1300kg dry weight

S1



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project:

Location: FÆRØYENE

Position: 61 N 54.87' 009 W 28.98'

Depth: 610 m

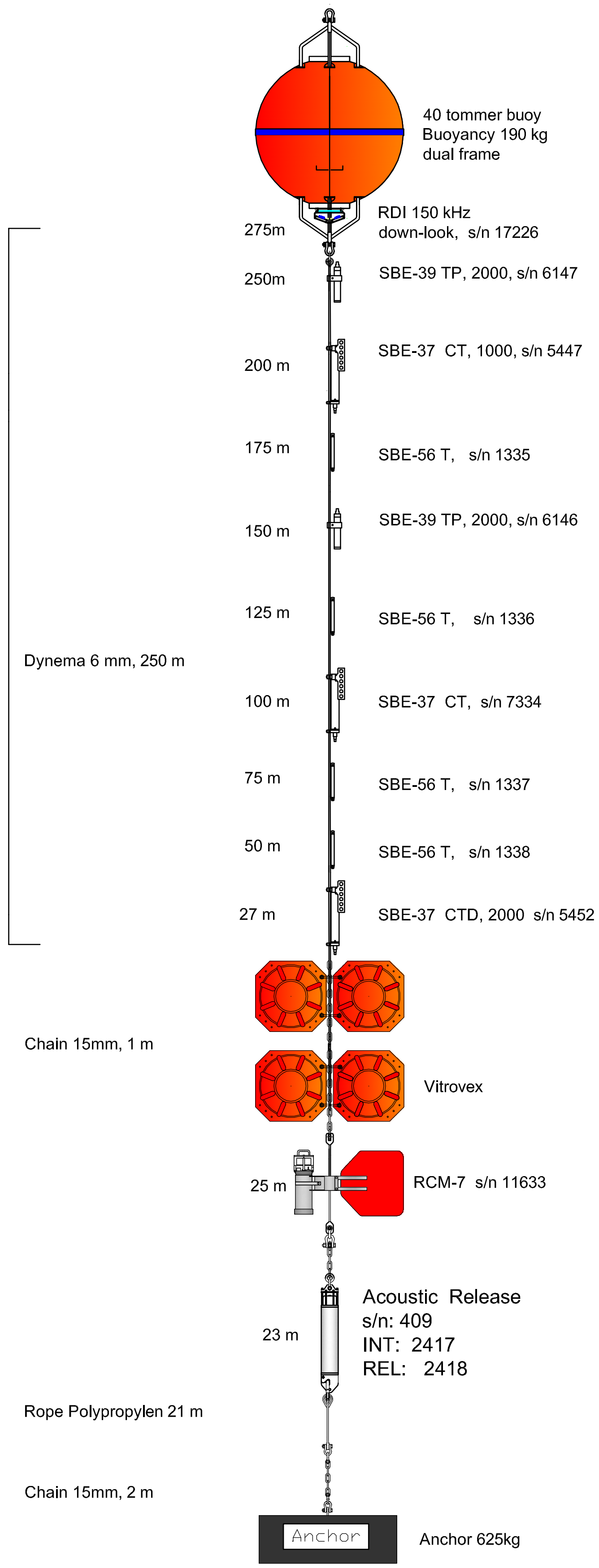
Deployment: 29.05.2012 11.30 UTC

Retrieval:

Comments:

8 stk	Vitrovex, 25kg Buoyancy
1 stk	RCM-7
1 stk	Acoustic Release
70 m	Dynema line 6 mm
1 m	Chain 13 mm
2 m	Chain 13 mm
6 m	Rope Polypropylen 18 mm
	Anchor 380kg

S2



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project:

Location: FÆRØYENE

Position: 61 N 49.2' 009 W 36.54'

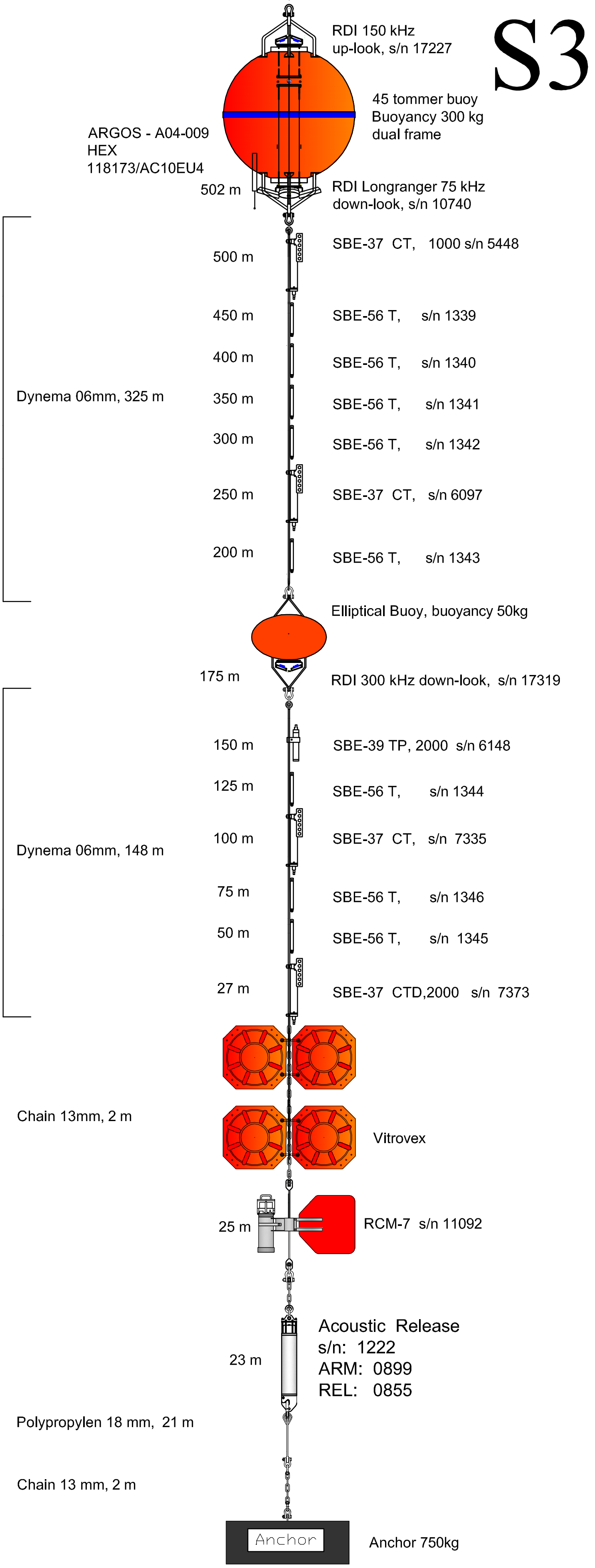
Depth: 805 m

Deployment: 29.05.2012 14:25 UTC

Retrieval:

Comments:

4	Vitrovex , 20kg buoyancy
1	40" Buoy, 190 kg buoyancy, Flotation Technologies
1	RDI 150 kHz ADCP
3	SBE - 37
2	SBE - 39, TP 1000
4	SBE - 56 T
1	RCM-7
1	Acoustic Release
274 m	11mm Kevlar Line
1m	11mm Kevlar Line
21m	Rope Polypropylen 18mm
2m	Chain 15mm steel galvanic
1m	Chain 15mm steel galvanic
|1m	Chain 15mm steel galvanic
1	Anchor 300kg wet weight



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project:

Location: FÆRØYENE

Position: N 61 43.591 E 009 43.221

Depth: 950 m

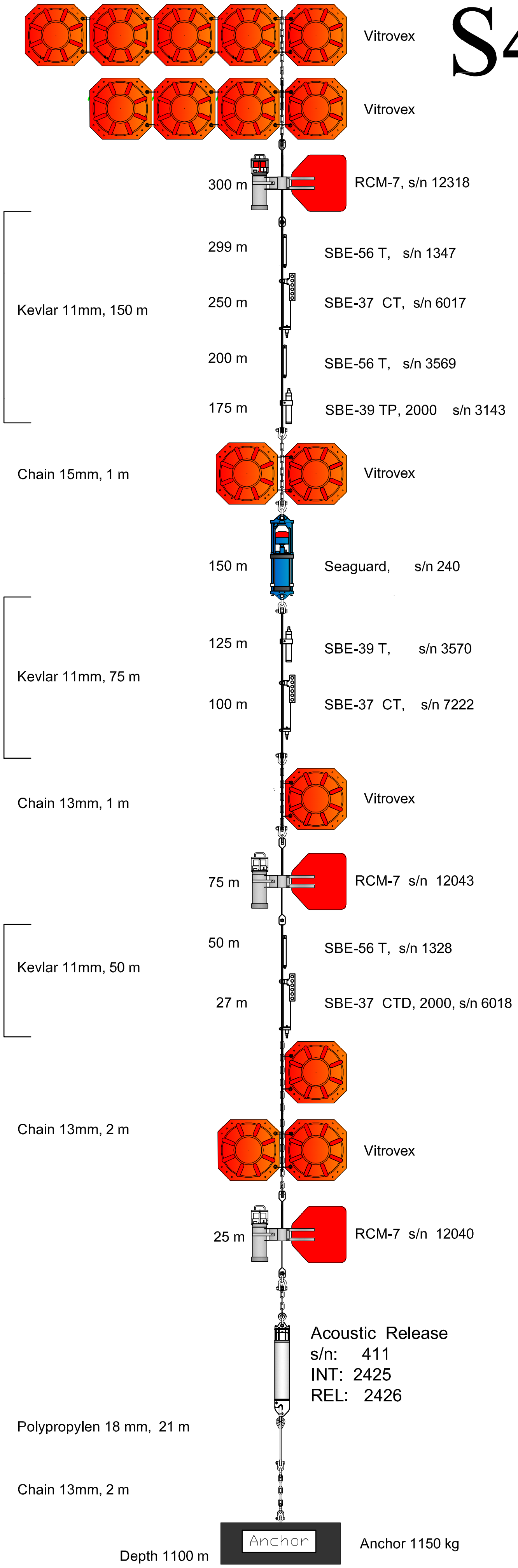
Deployment: 29.05.2012 20:00 UTC

Retrieval:

Comments:

1	45" Buoy, 300 kg buoyancy, Flotation Technologies
1	Elliptical Buoy, 50 kg buoyancy,
4	Vitrovex , 20kg buoyancy
1	RDI Longranger 75 kHz ADCP
1	RDI 150 kHz ADCP
1	RDI 300kHz ADCP
4	SBE - 37
1	SBE - 39, TP 1000
8	SBE - 56 T
1	RCM-7
1	Acoustic Release
325 m	06 mm Dynema Line
148 m	06 mm Dynema Line
21m	Rope Polypropylen 18mm
2m	Chain 15mm steel galvanic (Anchor)
1m	Chain 15mm steel galvanic (Vitrovex)
|1m	Chain 15mm steel galvanic (Vitrovex
1	Anchor 750 kg

S4



UNIVERSITETET I BERGEN
Geofysisk Institutt

Project: ____________________

Location: FÆRØYENE

Position: N 61 38.89 E 009 49.102

Depth: 1082 m

Deployment: 30.05.2012 10:50 UTC

Retrieval: ____________________

Comments:

9	Vitrovex , 20kg buoyancy
3	SBE - 37
1	SBE - 39, TP 2000
4	SBE - 56 T
1	Seaguard
2	RCM-7
1	Acoustic Release
150 m	11mm Kevlar Line
125 m	11mm Kevlar Line
1m	11mm Kevlar Line
21m	Rope Polypropylen 18mm
2m	Chain 15mm steel galvanic
2m	Chain 15mm steel galvanic
1m	Chain 15mm steel galvanic
1m	Chain 15mm steel galvanic
1m	Chain 15mm steel galvanic
1	Anchor 300kg wet weight